MAE 540 - Advanced Product Design Methodology

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Smart Pill Dispenser

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Introduction

Approximately 1.3 million people are injured annually in the United States following so-called "medication errors" according to The National Coordinating Council for Medication Error Reporting and Prevention. [1]

In a study by the FDA that evaluated reports of fatal medication errors from 2005 to 2010, the most common error involving medications was related to administration of an improper dose of medicine, accounting for 41% of fatal medication errors. Almost half of the fatal medication errors occurred in people over the age of 60. Older people may be at greatest risk for medication errors because they often take multiple prescription medications. [2]

According to the journal published by Mayo clinic, more than 50% of the Americans take at least 2 prescribed drugs, and 20% of the Americans take at least 5 prescription drugs. [3]

This has motivated the team to develop an automatic pill dispensing machine to reduce the “medication errors” and provide the people with a reliable and efficient way of consuming the pills.

Beneficiaries

- Aged people
- Hospitals
- People who need to take multiple prescription drugs
- Differently abled

Who will it negatively affect

- Caretakers
- Home nurses

Market

- **Hospitals**

There exist about 6000 registered Hospitals in the US with about 900,000 beds. About 35 million people get admitted to a Hospital in a year. This creates about 10% of the American population as our market.

- **Personal Use**

There are about 20% of the Americans who take more than 5 pills a day and 50% who take at least 2 pills a day on an average. It a challenge to keep track of prescription and to keep in mind the dosage and time. Hence, the pill dispensing machine can cater to these problems.

Assumptions

- User takes pill upon notification and there is no spillage of medication causing replacement
- The user empty’s all the prescribed pills in the pill box
- Data entered by the user is correct

Review of the current state-of-the-art solutions

Pill Organizers [4]

Pill organizers are basic pill storage boxes organized with labels with respect to the days in a week. The pills must be sorted and put into respective boxes for that day. The pill box does not provide separate compartments to accommodate dosages for a day. It does not provide any dispensing mechanism as well. Pill organizers do not include any kind of alerting device.

Automatic pill dispenser [5]

It is more advanced version of pill organizers. It consists of a dispensing mechanism which dispenses pills to be taken for one time. It provides alerting mechanism by sending a message or e-mail to the user at the dosage time. One downside of this product is that the pills must be sorted manually into the compartments for each dosage.

Philips automated medication dispensing service [6]

The dispenser can accommodate 60 pre-filled dosage cups. It provides reminder alerts for instructions on taking meds. It also provides the optional early dosage feature. The activity of the user can be tracked using the Monitoring report available online, 24 hours per day. The dispenser also keeps track of missed dosages and the caretaker also receives alert regarding the missed dosage. The service also provides security features with locked cabinets and control access. The limitations of this service are that the caretaker must sort all the pills and put them in the cups.

Lumma smart pill dispenser [7]

Lumma is a Kickstarter project demonstrating the smart pill dispenser. This smart pill dispenser can store pills and the pills are automatically sorted in different reservoirs. The pills are dispensed automatically, a built-in alarm will ring and the device will light up when it's time to take the pills. The user gets notification via text message or e-mail to take the pills on time. The device also keeps track of the medication and the missed dosages. This report can also be shared with the doctor and nurses. This product is not commercially available in the market yet. This product if made commercially available, it will be very expensive.

Proposed Design Solution

After reviewing all the existing designs, we find that the commercially available products in the market do not serve the purpose of avoiding the patient from taking wrong medication. This is because, in all the commercially available products the sorting of the pills is done by the caretaker or the patient. The commercially available products are also priced high and is not affordable by majority of the people.

To eliminate all these problems a design solution is proposed with the following features:

- Sorting of pills into separate compartments there by eliminating sorting
- Automatic dispensing of pills at the given time of dosage
- Notification of the pills to the user via E - Mail
- Affordability of the product

These features will cater to all the needs of the patients and will serve the purpose.

Product positioning chart

Table 1: Product positioning chart

Products → / Attributes ↓	Pill Organizers	Automatic pill dispenser	Philips automated medication dispensing service	Lumma smart pill dispenser	Proposed design solution
Notification	×	×	×	✓	✓
Price(Affordability)	✓	×	✓	×	✓
Portability	✓	×	×	✓	✓
Modular	×	×	×	×	✓

Proposed design models for the dispensing mechanism

Design 1

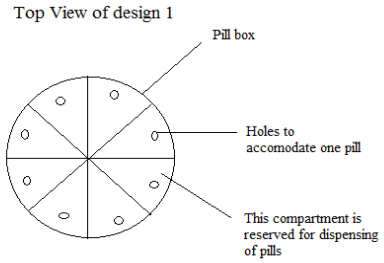


Figure 1: Proposed Design 1

In this design, the pill box is rotated by a stepper motor. The holes in each compartment accommodates only one pill at any given time. The pill which must be dispensed comes to the position of the compartment which is reserved for dispensing of pills. Actuator is placed below the compartment reserved for dispensing pills which dispenses one pill at a time.

Design 2

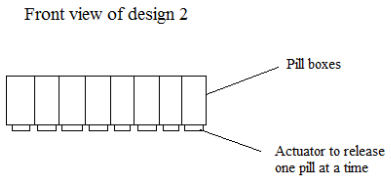


Figure 2: Proposed Design 2

In this design, the pills are stored in the pill box in separate compartments. Each compartment is setup with actuator below the box. This actuator controls the flow of the pills by dispensing one pill at a time.

Design Attributes and Variables

Problem Statement

With ever changing lifestyle in this fast-paced world, people often get affected with diseases and tend to consume a lot of pills. However, with the busy lifestyle people tend to forget or they take the wrong pills. Approximately 1.3 million people in the United States are affected annually due to **Medication** Errors. To overcome the issues related to medication errors, we are developing a solution called the **Smart Pill Dispenser.**

Attribute

Price

One of the most key attributes to any product is the cost. The customer always has a close eye on this attribute. The price is a crucial factor for us because that will decide what features could be added to the product. The price point should be such that it does not burn a hole through the customer's pocket and does not cause inconvenience to the manufacturer.

Portability

This is an attribute which decides on the compactness of the product and its space consumption. Thus, giving us a brief idea about the dimensions of the product. Portability affects other attributes as well. The compactness of the product depends on the user's preference as even weight of the product is affected by the compactness. The attribute levels are based on a 'yes' or 'no' answer.

Pill Sorting

From the daily dosages to be taken, there needs to be sorting of the medicines done to match with the dosage time. This sorting is done before taking the pill, to ensure correct dosage is taken at the correct time interval. The attribute levels are based on making the pill sorting 'manual' or 'automatic'.

Device Connectivity

This attribute is used to determine if the consumer's preference of connection and the type of

connector to be used. There are a wide range of ways in which the devices are connected today and the levels are used to decide the method of connection such as ‘Wi-fi’ or ‘LAN Cable’.

Notification
A notification is a message you can display to the user outside of your product's normal User Interface. These can be used as alerts by the developers to bring it to the attention of the user. Attribute levels defined here are as ‘Email/Text’ or ‘None’. This will determine if this is an important attribute.

Security
It is the resistance to or protection of the system from harm. This attribute is used to safeguard our product in case of accidental harm. The security levels are based on the extent of manhandling the product can suffer from. The levels are defined as ‘Pincode‘ or ‘Key’.

Design Objectives

Functions

- **Timer** – A timer to register and store the time for dispensing the pill
- **Notification** – An application that sends an e-mail and a message
- **LED Light** – An LED light to notify the user to take the medication

Design Variables

- **Dispensing Time** – The pills must be dispensed at the right time for the user.
- **Dosage of each pill** – The device must dispense the required dosage to ensure that proper medication and prevent over dosage
- **Pill size** – Based on the pill shape, the pill storage box varies

Objectives

- To develop a mechanism to hold the pills in different boxes and dispense the required pills
- Write a code for notification timing
- Write a code for the controlling LED light and the notification

Design Concept & Final Prototype

Design Concept 1

The first design we came up with to dispense pills is as shown in the figure below. This uses a mechanism with a cylindrical container and a slider which slides open to dispense pills through an opening at the bottom. The cylinder is inclined at an angle of 20 degrees to allow the collection of pills towards one end. The dimension of the hole is such that exactly one pill falls through it. The slider is actuated using a solenoid actuator.

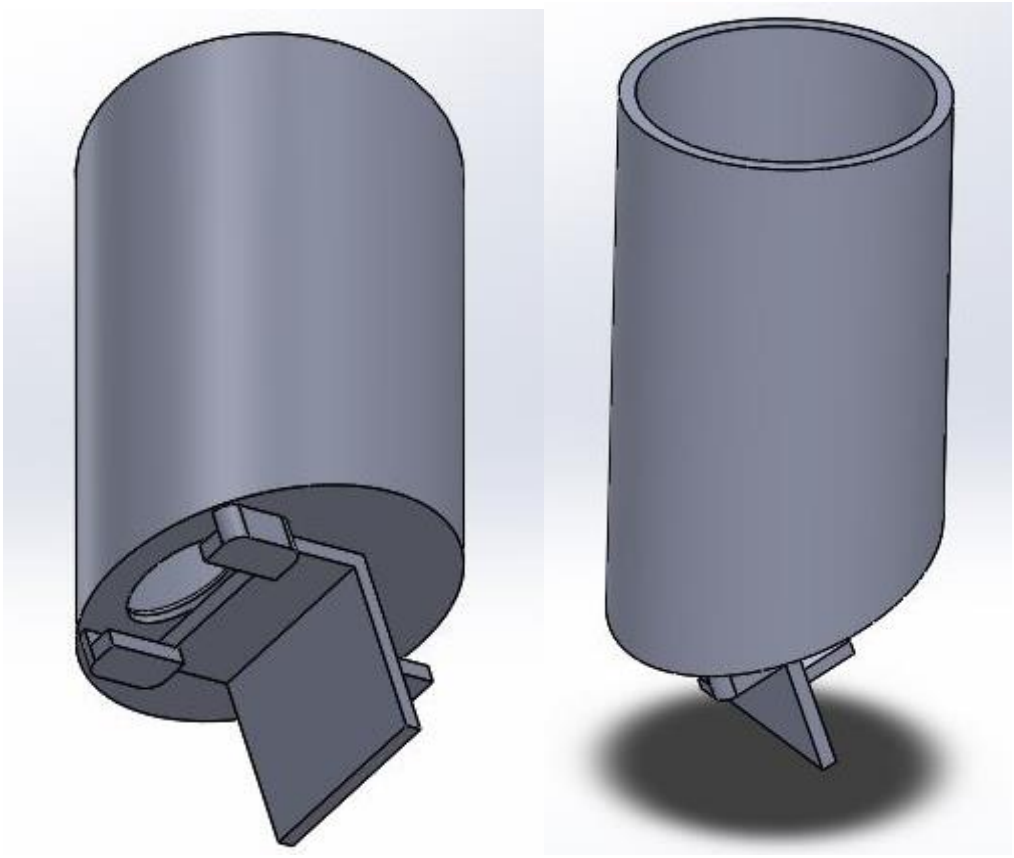


Figure 3: Isometric View of Design Concept 1 showing the Slider

The prototype was 3D printed and tested manually without the solenoid actuator. The below image shows the 3D printed models.

