



# **Final Report**

## **Group 2**

### **Laundry Mate**

Brett Bussell  
Mohammad Izwan Zainol Bahar  
Fayyad Azhari  
Gurkirat Singh

## **Problem Definition**

Coming up with a particular problem for this class project was not easy for us simply because of the diversity that was present within our team. We all had different ideas that we were passionate about and wanted to work on over the course of this semester. Due to the lack of time, it was not possible for us to consider all the great ideas that we had planned initially, so there was this pressure within our team members to come up with an idea that we all were invested in equally and wanted to see it come together as a whole product.

With that mindset, our team decided to perform different brainstorming activities to come up with a problem that we wanted to find a solution for. It was not as easy as we thought it would be because we wanted to find something that we all have experienced or can relate to.

Therefore, we decided to look at our daily day to day routine to see if there is anything that could be improved or can be modified. During a lecture, the professor said, “There are bad designs everywhere” and surprisingly we were able to find one that we all related to and agreed upon to work on as a project for this class.

Shared spaces or communal living has its many pros and cons depending on a person to person but one of the cons being the uncertainties that come with communal laundry rooms or shared laundry spaces with limited number of washers and dryers. Personally, I do not enjoy doing laundry and it takes me a good amount of time to make up my mind about doing a load of laundry that is if the washers and dryers are not out of service or they are not being used by someone else or if people actually took their clothes out of the washer for the next person to use which my teammates completely agree with because they also face these issues in their lives. In addition, there is a lot more that could go wrong with the communal laundry rooms or with the shared laundry room in an apartment complex and a person might not be able to finish a load of laundry that he or she actually planned for and ultimately wasting time when he or she could be doing anything else. In concise:

Laundry should not take HOURS let alone DAYS to do. College students or residents sharing laundry machines waste time making multiple trips down to the laundry room simply to find that all the machines are being used up or people have not taken their laundry out yet. This ultimately leads to the students or apartment residents having to haul their whole laundry back up the stairs again, and the cycle is repeated.

Therefore to address the problem mentioned above, our group came up with a low-cost alternative “Laundry Mate” to smart washers/dryers to increase efficiency and useability of the shared laundry spaces. Small, easy-to-install, WiFi-enabled device that attaches to the machine and sends status updates to users and allows them to check the availability of / reserve machines.

With a product like this, our main goal was to resolve the problem of forgotten laundry in a shared spaces and to provide updates about the progression of the whole cycle such as sending text confirmation when the washer’s spin cycle starts and when it ends also providing with a text to the user saying that the laundry is done and is ready for pick up so that the next user can use it,

increasing the efficiency of shared laundry spaces. With that, we also enabled the product with the reserving system where the user can reserve the washer or dryer either in person or via text messages. During this process of brainstorming, identifying the problem that actually aligned with all of our interests was the biggest challenge for us and as soon as we did that our team was able to start with the next steps of product development which included idea generation, customer research, concept generation, and prototyping.

## **Idea Generation**

After agreeing on the problem, we started with the idea generation of the product to make sure we decide on the right project and it is achievable by a group of four students in three months. So early in the semester, the SWOT analysis was used to explore the use of notification and reservation system on washer and dryer.

<b>SWOT Analysis</b>	
<b>Laundry Mate</b>	June 20 <sup>th</sup> 2019
Topic: To explore the use of notification and reservation system on washer/dryer	
<b>Strengths:</b> <ul style="list-style-type: none"> <li>· Saves trip to laundry</li> <li>· No need to wait for some else's clothes</li> <li>· Never forget to swap clothes to dryer</li> <li>· Non-invasive</li> <li>· Easy to installed</li> <li>· Inexpensive</li> <li>· Our team have ME backgrounds</li> </ul>	<b>Weaknesses:</b> <ul style="list-style-type: none"> <li>· We don't have a lot of experience compared to established business</li> <li>· Limited marketing budget needed to create brand awareness</li> </ul>
<b>Opportunities:</b> <ul style="list-style-type: none"> <li>· Saves a lot of time for because of efficiency</li> <li>· Busy students who don't have time to waste</li> <li>· Building with shared laundries</li> <li>· Laundromat</li> <li>· Campus laundry facilities</li> <li>· Minimum time and labor are involved</li> </ul>	<b>Threats:</b> <ul style="list-style-type: none"> <li>· There's a lot of laundry app in the market WASH, smart washer/dryer by Samsung and GE</li> <li>· People ignoring the reservation and notification system</li> </ul>
Team member: Izwan Team member: Gurkirat	Team member: Brett Team member: Fayyad

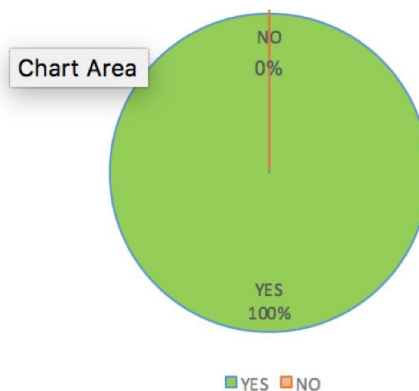
From the SWOT analysis, the main discussed strengths that make us decide on our project are that the system will increase the efficiency of doing laundry in shared spaces, it will be small, non-invasive and easy to be installed by the laundry owner. We also considered that our team which consists of 4 mechanical students are capable of making the project throughout the 10 weeks of summer semester.

