1.6 Concept Selection

House of Quality

After talking with our project sponsor we were able to deeper assimilate our customer needs; a detailed explanation of those are shown in table 6 (**Table 6:** Customer Requirements and Engineering Characteristics) and quantify the importance of the comstor needs and rank them according within our binary pairwise comparison chart. The binary pairwise comparison table allows us to assign weight based upon importance of either 1 or 0. Those customer needs are then compared against each other to determine the importance of that customer need and tallied at the bottom showing *that barbot mixing two beverages* and *the machine does not take too much time dispensing the drink* have the most weight; this can be seen looking at table 7 (**Table 7:** Binary Pairwise Comparison).

#	Customer Requirements	Engineering Characteristics
1	Barbot mixing two beverages	Having the capacity to hold bottles; Bottle count
2	Is approved Dr.McConomy's my wife	Is compact and has a form factor that can fit inside of a cabinet when not in use; Machine size
3	Easy to use and operate	Users will be given an easy to understand manual.
4	Competing in InNolevation	Have a finished product that can be shown in the competition

5	Run off USB C power	Keep electronics within the specification of the power USB C can provide; Power supply
6	Can use most bottles that are available to purchase in store	Will be able to use the given percent of bottles available in-store; Percentage of usable bottles
7	The material selected is suitable for use and can withstand environmental factors	Build material of our device should be able to be left outside without any major consequences; Environmental resistance
8	The machine does not take too much time dispensing the drink.	Operation time
9	Easy and sturdy enough to handle.	Light enough that a person would be able to pick this device up using two hands; Weight

Table 6: Customer Requirements and Engineering Characteristics

Binary Pairwise Comparison										
Customer Needs	#1	#2	#3	#4	#5	#6	#7	#8	#9	Total 2
#1	-	0	1	0	1	0	0	0	0	2
#2	1	-	0	1	1	1	0	1	1	6
#3	0	1	-	0	0	1	1	1	1	5
#4	1	0	1	-	0	0	0	1	0	3
#5	0	0	1	1	-	0	0	0	1	3
#6	1	0	0	1	1	-	0	1	1	5
#7	1	1	0	1	1	1	-	1	1	7
#8	1	0	0	0	1	0	0	-	0	2
#9	1	0	0	1	0	0	0	1	-	3

	6	2	3	5	5	3	1	6	5	n-1 = 8

Table 7: Binary Pairwise Comparison

After the "importance" weight was assessed we used those values within our House of quality to resolve our *IMPROVED DIRECTIONS* as a method of determining how our customer needs could be improved, an arrow was used to signify whether that customer need should be decreasing, increasing or left blank for no change. The House of Quality as a whole allows us to companies the engineering characteristics of the *IMPROVED DIRECTIONS* against our project sponsors requirements. The engineering characteristics are then ranked on how well it did to meet that specific customer need. This can be seen in the following table 8 (Table 8: House of Quality).

House of Quality	Engineering Characteristics									
Improvement Direction		↑	↓				↑	↑	↓	↓
Units		#	in^3	N/A	N/A	W (Watts)	%	N/A	sec	lbs
Customer Requirements	IPF	#1	#2	#3	#4	#5	#6	#7	#8	#9
#1	6	9	9	1	9	1	3	0	3	0
#2	2	1	9	3	0	1	1	0	1	3
#3	3	1	3	9	3	0	1	3	3	1
#4	5	3	3	1	9	0	1	0	0	0
#5	5	0	3	0	0	9	0	3	3	0
#6	3	1	2	0	0	0	9	0	0	9
#7	1	0	0	0	0	1	1	9	0	1
#8	6	3	0	3	0	3	0	1	9	0
#9	5	3	3	0	1	1	3	1	0	9
Raw Score	789	110	132	62	113	77	71	44	98	82
Relative Weight		13.9	16.7	7.6	14.3	9.8	9.0	5.6	12.4	10.4

Rank Order		**3**	**1**	**8**	**2**	**6**	**7**	**9**	**4**	**5**

Table 8: House of Quality

The completion of our House of Quality showed us that *Machine size*, *Having a finished product that can be shown in the competition* and *Bottle count* were our most important functions while *Percentage of Top 12 Bottles, Users will be given an easy to understand manual* and *Environmental resistance* were our least important functions (in that order). This evaluation helped us separate from what we thought were good ideas and designs to ideas and designs that are more competently and function intended.

Next through using Pugh Charts which serve a purpose of looking at all the high and medium fidelity concepts and comparing them relative to a starting point. The Pugh Charts help us figure out if the concept is better (+), satisfactory (S), or worse (-) than the predetermined starting point.

Depicted in the first Pugh Chart, our starting point is a minimum of two bottles. From the chart the concepts that were selected to move to the next round of Pugh Charts were concepts 3, 5 and 6.

Pugh Chart

After the house of quality, the team systematically compared how important the customer requirements were to how our concepts compared. This was done by using multiple Pugh Charts

to eliminate poor performing concepts. A Pugh Chart determines concept potentiality based on if the concept is better, worse, or equal to a datum concept based on the designated criteria.

For the first iteration of the Pugh Chart, the datum used is the Barsys cocktail maker. This is a similar product to the Barbot. There are distinct qualities compared to our customer needs, including the use of pods instead of bottles and a smaller carrying capacity compared to most of our concepts.