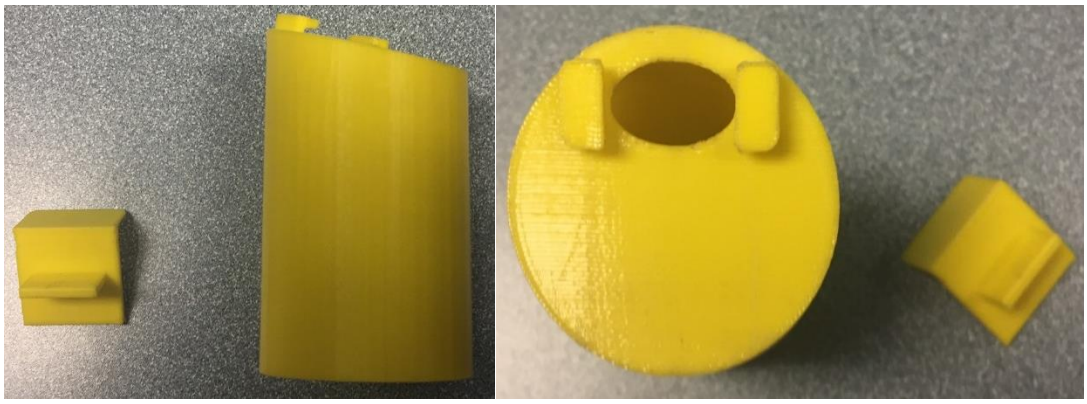


Figure 4: 3D Printed Model of Design Concept 1

Drawbacks

- Dispensed more than one pill at a time
- Clogging of pills
- Solenoid needed to actuate the dispensing action

Design Concept 2

To overcome the drawbacks of the first design, we came up with a new design that uses a funnel with a tube attached. This allows the pills falling to get aligned vertically one above the other. This facilitates dispensing of one pill at a time. The pill falls into the pit in the slider and when the user actuates the slider, the pill is dispensed.

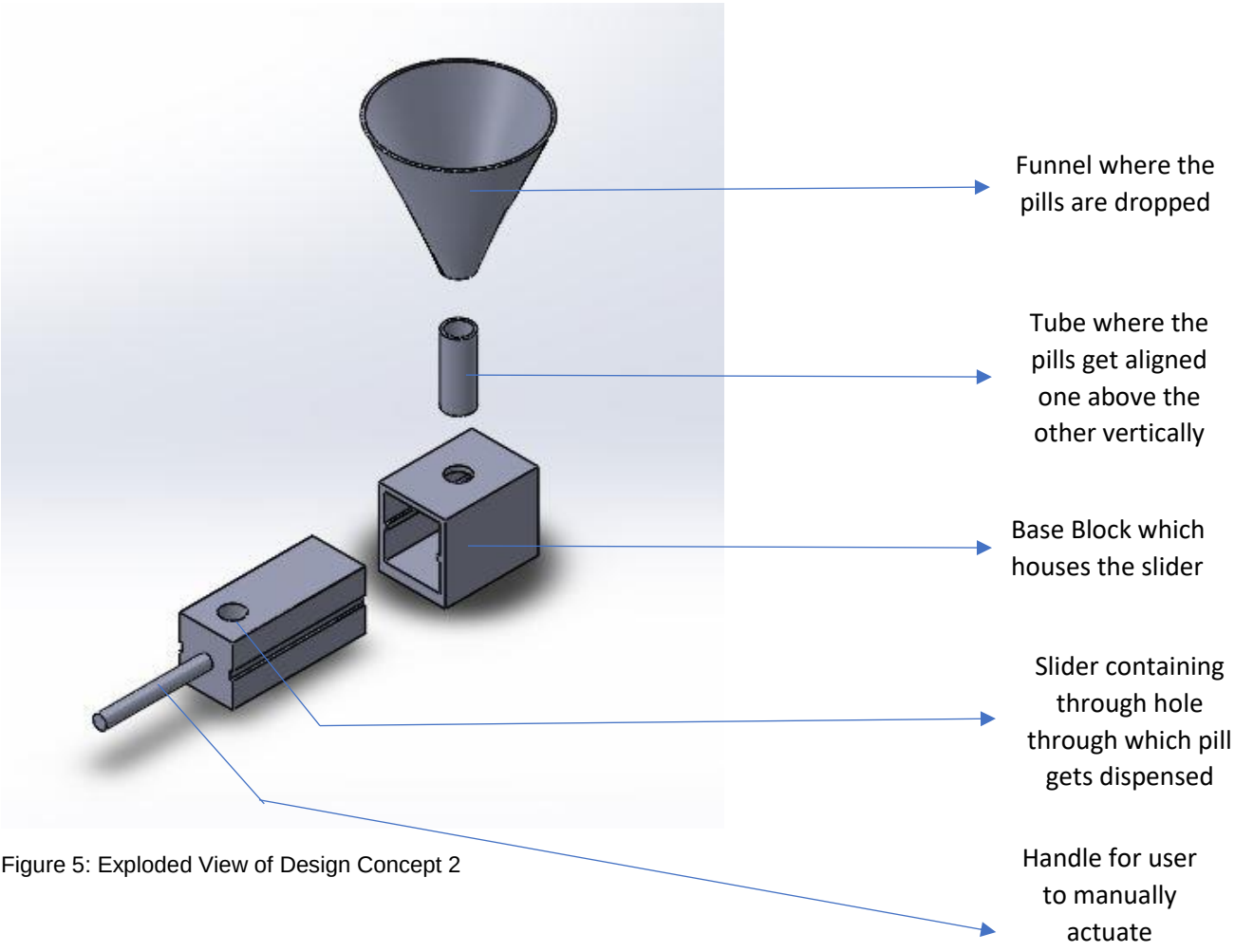


Figure 5: Exploded View of Design Concept 2

The above is the exploded view of the new concept. The slider has a long handle at the end on which the user can manually actuate to dispense the pills. Once again, the above CAD model was 3D printed and tested manually.

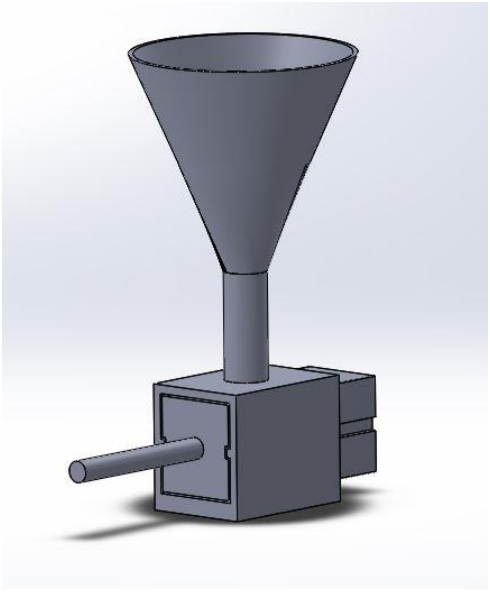


Figure 6: Isometric View of Design Concept 2

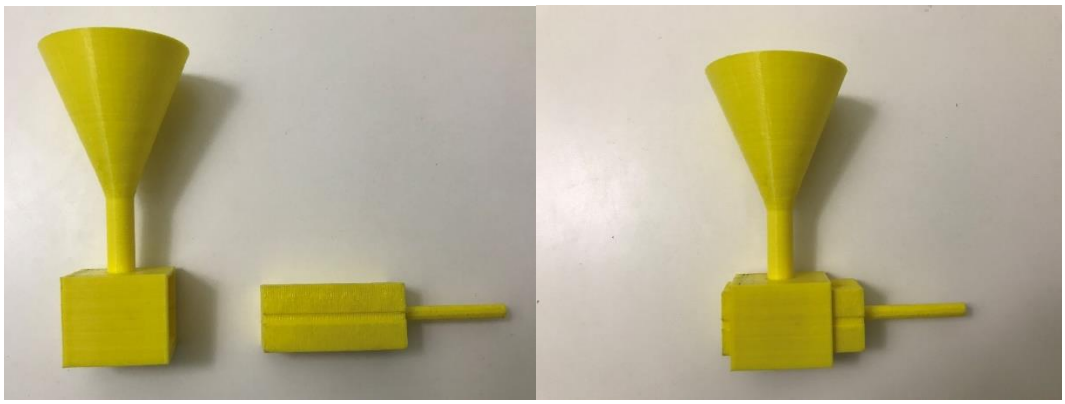


Figure 7: 3D Printed Model of Design Concept 2

Although the new model did overcome the drawbacks of the previous model, there were latest problems to be addressed.

Drawbacks

- Dispensed one pill of only one size.
- Container could hold very few pills.
- No motion restriction for the slider causing it to slide completely out of the base block.
- 2-way manual actuation.

Design Concept 3

Once again, we came up with a modified design to overcome the new drawbacks. This design incorporated a mechanism to adjust the height of the slider below the tube to facilitate pills of varied sizes to get dispensed. Also, a spring was added to make the slider spring back to position once manually actuated. Furthermore, the size and shape of the funnel was modified to accommodate more pills.