### Customer Survey

A customer survey was conducted to explore and research the features needed for our product across an entire segment of people. The survey was handed out to our house mates and people who live in our apartment complex since we know they are using a shared laundry room and they are our targeted user of our product. We managed to get 28 people to participate in our survey.

Ever forget to pick up or swap clothes to dryer?

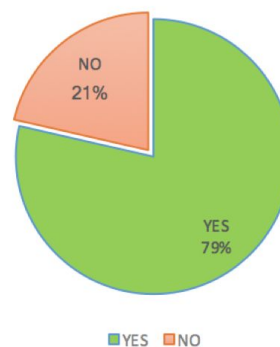
YES	NO
28	0

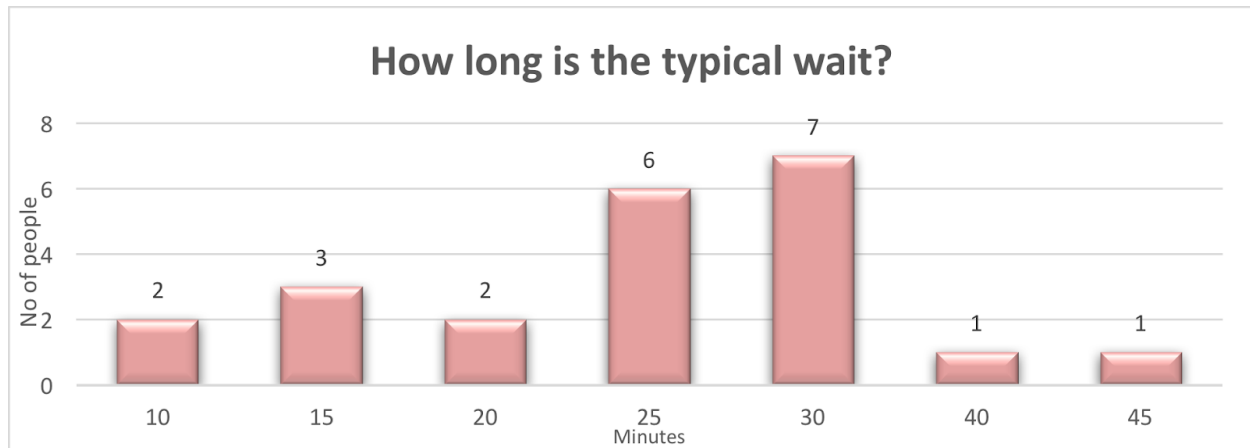


The first question was if they ever forget to pick up their clothes from the washer or dryer or swap their clothes from the washer to the dryer and all 28 of them answered yes.

YES	NO
22	6

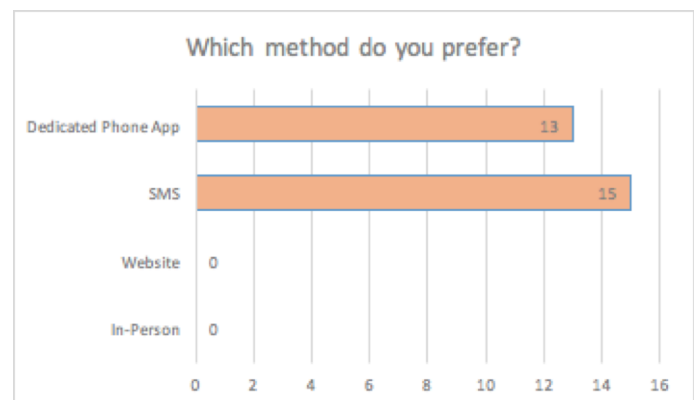
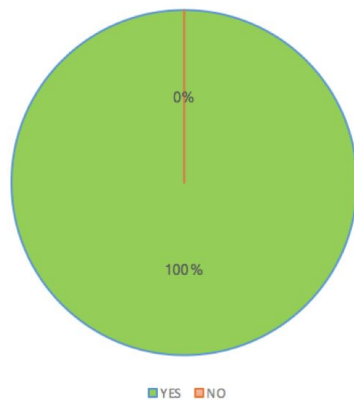
Ever walk to laundry spaces and have to wait for available machine?





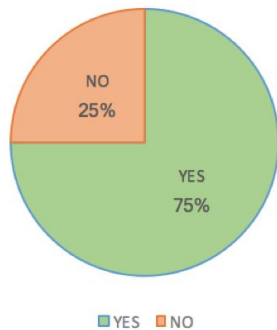
The second question was if they ever experience waiting for someone else to finish their laundry and 22 people out of 28 said yes to the question. The follow up question for the people who said yes was how long is the typical wait time and most of them said it was between 25-30 minutes. For those who said no, the most common reason was that they have been using other notification system.

Prefer to have a reservation and notification system or already have the system?

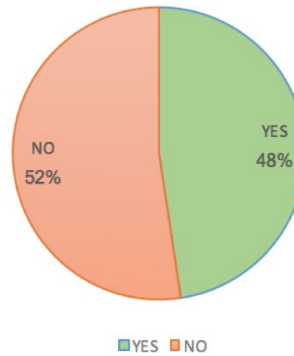


The next question was if they prefer a notification system or already have the system installed at their place and all the 28 people prefer them. The follow up question for the people who said yes was which method would they prefer and 13 people said a phone app and 15 people said they prefer text messages.

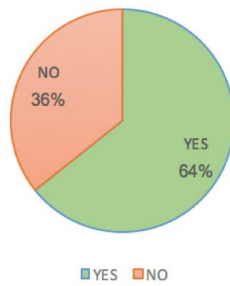
Willing to remove someone else's clothes from machine with pair gloves?



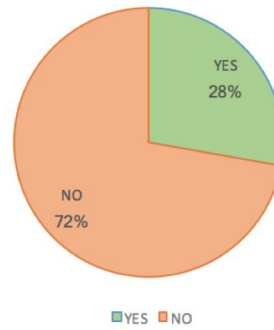
Without gloves?



Would you allow someone else to remove your clothes with gloves?



Without gloves?



The final question was if they willing to remove or allow someone else to remove their clothes from a washer or dryer to laundry basket. We found out that most of the people said yes and there are much more people who prefer to do that with their gloves on.

From the survey, we learned that people are forgetful and they always wanted to have a simple notification system to remind them and a reservation system to assure that they do not have to wait for someone else to do their laundry. We also found that time is really valuable and we do not want our users to waste 30 minutes to just waiting for other people. Other than that, if the average wait time is 30 minutes which is equal to a wash cycle, we discovered that it will cost the owner \$1.50 for every single wait time. In a month, we calculated that the average cost would add up to \$80 for the inefficiency.

### **Customer**

From the survey that we have done, we decide to focus our market to certain group of people which are renter, laundromat, shared laundry in apartment, busy person and people who want to save budget. Then, from the survey we can focus the requirement that customers want which are the device has to be easily installed, user friendly, non-invasive, and cheap.

## Competition

We do some research on what has been done by other people to solve our problem. We focus our research on the solution that revolve around our main customers requirement. From the research that we did, we found two competitors that can rival our product. The competitors are Samsung Smart Washer and WASH.

<b>Quality</b>	 <b>Samsung Smart Wash</b>	 <b>WASH</b>
<b>Price</b>	\$1259.00	Need quote
<b>Installation</b>	Need professional to install	Need professional to install
<b>User friendly</b>	<ul style="list-style-type: none"><li>- Using app</li><li>- Additional features</li></ul>	<ul style="list-style-type: none"><li>- Using app</li></ul>
<b>Non - invasive</b>	Pre installed in washer	Too invasive

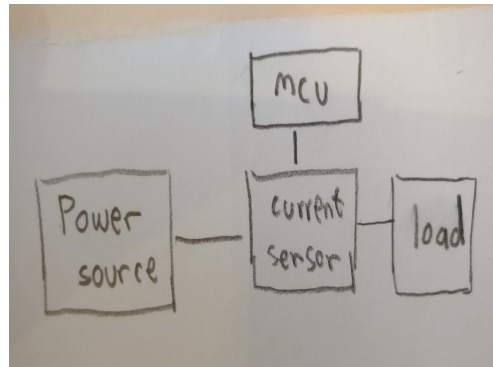
## Engineering Concept

Most of laundry machines have typical cycle modes which are pre-wash, wash, rinse, and spin. So, we conclude that every mode cycle will have different vibration and current magnitude. So, we developed a theory if we can measure the vibration or current magnitude of the laundry machine, we can identify the cycle mode of the laundry machine. Hence, we can use the data that we get to send relevant information to user.