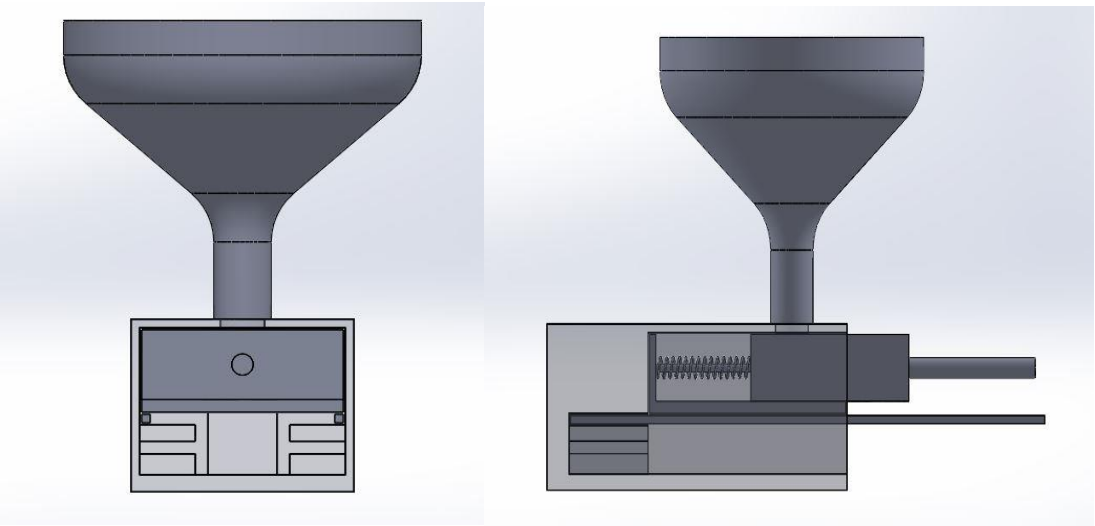


Figure 8: Front & Side View of Design Concept 3

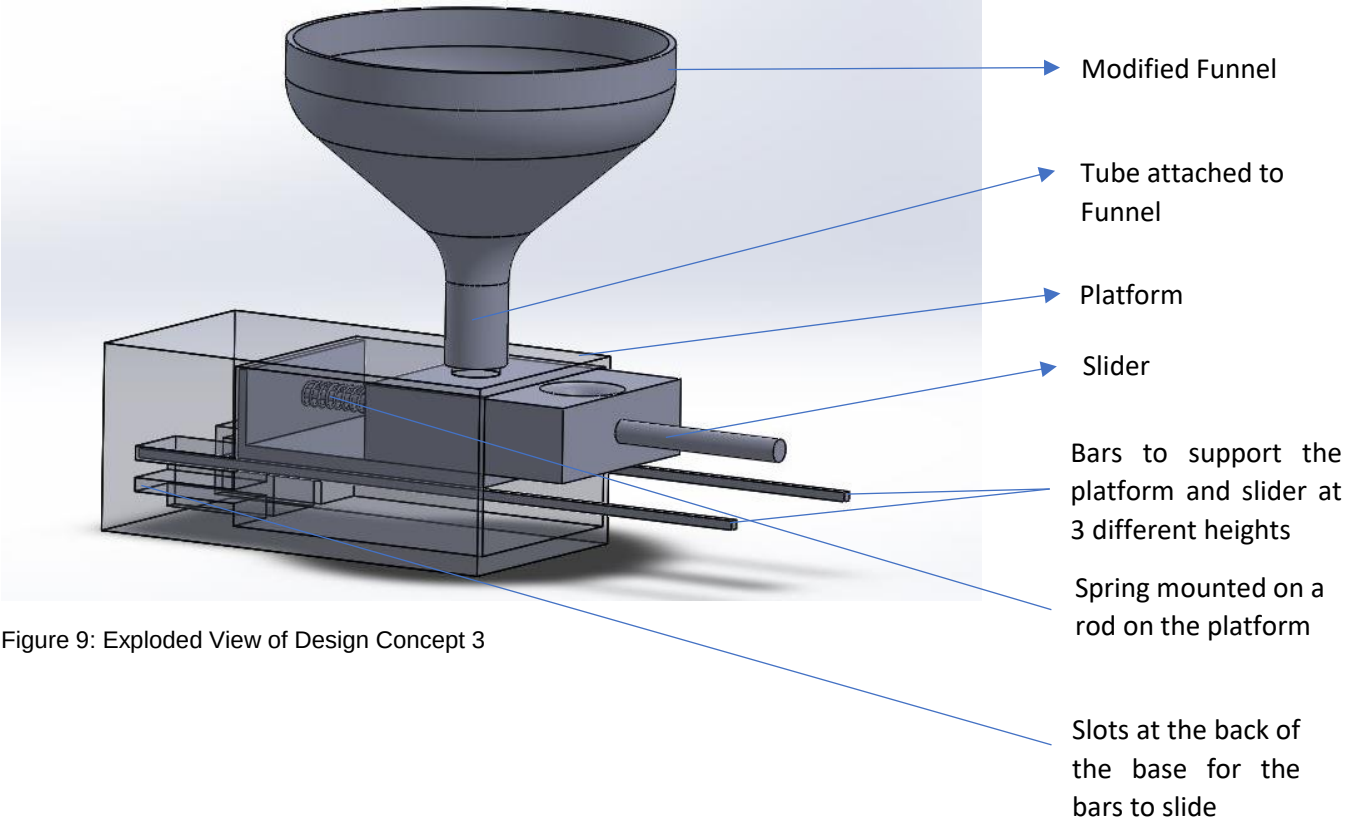


Figure 9: Exploded View of Design Concept 3

The height of commonly used capsules ranges from 11.1 mm to 26.14 mm [8]. To facilitate dispensing of varied pill sizes, the height of the platform and slider can be adjusted using the bars. The bars sit in the slots at the back of the base which help in supporting the platform and the slider. The slot has an inverted F shape and so the platform and the slider have three different positions to dispense pills of varied sizes. The user can slide the bars in the slot and bring them to the required position depending on the pill size used. The image below shows the positions of the bars and the corresponding pill sizes to be used.

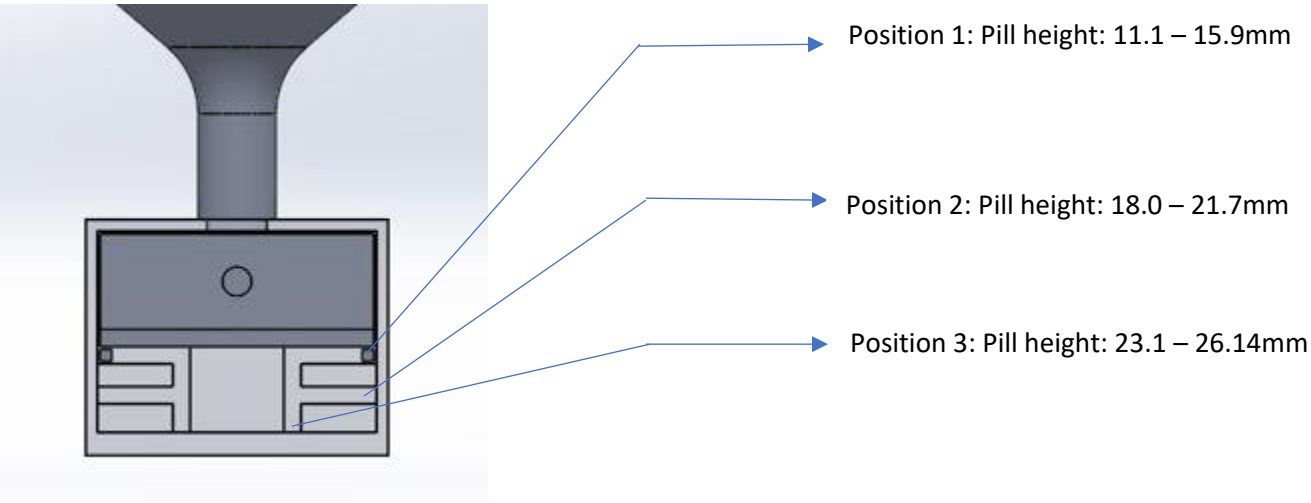


Figure 10: View Showing Slot for Different Pill Heights

Once again, the above CAD model was 3D printed and tested manually. Although the new model did overcome the drawbacks of the previous model we encountered other issues as explained below.

Drawbacks

- The rod on which spring was mounted was too thin.
- The bars were not sturdy enough to support the platform and the slider.
- Platform moved along with the slider.
- No motion restriction for the slider causing it to slide completely out of the base block.

Final Design & Prototype

The fourth and the final design iteration involved improvement on design concept 3. The diameter of the rod used to mount the spring was made thicker. A major modification made was that instead of using bars to support the platform and slider, male part on the platform and female part on the base were provided to slide the platform and slider in and out of the base just like a drawer. To make the platform stay in its place while actuating the slider, a plug was used to lock the platform in place. Also, a stopper was placed to restrict the retracting motion of the slider.

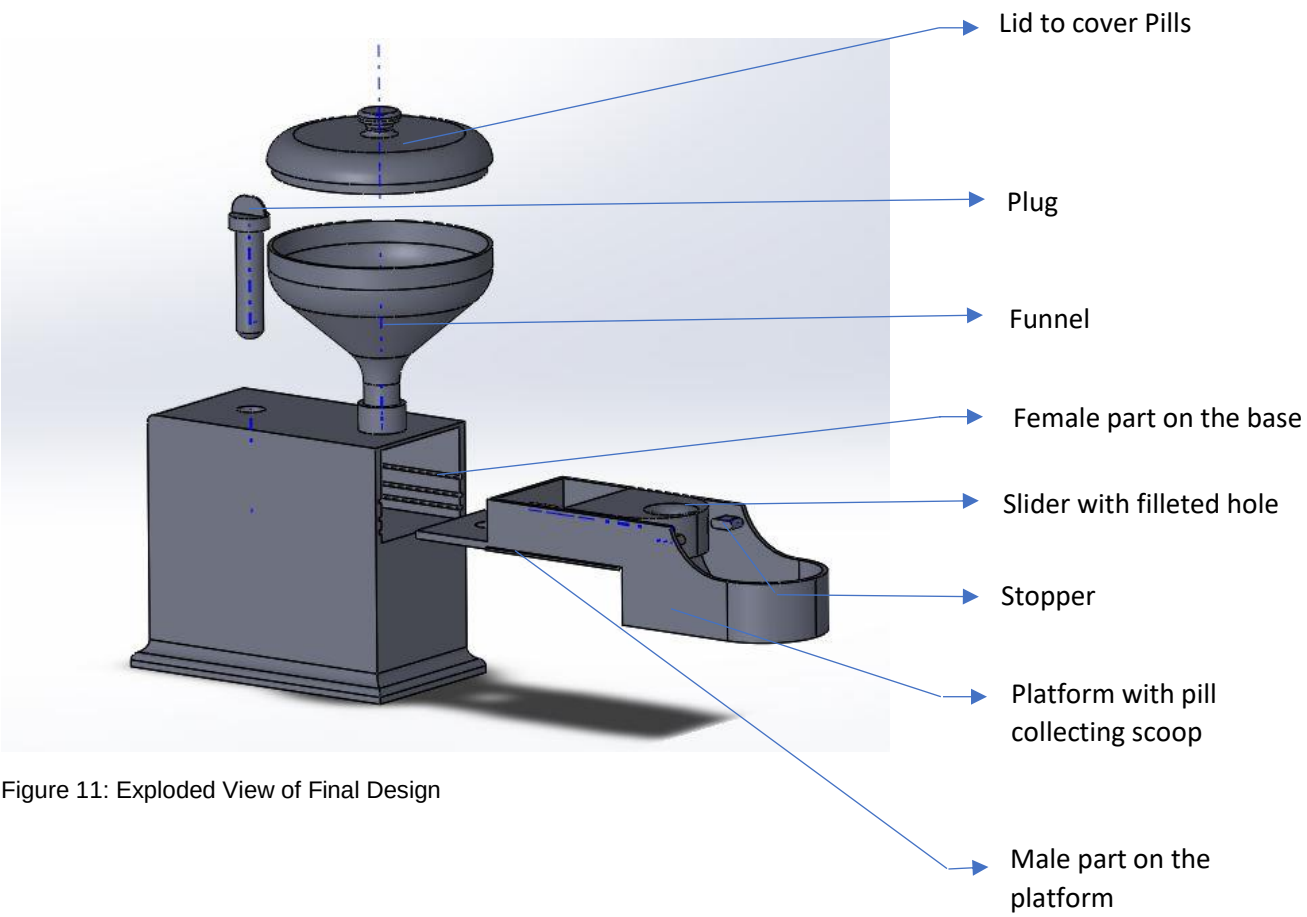


Figure 11: Exploded View of Final Design

To collect the pills more easily after it gets dispensed, the platform has a collecting scoop from where pills can be collected easily.