## **Concept generation**

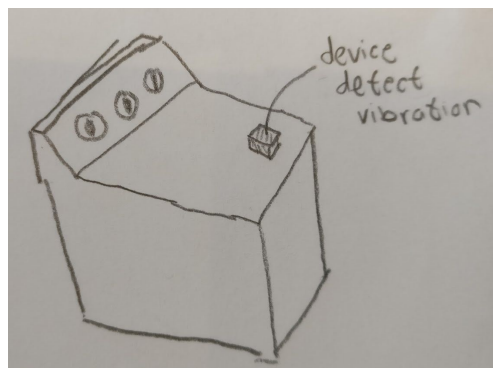
From the theory that has been developed, we produce four different concepts. Our concept can be generalized into three which are to detect current magnitude, detect vibration magnitude, and the last one is a reservation system.

### **First concept**



In detail, the first concept that we produced is we hardwired the laundry machine and use it to get a current value. We use a current sensor to get the current value.

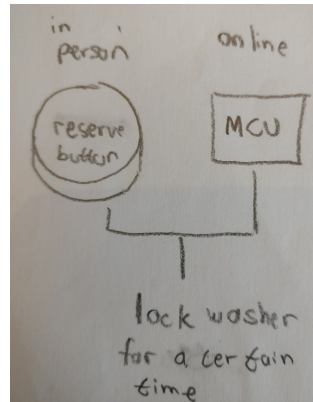
### **Second concept**



The second concept is, we used IMU to get vibration magnitude from the laundry machine. We process the data gathered and used it to send relevant information to user.

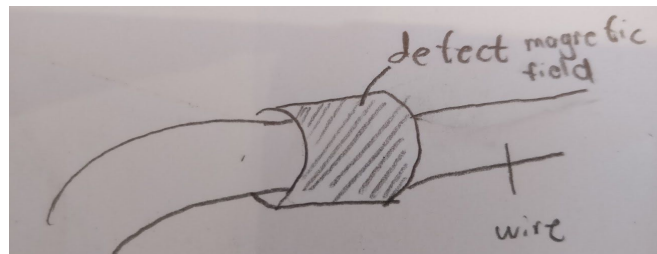


### Third concept



The third concept is we created some reservation system online or in person. The in-person reservation system is used by using button and interact with MCU. For online reservation system we used MCU and server to interact with the user. The reservation system had a locking mechanism that will lock the laundry machine temporarily.

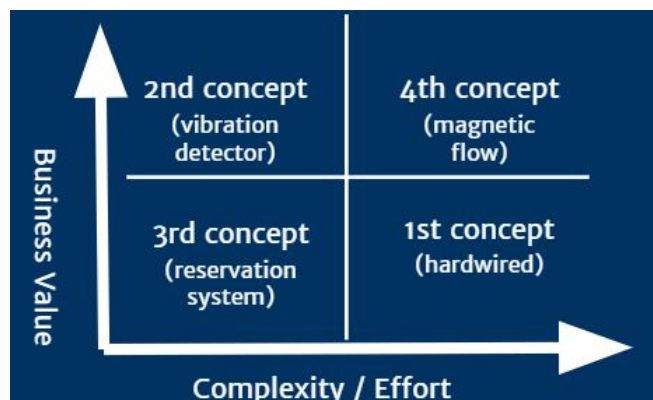
### Fourth concept



The last concept is used to detect current. We are going to use magnetic field around the wire to get current magnitude.

### Concept Evaluation

Then, we evaluate all the concepts in terms of their complexity and business value.



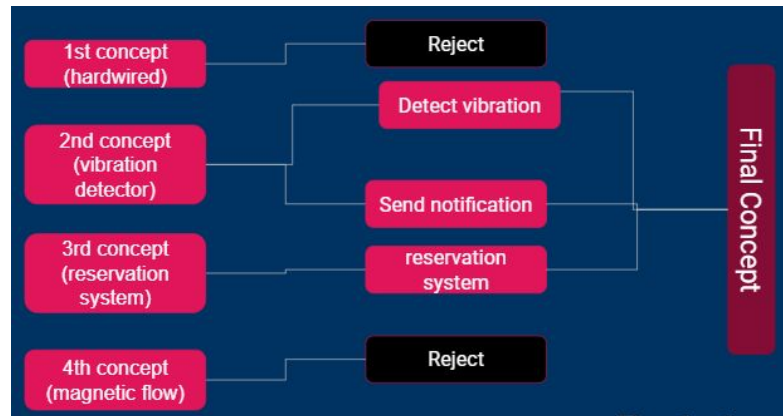
We found out that the 1st concept (hardwired) is a complex concept to do and has low business value. Followed by the 4th concept (magnetic flow) that has the same complexity with the 1st concept (hardwired) but has higher business value. Then, the 3rd concept (reservation system) is a simple concept to do but has a low business value. The last concept which is the 2nd concept (vibration detector) has a low complexity and high business value.

After this, we decided to use a plus minus table to see the pros and cons of each product.