PIR sensor with the microprocessor were integrated with the final 3D printed model to connect the Smart Pill Dispenser with a smartphone.

Based on the market study, we identified 11 types of pills and capsules with height varying from 11.1 mm to 26.14 mm and diameter varying from 4.91 mm to 9.91 mm [8]. Three positions were chosen for the platform to accommodate all the pill sizes. The image below shows the positions of the platform and the corresponding pill sizes to be used.

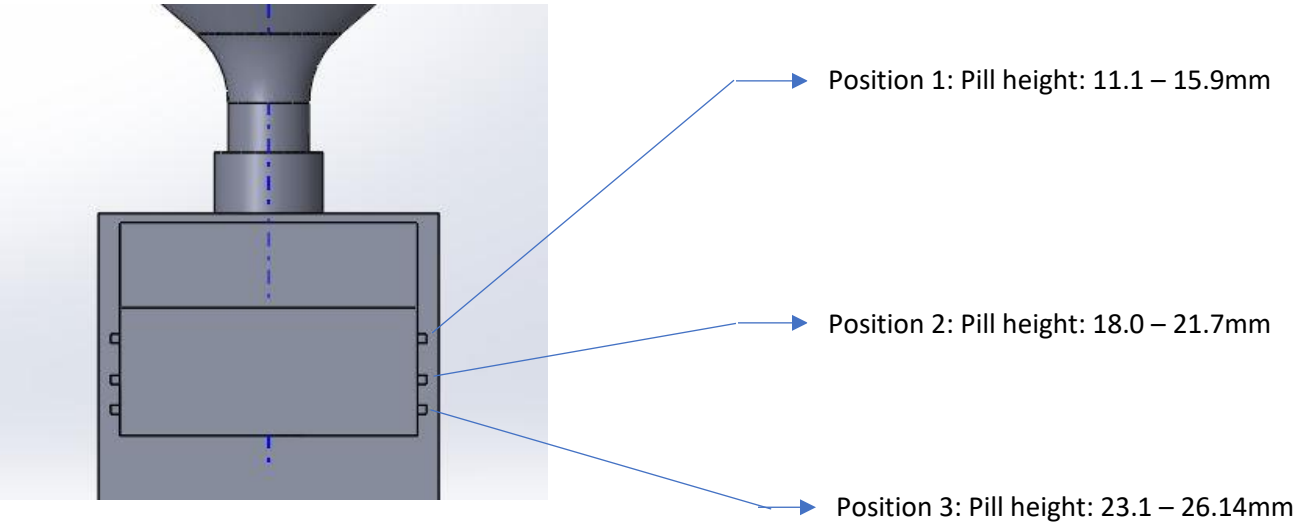


Figure 12:Slots in the body for varying pill heights

To determine the positioning of the platform on the product, the user needs to use a pill template. The image below shows the pill template.

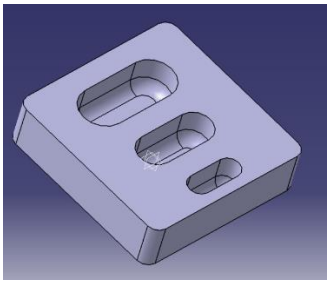


Figure 13: Pill Template

Each of the slots in the pill template correspond to the largest pill size that can be dispensed at each position of the platform. The slot at the top is the largest pill that can be dispensed at Position 3. The slot at the middle is the largest pill that can be dispensed at Position 2. The slot at the bottom is the largest pill that can be dispensed at Position 1.

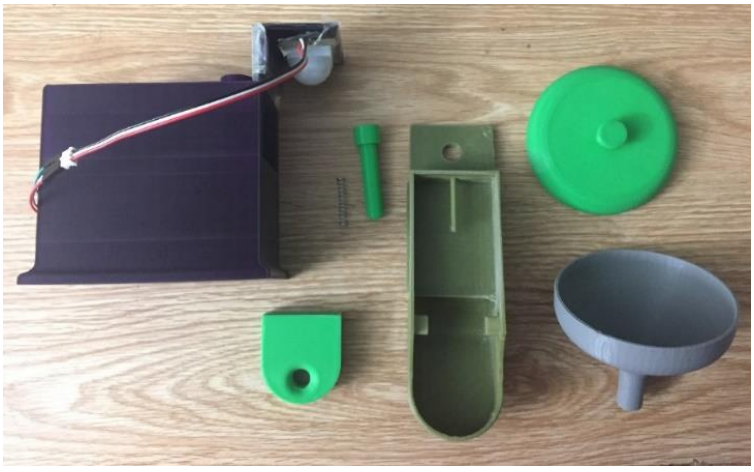


Figure 14: 3D Printed Components of Final Design

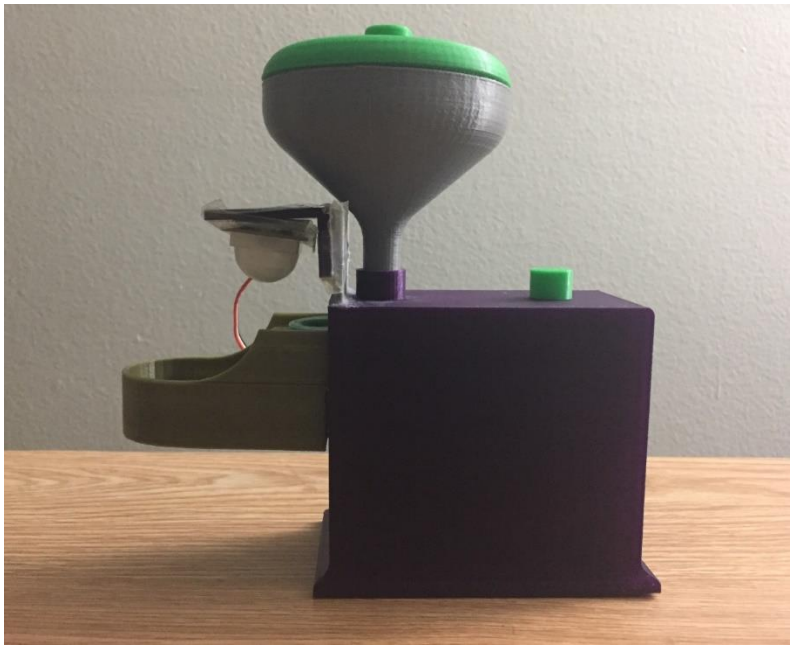


Figure 15: Side View of Final Design

Figure 16: Front & Back View of Final Design

Working Mechanism of the Prototype

Arduino Code and Blynk Application

The prototype was connected to the SparkFun ESP8266 Thing board and a PIR motion sensor to develop IoT. An arduino code was written and a Blynk app was designed to input the number of dosages per day and the time for each dosage. The code would turn on the LED light and send notifications via e – mail at the time of each dosage and when the motion was detected by the PIR sensor, the LED light would turn off.

The code for acquiring the time and the date was written. The Real-Time Clock (RTC) widget was to time keeping and a LCD widget was used to display it. The library files [9] [10] for the RTC was downloaded and saved in the library folder of arduino. The RTC is based on the 24-hour format.

Figure 17: Blynk App with RTC Widget

A code was written to integrate the PIR motion sensor with the LED and the e – mail notification such that the LED would turn on at the time of dispensing and an e -mail would be sent to the user and turn off when motion was detected. A LED light & e – mail widget was used in the Blynk app for this purpose.

Figure 18: Blynk App with LED

A terminal widget was used in the Blynk app to interact with the user. A code was written to read the user's inputs on the terminal widget and was stored in variable (number of dosages) and array (time for each dosage).

Figure 19: Blynk App with Terminal Widget

The entire code was integrated and uploaded on to the SparkFun ESP8266 Thing board and the PIR motion sensor was connected to the board to complete the setup.

Working

The sequence of images below shows the working of the Smart Pill Dispenser.

1)

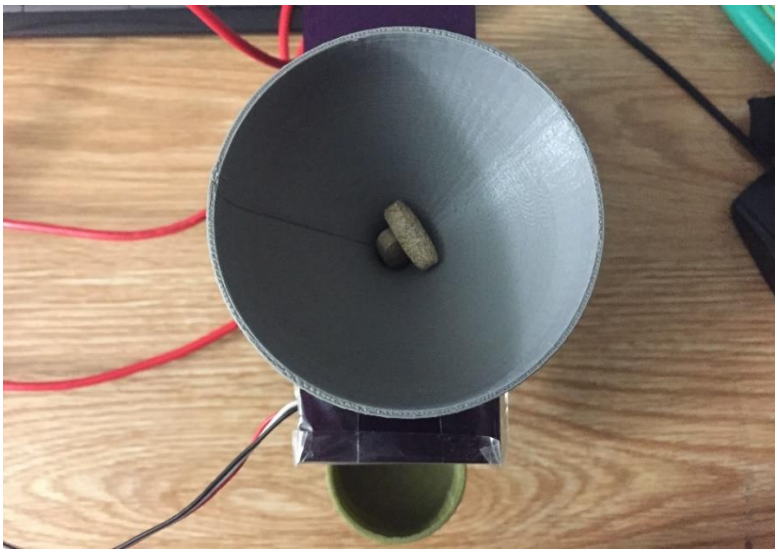


Figure 20: Pills Stored in the Capsule

The user must first empty the prescribed pills into the funnel as shown above and the lid must be closed to prevent spillage of pills. The platform must be placed in the appropriate position using the pill template.

2)

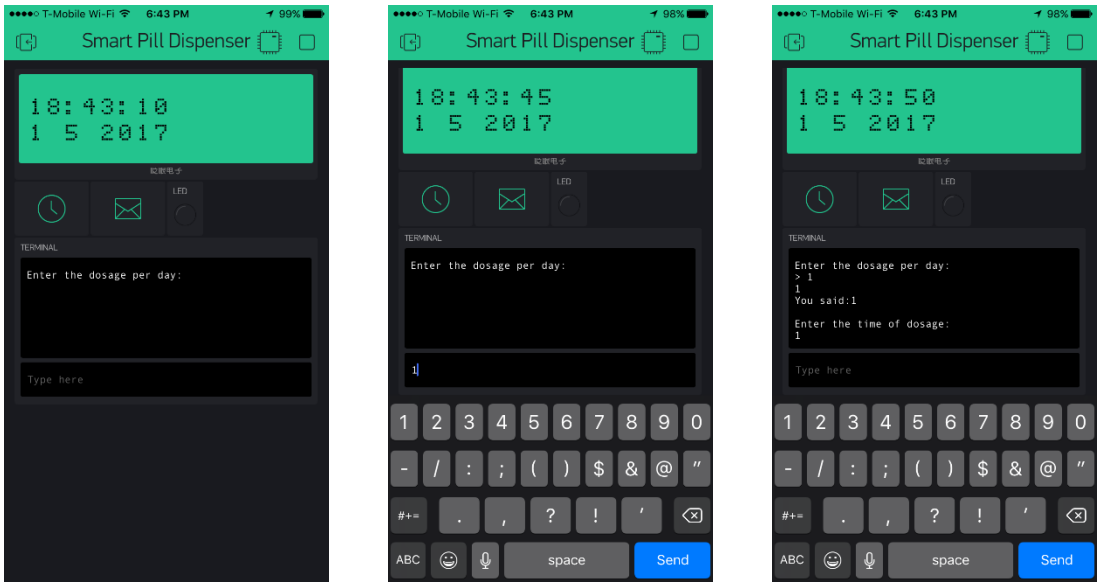


Figure 21: Entering Dosage per Day Using Blynk App

After emptying the prescribed pills into the funnel, the user must first enter the dosage per day using the Blynk app installed in the smartphone.

3)

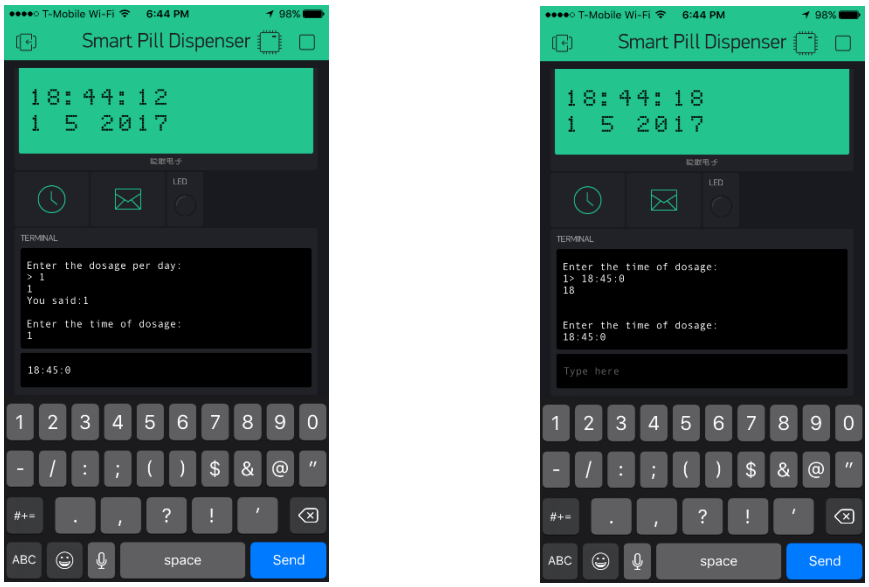


Figure 22: Entering Time for Each Dosage Using Blynk App

Next the user must enter the time of each dosage. Care must be taken to ensure that the time is entered in the format as shown:

If the user needs to take the pill at 6:01 am, then he must enter the time as 6:1:0 (hour: minute: second)

4)

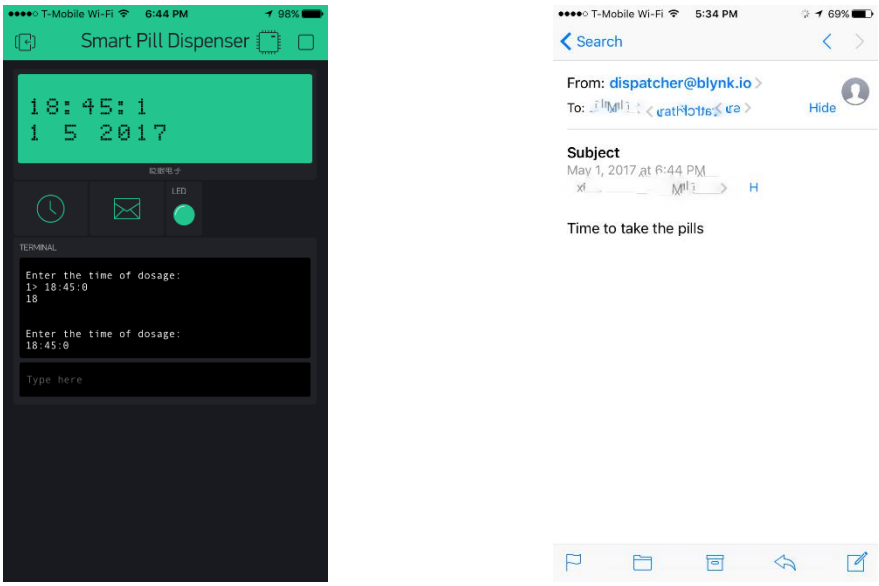


Figure 23: LED & E - Mail Notification at the Time of Dosage

At the time of dosage, the LED Light in the app switches on which is to alert the user that it is time to take the pill. Also, the user receives an email notification that it is time to take the pill.

5)

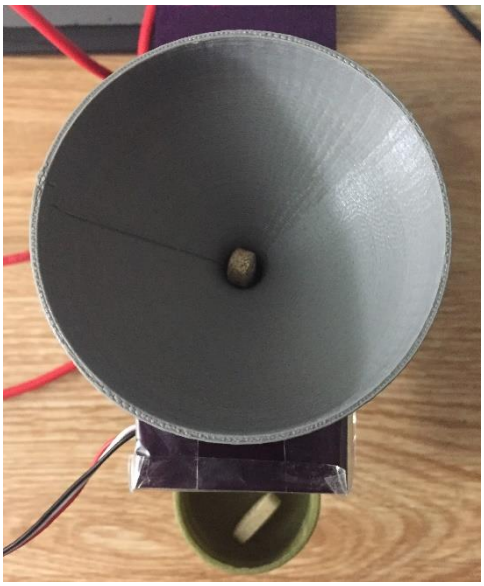


Figure 24: Pill Dispensed & Collected in the Collecting Scoop

Once the user receives the notification, the user should just push on the slider and a pill gets dispensed on the retracting motion. The motion of the user's hand is sensed by the PIR sensor and this switches off the LED light in the app which means the pill has been dispensed (shown below).

Figure 25: LED Turns OFF After Detecting Motion

Survey Analysis

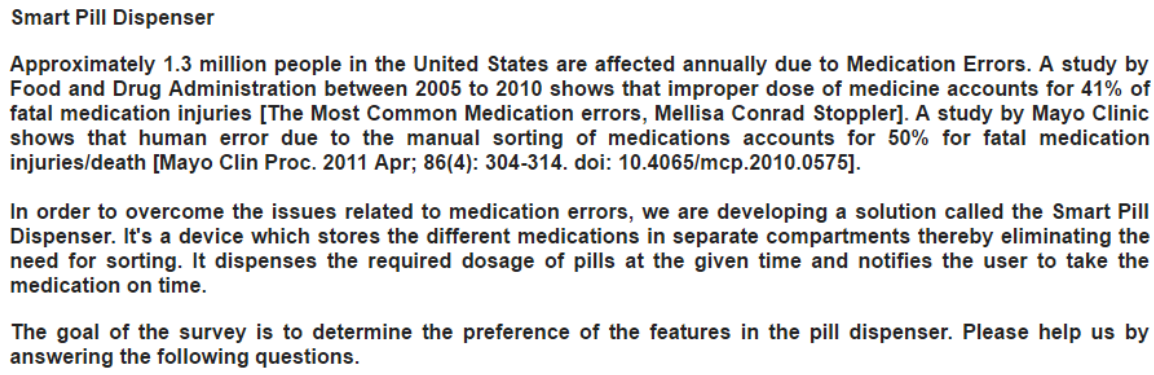
Description of Survey Goal

This survey was designed to get customer preferences about certain functionalities of our product. The survey mentioned these functionalities in a generic manner to ensure customer understanding. The team's goal through the survey was to figure out the absolute essential features of the product. Thereby, helping us chart our product development course in realizing the more viable product.

Survey Preview

The **generate_survey.m** file was edited to include our product attributes and suitable attribute levels. Using MATLAB, the **generate_survey.m** file was run and the **survey.qsf** file was generated. This file contained the discrete choice questions and the options were randomized for each question based on the attribute level. The survey.qsf file was uploaded on Qualtrics to build the survey. The team also used five closed response questions to get an idea about the demography and medication behavior of the people.

Shown below is a snippet of the survey presented to the customer. The price level is declared to be between 100 - 500 dollars, keeping in mind real world manufacturing costs and profits. The second selection is about portability, whether they would be interested in making the product portable or not. Next is pill sorting, if the user is comfortable doing it manually or they would rather have it automated. Device connectivity is for the user to choose the preference of connection. Similarly, if the notification would be useful alerting tool or not. At the end, method of security of the device is to be chosen. The survey will be a tool used by the team to develop the product.



Smart Pill Dispenser

Approximately 1.3 million people in the United States are affected annually due to Medication Errors. A study by Food and Drug Administration between 2005 to 2010 shows that improper dose of medicine accounts for 41% of fatal medication injuries [The Most Common Medication errors, Mellisa Conrad Stoppler]. A study by Mayo Clinic shows that human error due to the manual sorting of medications accounts for 50% for fatal medication injuries/death [Mayo Clin Proc. 2011 Apr; 86(4): 304-314. doi: 10.4065/mcp.2010.0575].

In order to overcome the issues related to medication errors, we are developing a solution called the Smart Pill Dispenser. It's a device which stores the different medications in separate compartments thereby eliminating the need for sorting. It dispenses the required dosage of pills at the given time and notifies the user to take the medication on time.