Concept	Plus	Minus
1st concept (hardwired)	<ul style="list-style-type: none"> <li>• Accurate reading</li> </ul>	<ul style="list-style-type: none"> <li>• Too invasive</li> <li>• complex</li> </ul>
2nd concept (vibration detector)	<ul style="list-style-type: none"> <li>• Reliable reading</li> <li>• Easy</li> </ul>	<ul style="list-style-type: none"> <li>• Need to recalibrate for different washer</li> </ul>
3rd concept (reservation system)	<ul style="list-style-type: none"> <li>• Reservation features</li> </ul>	<ul style="list-style-type: none"> <li>• Locking system is invasive</li> </ul>
4th concept (magnetic field)	<ul style="list-style-type: none"> <li>• Not invasive</li> </ul>	<ul style="list-style-type: none"> <li>• Too complex</li> </ul>

From the table above, we can see that for the 1st concept (hardwired) has an accurate reading for its plus, but the cons for this concept are the concept is too invasive and complex as well. For the 2nd concept (vibration detector), the pros for this concept are that we can get a reliable reading of the vibration magnitude and it is easy to do. The only disadvantage is that we have to recalibrate for every different washing machine. The 3rd concept (reservation system), the advantage of this concept is because of the reservation features. But, the disadvantage of this concept is the locking mechanism of this concept seems to be too invasive. The last concept, 4th concept (magnetic field) has the pros which is not invasive. The cons for this concept is that it is too complex to do. With the amount of time and resources that we have, we decide to proceed with the project that easy to do and needs the least amount of resources.

## Concept derivation



From the flow chart above, we can see the derivation of all the concept to become our final concept. We decided to take all the plus that are useful and relevant then try to combine it to become our final concept.

We took vibration detector and notification system from the 2nd concept (vibration detector) and from the 3rd concept (reservation system) we took the reservation system features only. From all the features of the concept that we selected, we proceeded with our final concept.

## House of Quality (HOQ)

We created the House of Quality (HOQ) table and found that we have 17 demanded qualities and 15 functional requirements. From all the 17 demanded qualities, there are 7 main demanded qualities which are :

- ☐ Small
- ☐ Non-invasive
- ☐ Inexpensive
- ☐ Easy to be installed
- ☐ Ease of use
- ☐ Reliable
- ☐ Aesthetic

Then from all 15 functional requirements, there are 6 main functional requirements that have to be prioritized which are:

- Manufacturing cost
- Dimension
- Response time

- Waterproof rating
- Battery capacity
- Sensitivity

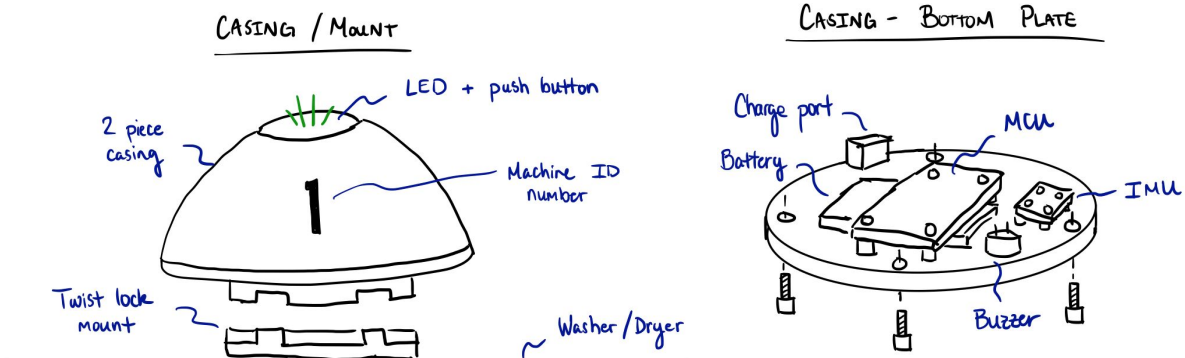
We want to emphasize a few of engineering requirements that we want to meet for our final prototype. The table below shows the engineering requirements and its respective value that we want to meet.