The goal of the survey is to determine the preference of the features in the pill dispenser. Please help us by answering the following questions.

Figure 26: Survey Summary

Scenario 1 out of 10

	Candidate 1	Candidate 2
Price	100	100
Portability	No	Yes
Pill Sorting	Manual	Automatic
Device Connectivity	Wi-Fi	LAN Cable
Notification	E-mail/Text	E-mail/Text
Security	Pin Code	Pin Code

Which of these two would you be more likely to buy?

○ Candidate 1 ○ Candidate 2

Figure 27: Sample Question in the Survey

The survey included five closed response questions that included questions on demography and medication. The medication questions would give us a clear picture on the number of medications taken and how often they are taken.

Gender:
- Male
- Female
- Others

Age:
- Under 18
- 18 – 24
- 25 – 34
- 35 – 44
- 45 – 54
- 55 – 64
- 65 – 74
- 75 – 84
- 85 and above

Consider that you take certain number of medications every week. How often would you forget to take the medications?
- Never
- Sometimes
- About half the time
- Most of the times
- Always

How many different types of medication are you currently on?
- None
- 1
- 2
- 3
- 4
- 5 or more

How often do you need a refill for the medication?
- Weekly
- Bi-weekly
- Monthly
- Once in 90 days

Figure 28: Demography & General Questions

Data collection

The data was collected from various groups of varying age, gender and ethnicity. Our product targets the daily pill takers. We have surveyed people right from healthy people to people with chronic ailments. This would give us a broad spectrum and highlight target demography. The team with the aid of the professor conducted the survey by asking friends and relatives to take the survey. The survey takers were not explained anything before hand to ensure they took the survey with an unbiased opinion.

Once the survey was tested and validated by the team it was launched on February 9th 2017. The survey was sent to friends and family over WhatsApp, E – mail and Facebook. The last response for the survey was on March 7th 2017. Over the course of nearly one month, the team managed to get 52 responses.

Qualtrics was used to create and upload the survey. The results and data analyzing is done based on the survey findings. The data is analyzed using the in-built applications in Qualtrics and Excel. MATLAB was used to find importance of the features and determine how the importance of the feature varies from person to person.

Data Validation

The team set the survey such that the user had to answer each question before proceeding to the next one. Failing to do so prevented the user from moving on. But there was data missing from a few entries since only 33 entries had the complete data out of the 52 entries. The team couldn't determine why the data was missing. This way, the obtained data was validated and the team ensured that the data used for analysis was legitimate and error free.

Analysis results

The results obtained from the MATLAB file is given below:

		Mean	StdDev	Share<0	Share=0
Price	normal	-0.7708	0.8020	0.8320	0.0000
Yes	normal	2.2884	1.2742	0.0325	0.0000
No	normal	1.3101	1.1983	0.1425	0.0000
Manual	normal	2.4000	3.4724	0.2370	0.0000
Automatic	normal	3.8368	1.6436	0.0070	0.0000
Wi-Fi	normal	2.1471	1.0103	0.0150	0.0000
LAN Cable	normal	0.1854	0.7872	0.4060	0.0000
E-mail/Text	normal	5.6253	1.5883	0.0010	0.0000
None	normal	3.9406	1.8872	0.0210	0.0000
Pin Code	normal	-1.2297	1.0020	0.8960	0.0000
Key	normal	-1.4441	1.1960	0.8830	0.0000

Figure 29: MATLAB result of Survey

Insights from the analysis

1. Notification is the key feature according to the survey takers.
2. There is a preference of automatic sorting of pill over manual sorting.
3. Security system doesn't seem on the consumer priorities for a pill dispenser.
4. Portability and Wi-fi connectivity are preferred by the consumers.
5. The cost of the product needs to be driven down in order to persuade the potential customers from buying them.

Visualization of Results

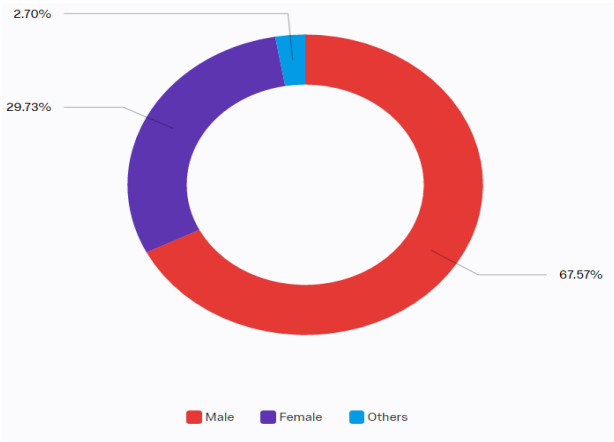


Figure 30: Sex Ratio

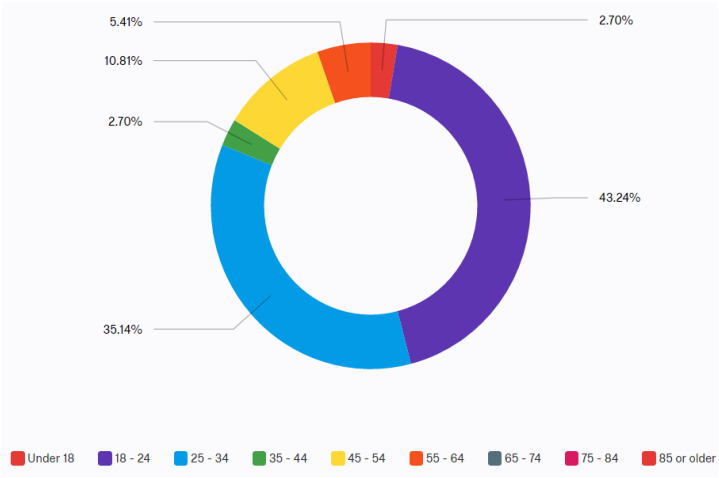


Figure 31: Age Demography

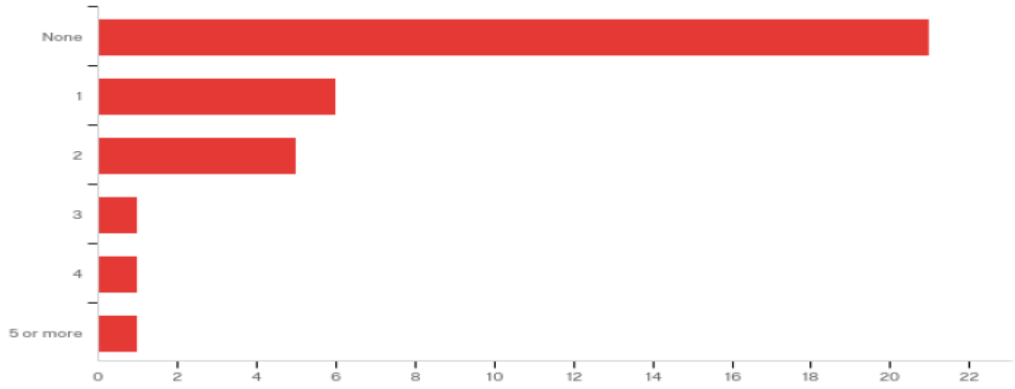


Figure 32: Number of Pills taken Daily

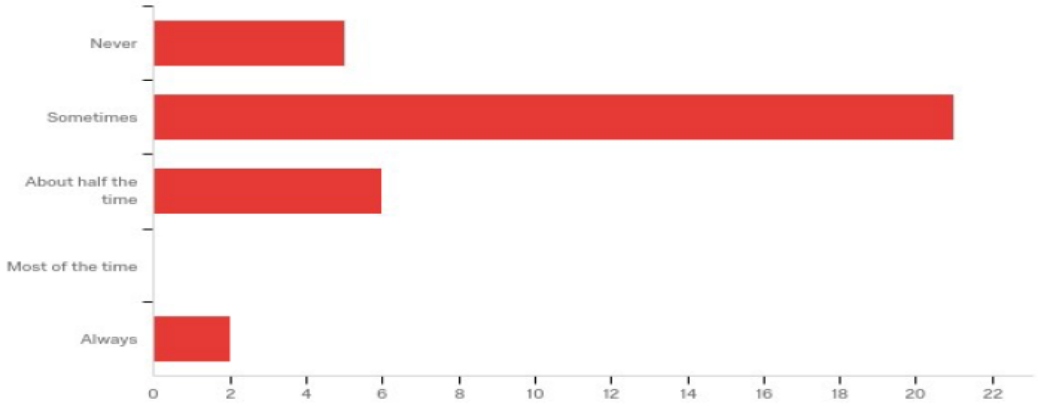


Figure 33: Non-consumption of the pill due to forgetfulness

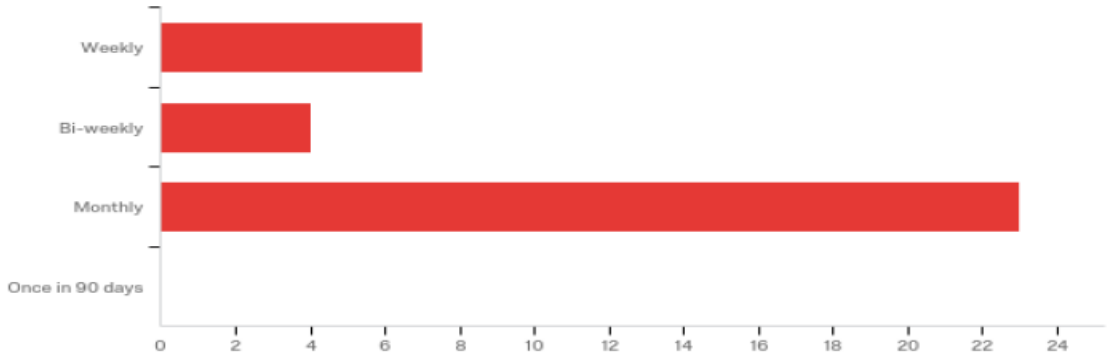


Figure 34: Refilling of the pills

The following graphs show the attributes preferred by the survey takers.

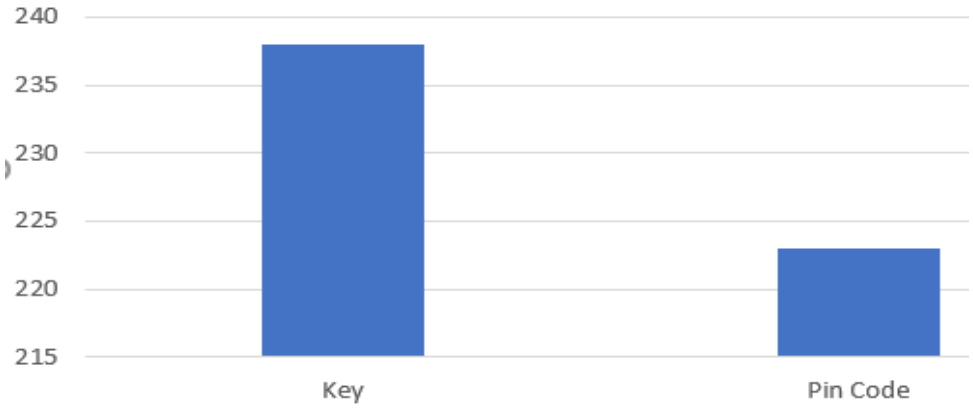


Figure 35: Pincode vs Key

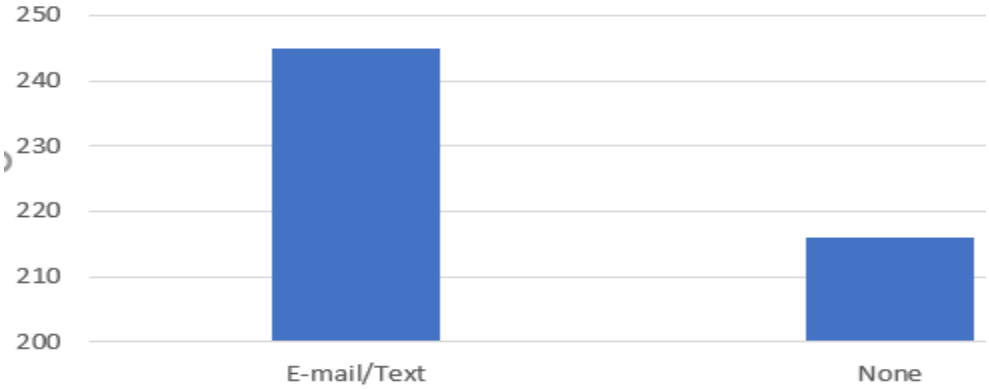


Figure 36: Notification preference

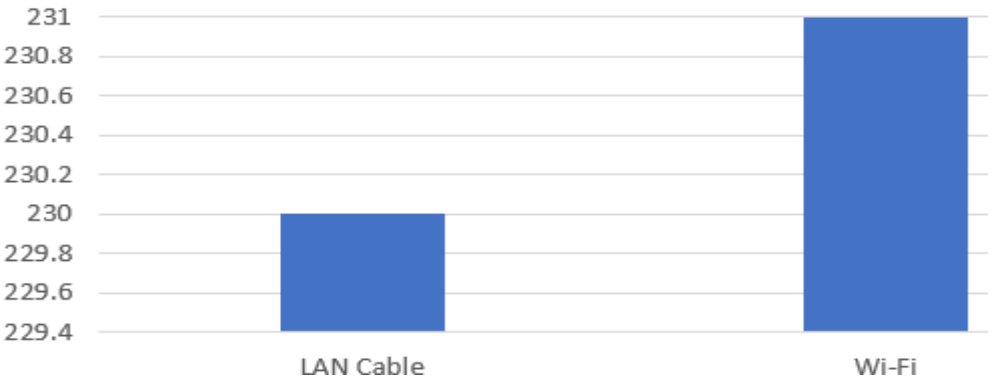


Figure 37: Type of connectivity preferred

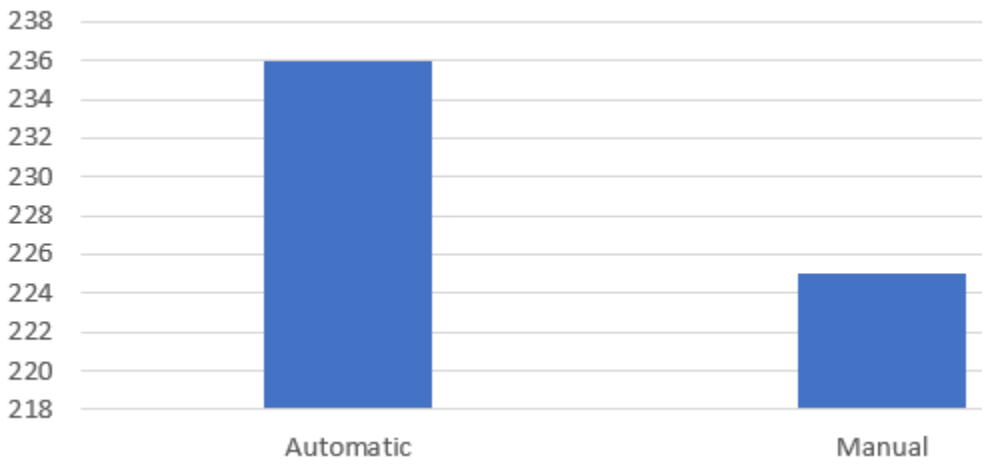


Figure 38: Automatic or Manual Pill Sorting

Business Plan

Business Objective

With ever changing lifestyle in this fast-paced world, people often get affected with diseases and tend to consume a lot of pills. However, with the busy lifestyle people tend to forget or they take the wrong pills. Approximately 1.3 million people in the United States are affected annually due to **Medication** Errors [1]. To overcome the issues related to medication errors, we are developing a solution called the **Smart Pill Dispenser.**

Product Description

Our product is a SMART PILL DISPENSER which stores pills, notifies the user with an email to take pills at the right time and dispenses the right dosage and it does all this at a cheaper cost! Smart Pill Dispenser eliminates sorting and directs the user with an LED to take the right medication.

Market Analysis

To determine where our product would fit in the market, to identify our competitors, market share and to determine the optimum cost of our product, a market analysis was conducted. Based on the survey results, we determined that the customers preferred a smaller, portable product with smart features (internet connectivity, notifications, sorting of pills and ease of usage).

The products in the market were identified along with their price. It became clear that the products in the market either had fewer smart features and costed less or they had all the smart features and costed more. There is no product in the market that costs less and has all the desired features. The figure below shows the market gap and where our product will fit in the market.

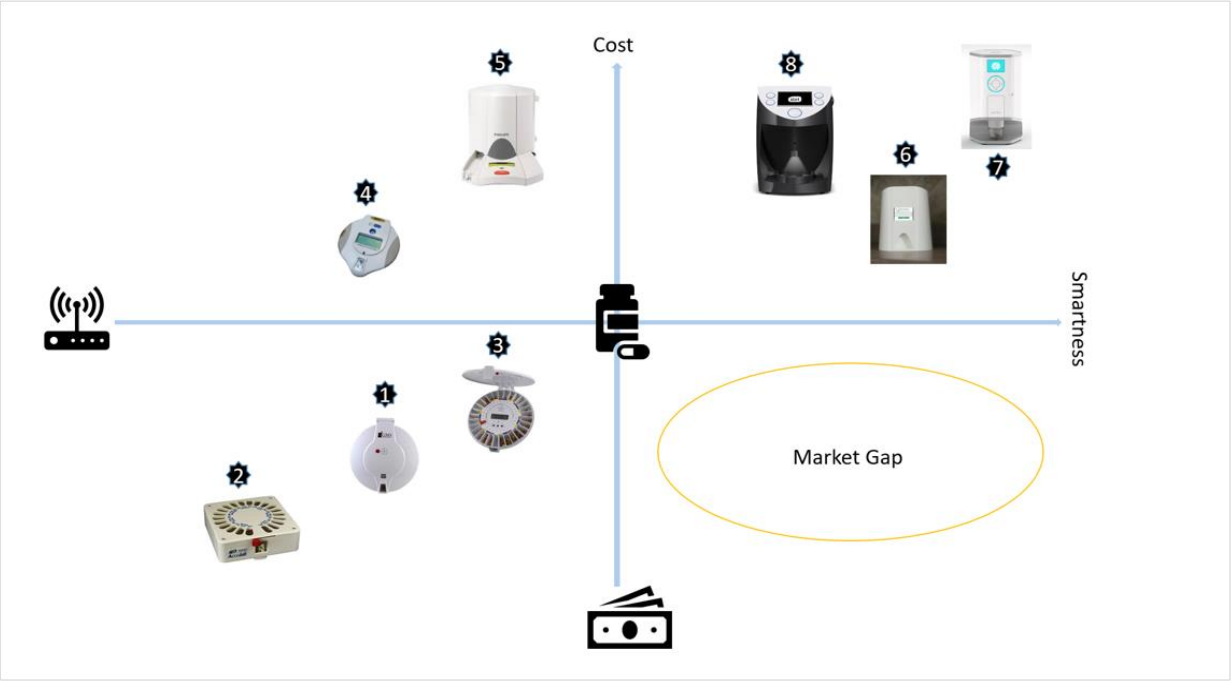


Figure 39 : Market Gap

The product in the market were judged based on the size and the smartness.

- Smartness (2.5 to 10) – 2.5 points were awarded to each of the four smart features (internet connectivity, notifications, sorting of pills and ease of usage) with the highest value of 10
- Size (1 to 10 $inch^3$) – 1 point was awarded for increase in size with smallest product getting a score of 1 and the largest product 10

Based on the survey analysis the price, size and smartness were determined as the most sensitive attributes for our product. Part – worth of -0.1, -0.5 and 2 was assigned to the price, size and smartness respectively. The negative sign indicates that lower the better and positive sign indicates that the higher the better for the attributes.

To perform the analysis, the following assumptions were considered:

- Market size of 100000
- $1 for increase in size of the product
- $7 for increase in smartness of the product

Our product was given a score of 5 for the size and 10 for the smartness bringing our unit cost to $75. After performing the analysis, we can see from the image below that when our product is priced at $150, we capture a market share of about 70%. Since our unit cost is only $75, we see large profits.

Product name	Price	Size	Smartness	Market share	Unit cost	Revenue	Profit
GMS med alert	80	3	5	9.52%	$38	$761,915	$400,005
Accu Tab	27	8	2.5	1.06%	$26	$28,493	$1,583
Ivation	80	3	5	9.52%	$38	$761,915	$400,005
Med Smart	490	4	5	0.00%	$39	$0	$0
Philips	720	10	5	0.00%	$45	$0	$0
Lumma	170	5	10	9.52%	$75	$1,619,069	$904,774
Hero	599	10	10	0.00%	$80	$0	$0
Livi	450	10	10	0.00%	$80	$0	$0
Smart Pill	150	5	10	70.37%	$75	$10,555,936	$5,277,968
				100.00%		$13,727,328	$6,984,336

Part-worth - Price	Part-worth - Size	Part-worth - Smartness	Market size
-0.1	-0.5	2	100000
Cost - Size ($/inch^3)	**Cost - Smartness ($/smartness)**		
1	7		
Range - Size	**Range - smartness**		
1 - 10 (inch^3)	2.5 - 10		

Figure 40: Market Share, Price & Profit

A MATLAB code was used to determine the optimal cost for the product. Using the data from the excel sheet, the code was executed and the optimal cost was found to be $158 for a product size of 1 and smartness of 10.