Item	Value
Battery Capacity	3000 mAH
Size	10 cm diameter, 5cm height
Response time	< 3 seconds
Waterproof rating	5000 mm
Assembly step	2 steps
Accelerometer sensitivity	300 mV/g

### **Final Concept**

Some of the key features of Laundry Mate are:

- Plastic casing to house electronics
- WiFi-connectivity for communication
- Rechargeable battery (making the device completely wireless during operation)
- Vibration sensing to sense steps of the wash cycle
- SMS reservation and laundry updates to increase laundry room efficiency
- Theft protection alarm



The outer casing is designed to consist of two major pieces (the upper dome and bottom plate) of injection-molded thermoplastic which, when screwed together, form a splash-resistant housing for the electronics inside. The bottom plate has an open and flat design that allows the electronics to be easily attached and soldered in place by automated machinery. The only electronics that are not attached to the bottom plate are the LED and push button switch. Since the LED and push button are housed in the upper dome, they will be connected to the MCU by JST connectors to allow easy disconnection when opening the casing. At the top of the upper dome is a semi-transparent section which houses/diffuses the LED light and acts as a large push button. Also, stickers are included so customers can number the machines (they will provide us these ID numbers upon initial device setup). Finally, the bottom plate consists of a twist-to-lock mount that allows easy removal from the washer/dryer for charging or replacement. The owner simply needs to attach the mount's receiver to the washer/dryer with the included mounting tape.

Laundry Mate's SMS update system is rather simple. The device can sense the beginning of a wash, the spin cycle, and the end of a wash (for dryers, just beginning and end). At each instance, Laundry Mate sends a message to our remote servers with the machine status at which point those servers relay the message (via SMS) to the person using the machine. For example, when the spin cycle begins, the user will receive a message that their laundry will be done in about five minutes. When the wash cycle ends, they will receive a message stating their cycle has finished and they have a grace period (setup by laundromat owner) to pick it up before the machine becomes available for others to use.

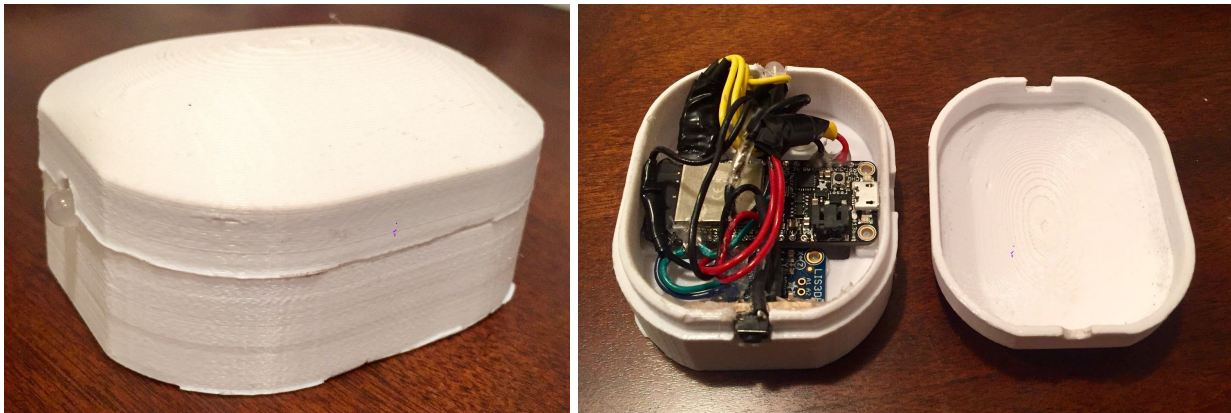
Laundry Mate also handles machine reservations via SMS. Using SMS keywords like "AVAIL", "RESERVE", and "CANCEL" the user can check if any machines are available in the laundry room, reserve any available machines, and cancel any reservations they have made. When reserving users are again given a grace period to show up for their reservation or their reservation will be forfeited. Also included is a virtual queue in the case that there are no machines available at the moment. The user opts to wait in the virtual queue, at which point they are given an estimated wait time and when a machine opens they will have the option to reserve it when their turn comes. For those who do not wish to use the SMS reservation system, the button on Laundry Mate can be used to process an in-person reservation on an available machine. Machine availability is made apparent by the LED color (red = not available, green = available). If for some reason the user never presses the button and starts the wash cycle, the reservation will automatically process and mark the machine as unavailable. Note that people using the in-person reservation system will not receive SMS updates.

Finally, Laundry Mate incorporates a buzzer/speaker that has many functions. First is theft deterrence. Laundry Mate can sense when it is removed from the machine, at which point

the speaker/alarm will blare until one of two things happens... (1) Laundry Mate is returned to its mount or (2) The units owner sends an SMS that everything is okay. The owner also has password protected capabilities to disable features like this so the alarm won't go off when he removes for charging. The second function of the speaker is for cycle end notification. This feature is mostly useful for machines with broken or nonexistent buzzers. Next is the unauthorized use alarm. After reserving a machine, the user will receive an SMS letting them know when their cycle begins. If someone else has started the cycle, they reply to tell Laundry Mate that it is not them. The speaker alarm will go off, letting the person know they are violating the reservation system and the alarm will continue to go off until one of two things happens...(1) They end the cycle or (2) the actual reserver sends an SMS that everything is okay. Finally, the buzzer is used with the LED in tandem to provide user feedback. For example, if someone tries to hit the in-person reservation button on a machine that is not available, the speaker will beep and the LED will flash to remind them that the machine is unavailable.

## **Prototype**

When creating the prototype, the team decided to focus on incorporating as many functions from the final concept as possible, rather than focusing on the appearance of the device. This decision was made to allow us the opportunity to get Laundry Mate in front of users as soon as possible to allow quick end-user feedback. Photos of the prototype are below.

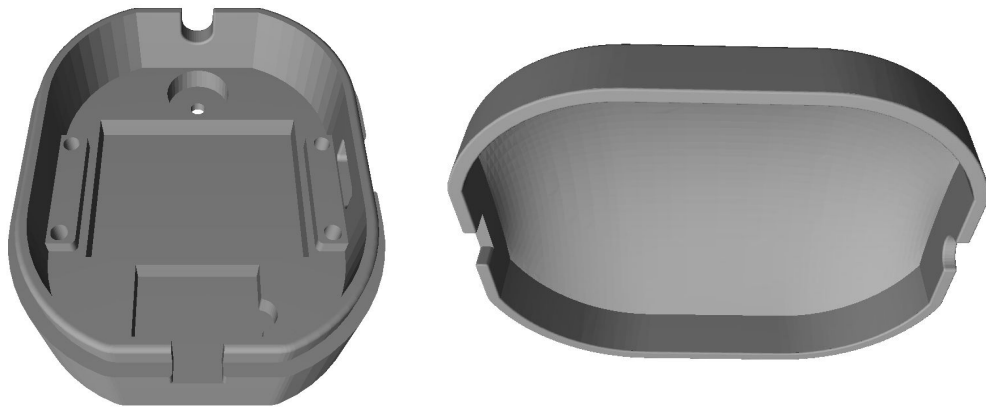


Features incorporated in the prototype include:

- Sensing cycle begin/spin/end
- SMS updates and reservation system (no virtual queue)
- In-person reservation button
- End of cycle buzzer

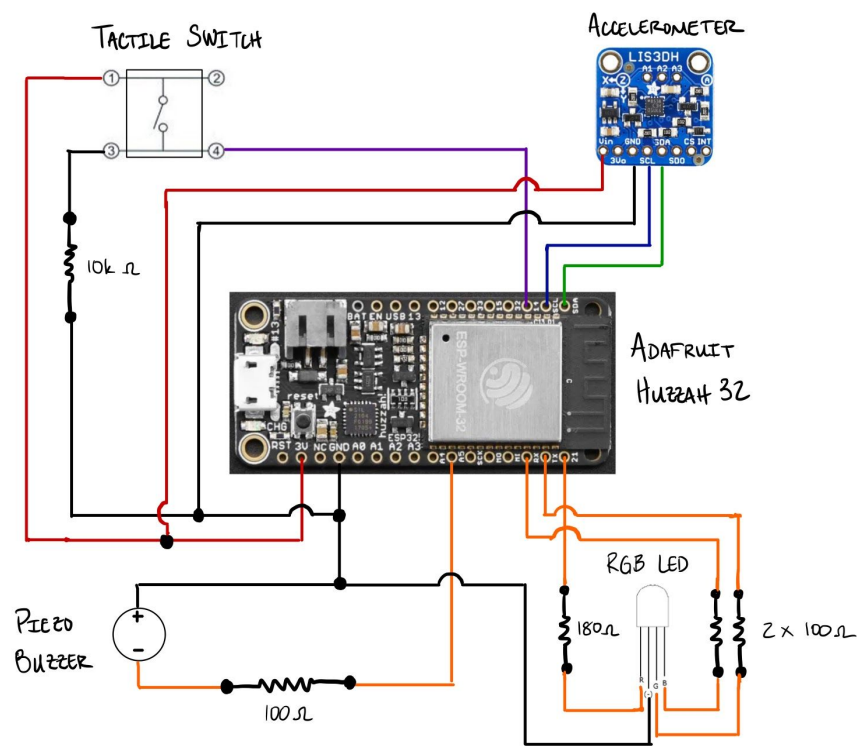
The casing design can be seen in the photos below. It consists of two pieces of 3D-printed PLA, the bottom section (with dedicated spaces for all electronics) and a simple

press-fit lid (for easy removal to allow quick repairs and debugging). Also note that the LED and push button were moved to the bottom piece (again, to allow for repairs/debugging).



The electronics used include (circuit diagram below):

1. Adafruit Huzzah32 WiFi-enabled MCU (for data processing and communication)
2. LIS3DH accelerometer (for sensing vibrations)
3. Piezoelectric buzzer (for auditory feedback)
4. RGB LED (for visual feedback)
5. Tactile switch (for in-person user input)
6. Resistors (to protect circuit components)



Finally, in practice the Laundry Mate units and user will communicate through a “middleman” of remote servers. For the prototype, a MacbookPro was used as this “middleman” by running two Python programs which handle all incoming and outgoing communication with the Laundry Mate units and the end user, relaying important information when necessary. A diagram of the communication flow can be found below.