We decided to keep the selling price of the product at $150 for a unit cost of $75.

Capital and Personnel Resources

We are trying to determine the minimum investment required to have the startup generate positive cash flow as soon as possible. For this extensive market survey and analysis was carried out to make it a lucrative offer for investors.

We estimated an initial investment of $150,000 will be required along with a future line of credit to fund purchase orders. The amount asked would help in covering up initial setup costs of machine, assembly station and salary for our employee. This amount would be taken as debt by the company and will have to be paid back to the investor with a reasonable multiple. The exact distribution of this investment can be seen in our pro forma income and profit projections in the subsequent sections of this report. In the beginning, we are going to acquire a small workspace in Phoenix, Arizona which will serve as the headquarters of operations. Arizona was chosen because of its low rent cost as well as well as many IOT industrial resources in neighboring areas. A portion of the investment would go towards manufacturing the required tooling, die, product & market testing and any other equipment that is needed for us to start making our product. After estimating the size of the market, we have conservatively assumed we could get 15% of the market share, thereby selling 15000 units at the end of the first year. Our costs to good sold is 75$ and marketed price is 150$. Based on prevalent interest and tax rates, we have prepared a Pro-Forma for the next 5 years with a predicted growth rate of 10%.

Capital Equipment & Supply List

Table 2: Initial Development & Manufacturing Setup Cost

Initial Development	
Engineering	$10000
Design	$10000
Marketing	$10000
Transportation	$10000
Manufacturing Process	
Injection molding machine	$47000
Set – up of machine	$3000
Tooling & molding die	$10000
Total cost	$100000

Fixed Cost

Table 3: Fixed Operating Cost Per Year

Fixed Operating Cost (per year)	
Maintenance	$10000
Marketing & sales	$5000
Employee salary	$20000
Rent	$30000
Utilities	$4000
Total cost per year	$69000

Supply List

Table 4: Supply List for Manufacturing the Product

Item	Use	Cost (Initial)	Cost (per year)	Cost (per part)
Material Cost	Manufacturing			$5
Machine Cost	Manufacturing			$4
PIR Sensor	Manufacturing			$7
Microprocessor	Manufacturing			$18
Rechargeable Battery	Manufacturing			$8
Worker 1	Manu/Manager		$20000	
Design Cost	Manufacturing	$10000		
Development Cost	Manufacturing	$10000		
Number of parts annual	15000			
Total		$20000	$20000	$42

Break Even Analysis

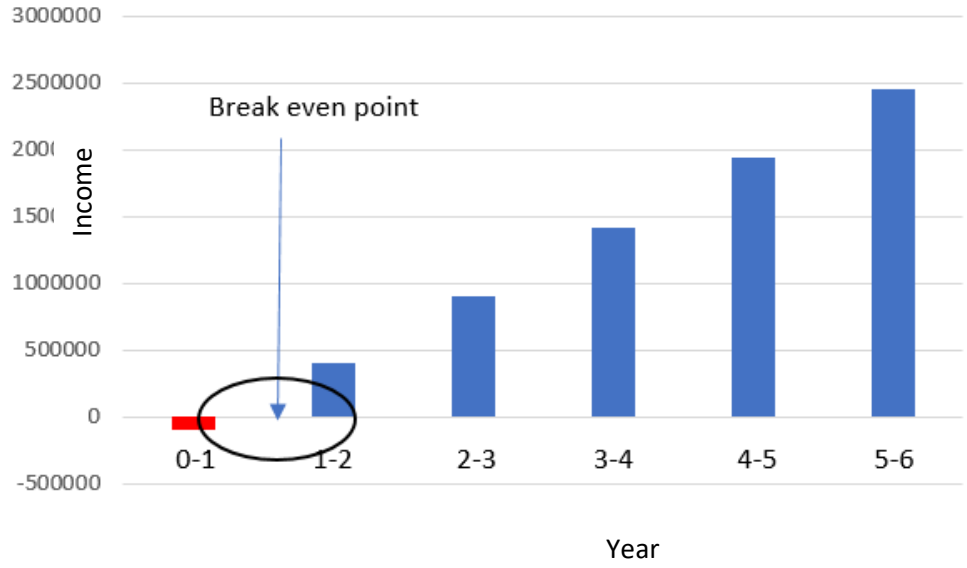


Figure 41: Breakeven Analysis

Break even analysis was carried out accounting the initial investment, operating costs and intended sales target. As seen from the above bar graph. At the start of the first year of operation, the company incurs a debt in the form of initial investment. This debt would remain until we reach a sale of 1300 units, after which positive cash flow is achieved. We have estimated that we break even at the end of the first year. After which there is growth in our market share, thereby driving our revenue higher. It is estimated that this product with the right marketing and development could be worth over a million dollars.

Assumptions

There were a quite a few assumptions made while performing market analysis and they are listed below:

1) First year sale of 15,000 units (15% of target market)
2) Sales growth rate as 10% (comparable to the growth of the market)
3) Present value discount rate of 6%
4) Profit of 30-50% on the marked price

Pro-Forma

Price	150
Cost per unit	75
Starting sales	15000
Sales growth rate	10%
Tax rate	39%
Discount rate	6%

Table 5: Pro Forma Analysis for 5 Years

Project year	0	1	2	3	4	5
Income						
Investor contribution	150000					
Total sales	0	15000	16500	18150	19965	21961.5
Sales revenue	0	2250000	2475000	2722500	2994750	3294225
Expense						
Initial cost	100000					
Cost of product	0	1125000	1237500	1361250	1497375	1647112.5
Fixed operating cost	0	247000	247000	247000	247000	247000
Net profit	50000	878000	990500	1114250	1250375	1400112.5
Post-tax profit	50000	535580	604205	679692.5	762728.75	854068.625
Running cash balance	50000	585580	1189785	1869477.5	2632206.25	3486274.875
Present value conversion	50000	552433.9623	1058904.414	1569649.358	2084953.891	2605147.393
Breakeven	-100000	402433.9623	908904.4144	1419649.358	1934953.891	2455147.393

Existing Patents

There are several patents for pill dispenser. The patents with products like our Smart pill dispenser are mentioned below.

1] Personal Medication Dispenser US7048141B2

2] Programmable Automatic Pill Dispenser US6510962B1

3] Electronic Pill Dispenser US7359765B2

The above-mentioned products provide similar features as provided by Smart Pill Dispenser. In the Personal Medication Dispenser, the funnel is changed to accommodate different pill sizes. In Smart Pill Dispenser, the drawer is slid into different slots to accommodate for different pill sizes. In Programmable Automatic Pill Dispenser, the pills need to be sorted according to the dosage and dropped into the

motorized pill storage-wheel. In Smart Pill Dispenser, the sorting of pills is eliminated. Electronic Pill Dispenser uses rotating disk to dispense pills, Smart Pill Dispenser uses a spring actuated push back mechanism. Therefore, we see that our product “Smart Pill Dispenser” does not breach any of these patents.

Patent References

1] https://patents.google.com/patent/US7048141B2/en?q=pill+dispenser&page=6

2] https://patents.google.com/patent/US6510962B1/en?q=pill+dispenser&page=2

3] https://patents.google.com/patent/US7359765B2/en?q=pill+dispenser&page=3

Appendix

Arduino Code

```
#define BLYNK_PRINT Serial
#include <SPI.h>
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include <SimpleTimer.h>
#include <TimeLib.h>
#include <WidgetRTC.h>

// You should get Auth Token in the Blynk App.
// Go to the Project Settings (nut icon).

char auth[] = "***"; //**your Auth Token
char ssid[] = "***";// ***your Wi-Fi name
char pass[] = "***";// ***and password
int i;
int j = 0;
int n;
int s = 0;
String pillTime[1000];
SimpleTimer timer;

//Defining the widgets for Blynk App

WidgetRTC rtc;
WidgetLCD lcd(V1);
WidgetLED led1(V3);
WidgetTerminal terminal(V4);
// Digital clock display of the time
const int MOTION_PIN = 4; // Pin connected to motion detector

void clockDisplay()
```

```
{
  String currentTime = String(hour()) + ":" + minute() + ":" + second();
  String currentDate = String(day()) + " " + month() + " " + year();
  Blynk.virtualWrite(V1,currentTime);
  Blynk.virtualWrite(V2,currentDate);
  for(i=0;i<n;i++)
  {
  if (currentTime==pillTime[i])
    {
      Blynk.email("Subject","Time to take the pills");
      led1.on();
      i++;
    }
  }
  int proximity = digitalRead(MOTION_PIN);
  if (proximity == LOW)
  {
  led1.off();
  }
}

// You can send commands from Terminal to your hardware. Just use
// the same Virtual Pin as your Terminal Widget

BLYNK_WRITE(V4)
{
  n = param.asInt();
  terminal.println(n);
  if (j != n)
  {
    while (s == 0)
    {
      s = 0;
      terminal.print("You said:");
      terminal.write(param.getBuffer(), param.getLength());
      s++;
    }

      terminal.println("\n");
      terminal.println(F("Enter the time of dosage:"));
      terminal.write(param.getBuffer(), param.getLength());
      pillTime[j] = param.asStr();
      j++;
```

```
  }
  // Ensure everything is sent
  terminal.flush();
//  terminal.println(pillTime);
}

void setup()
{
  Serial.begin(9600);
  Blynk.begin(auth, ssid, pass);
  rtc.begin();
  timer.setInterval(1000L, clockDisplay);
  pinMode(MOTION_PIN, INPUT_PULLUP);

  //Terminal
  terminal.println(F("Enter the dosage per day: "));
  terminal.flush();
}

void loop()
{
  Blynk.run();
  timer.run();
}
```

References

1. "The Most Common Medication Errors", Author: Melissa Conrad Stoppler
2. http://www.huffingtonpost.com/2013/06/19/prescription-drugs-prevalence-americans_n_3466801.html
3. Mayo Clinic Journal – Author: Jennifer St. Sauver, PhD
4. https://www.walgreens.com/store/c/pill-organizers/ID=361563-tier3
5. http://www.epill.com/medsmartplus.html
6. https://www.lifeline.philips.com/health-solutions/health-mdp.html
7. https://www.kickstarter.com/projects/402921688/lumma-automated-medication-sorter-and-dispenser
8. https://www.capsuline.com/empty-capsule-size-chart/
9. https://github.com/jfturcot/SimpleTimer
10. https://github.com/PaulStoffregen/Time/blob/master/TimeLib.h