### Manufacturing and Retail

Item	Price
ESP32	\$10
IMU (accelerometer)	\$5
Buzzer	\$0.35
RGB LED	\$0.08
Tactile switch	\$0.40
Rechargeable Battery	\$10.00
Micro USB charging cord	\$4.00
Miscellaneous	\$1.00



The table above shows all the cost of our prototype. We decided to make our retail price to be \$40. But, the price can go much lower if we do some improvement and mass produce it.

## **Test**

Since we had a few extra days before the end of the semester, we decided to run a general user testing to make sure our prototype is functional. The prototype was installed at one of our group members, Gurkirat's apartment where they are sharing a single washer and dryer with 6 people. We make sure everyone participated on the test for 5 days.



After five days, we asked them whether they wanted Laundry Mate to be installed at their washer and dryer and we got all of them to agree. Some feedbacks were also received from the people we tested on such as they wanted a bigger and more accessible button for the in-person reservation. Moreover, they also wanted a brighter and bigger LED to make sure its visible during the day. Lastly, they also said that they wanted a better finish on the casing since the prototype has a really low resolution of 3D printed casing.

## **Conclusion**

All in all, the whole process of developing a product was very great and we got to learn so much about the product development process and from each other. Because of the team diversity, it was possible for us to finish the project within a given timeline because everyone brought different skill sets to the table which were really helpful. In a competitive industry such as today, it is really important to use all the resources we can get, including skills and knowledge which can easily be attained by having a diversified team. The biggest challenge that our team faced while working on this project was to come up with a problem that we all wanted to work on and the one that aligned with all of our interests. The reason behind choosing something that we all wanted to work on was to make sure that everyone was happy with what we were doing and that we were all equally invested in the project. After choosing on a problem, the process of developing a product became a bit easier for us because now we all knew what direction we are headed in.

Right after, our team started the idea generation part of the process that included doing the SWOT Analysis, which provided us with useful information about our product like the strengths and weaknesses of the notification and reservation system of Laundry Mate. Purpose behind that was to really make sure that the efficiency of shared laundry spaces is increased. Like any other product in the market, it was really important for us to know what our actual customers think about our product i.e. Laundry Mate. The best way for us to know what our customers are actually looking for in our product features wise was to conduct an actual survey. Our team managed to get 28 people to participate in our survey and results were what we expected. Most of them wanted a simple notification system to remind them about their washer/dryer status. Furthermore, they also wanted a reservation system so that they can reserve ahead of time if the washer or dryer is available. These features in our product will increase the efficiency drastically. On average, it will cost about 80 dollars per month without our product in the market. Compared to other products in the market, our product is fairly cheap does not need a professional to install it. The owner can do the installation at their own without any professional help while other competitor products are required to be installed professionally.

As we were progressing along with our project, we stumbled across four different concepts. Main concepts were categorized as following detect current magnitude, detect vibration magnitude, and the reservation system. All of these concepts had their pros and cons. Now, it was upon us to choose the one that was perfectly suitable for the scale at which we were developing this project. Hence, we evaluated them in terms of complexity and business value which told us to go with vibration and reservation system. The final step under concept generation involved creating HOQ that really helped us to get the key features down such as: Plastic casing, wifi connectivity for communication, rechargeable battery, vibration sensing device, SMS reservation or in person reservation system, led to show the status of machine, and theft protection alarm system.

Now, we were ready to prototype. We decided to go with 3D printing for the casing with specified slots to secure the electronics. After the print, we learned that the resolution was not very great, but it was the best option for us considering we used the resources provided by the school. Later on, we are planning on changing the design of casing so that we do not have to deal with the fitting issues. In addition, creating prototype was really necessary for us because it provided us with important information about manufacturing and retail price. Including all the costs, we decided to make our retail price 40 dollars, which is fairly cheaper than the other products available in the market and it does not require professional installation. Now, we were at were testing stage, the test was conducted at one of our team mates apartments. They share a common laundry room among 6 people including our teammate. We installed the device “Laundry Mate” at their apartment and conducted another survey asking if they will get it installed ? and all of them said YES.

To wrap up, Laundry Mate is WiFi enabled device that senses and provides updates about the washer and the dryer state with an ability to reserve or cancel the reservation through mobile devices or in person by just pressing the button if the light is green. In addition, the lesson learned throughout this process was that no device is perfect and there is always room for improvement and we are planning on improving it by adding a smarter algorithm for vibration detection and by working on deep sleep programming logic to optimize the battery usage. This way we can make sure that we stay in the market.