Selection Criteria	**Barsys**	HF#1	HF#2	HF#3	MF#1	MF#2	MF#3	MF#4	MF#5	MF#6
Hold Bottles	DATUM	S	+	+	+	+	+	+	S	+
Compact Size		+	-	+	-	-	S	+	S	S
Ease of use		-	-	+	-	S	-	-	-	S
Innovative Design		-	+	+	+	-	+	+	+	S
USB C Power Source		-	S	-	-	-	-	S	S	+
Universal Fit		+	+	S	+	+	+	S	S	-
Durable		S	-	S	S	+	S	-	+	-
Timely Operation		S	-	+	-	S	-	-	+	+
Lightweight		+	-	-	-	-	-	S	S	+
# of Pluses		3	3	5	3	3	3	3	3	4
# of Satisfactory		3	1	2	1	2	2	3	5	3
# of Minuses		3	5	2	5	4	4	3	1	2

Table 9: Pugh Chart Iteration 1

For the second iteration of the Pugh Chart, High Fidelity #1 was used as the datum. This was done because it received three pluses, satisfactory, and minuses. HF #2, MF #1, MF #2, MF #3, and MF #4 were deemed not worthy of re-comparing because those concepts had equal if not more negatives than positives.

Selection Criteria	**HF #1**	HF #3	MF #5	MF #6
Hold Bottles	DATUM	+	S	+
Compact Size		S	S	S

Ease of use		S	-	S
Innovative Design		+	-	+
USB C Power Source		-	-	-
Universal Fit		S	S	S
Durable		-	-	S
Timely Operation		S	S	+
Lightweight		S	-	S
# of Pluses		2	0	3
# of Satisfactory		5	4	5
# of Minuses		2	5	1

Table 10: Pugh Chart Iteration 2

Below is the third iteration of the Pugh Chart. HF #1 was put back into the datum chart because of poor performance of the other concepts. HF #3 was not used to continue on because it received a minus in the section of 'durable.' A vision the customer has of this product is something that they can take to tailgates. The product needs to be durable to be taken outside and possibly be exposed to rain.

Selection Criteria	**MF #5**	HF #1	MF#6
Hold Bottles	DATUM	-	S
Compact Size		+	S
Ease of use		S	+
Innovative Design		-	S
USB C Power Source		-	-
Universal Fit		S	+
Durable		S	+
Timely Operation		-	S
Lightweight		S	+
# of Pluses		1	4
# of Satisfactory		4	4
# of Minuses		4	1

Table 11: Pugh Chart Final Iteration

After the final iteration of the Pugh Chart, MF #6 was selected as our design. It received three more pluses than HF #1. Specifically, MF #6 would hold more liquid, it would be more durable and could accept a wider range of liquor bottles.

Analytical Hierarchy Process

The analytical Hierarchy Process is used to try to eliminate bias and choose the design that best suits the customer needs. This is done by reading row then column. For example, Start and Stop Flow on Demand is equally as important as itself. It is slightly more important than mixing fluids so it was given a 3 in that place. This need is much more important than the need to hold different bottles so that is given a 9. These values are equal to their inverse in the transposed location.

	1	2	3	4	5	6	7	8	9	10
Start and Stop Flow on Demand	1.00	3.00	3.00	9.00	9.00	9.00	5.00	9.00	1.00	5.00
Mix Fluids	0.33	1.00	1.00	7.00	3.00	3.00	5.00	3.00	0.33	0.33
Maintain a laminar flow	0.33	1.00	1.00	3.00	3.00	5.00	0.33	3.00	0.20	5.00
Fits different types of bottles	0.11	0.14	0.33	1.00	0.33	0.33	0.33	0.33	0.11	0.33
Holds Mixers	0.11	0.33	0.33	3.00	1.00	0.33	0.33	0.33	0.20	0.33
Withstand handling	0.11	0.33	0.20	3.00	3.00	1.00	0.33	3.00	0.20	0.33
Display machine status	0.20	0.20	3.00	3.00	3.00	3.00	1.00	1.00	0.33	0.33
Check for I.C.s	0.11	0.33	0.33	3.00	3.00	0.33	1.00	1.00	0.20	0.33
Order to Mech Process	1.00	3.00	5.00	9.00	5.00	5.00	3.00	5.00	1.00	3.00
Store Menu Options	0.20	3.00	0.20	3.00	3.00	3.00	3.00	3.00	0.33	1.00
Sum	3.51	12.34	14.40	44.00	33.33	30.00	19.33	28.67	3.91	16.00

Table 12: Analytical Hierarchy Chart

The Normalized chart, below, can be used to calculate the criteria weight or how important each criterion is.

Criteria	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	Criteria Weights
#1	0.285	0.243	0.208	0.205	0.270	0.300	0.259	0.314	0.256	0.313	0.265
#2	0.095	0.081	0.069	0.159	0.090	0.100	0.259	0.105	0.085	0.021	0.106
#3	0.095	0.081	0.069	0.068	0.090	0.167	0.017	0.105	0.051	0.313	0.106
#4	0.032	0.012	0.023	0.023	0.010	0.011	0.017	0.012	0.028	0.021	0.019
#5	0.032	0.027	0.023	0.068	0.030	0.011	0.017	0.012	0.051	0.021	0.029
#6	0.032	0.027	0.014	0.068	0.090	0.033	0.017	0.105	0.051	0.021	0.046
#7	0.057	0.016	0.208	0.068	0.090	0.100	0.052	0.035	0.085	0.021	0.073
#8	0.032	0.027	0.023	0.068	0.090	0.011	0.052	0.035	0.051	0.021	0.041
#9	0.285	0.243	0.347	0.205	0.150	0.167	0.155	0.174	0.256	0.188	0.217
#10	0.057	0.243	0.014	0.068	0.090	0.100	0.155	0.105	0.085	0.063	0.098
Sum	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 13: Normalized Comparison Matrix Chart (NormC)

The weighted sum vector and the consistency vector are calculated and shown below.

After this table is calculated it is used to find the consistency ratio.

{Ws}=[C]{W}r	Cons={Ws}./{W}
3.186986	12.01955619
1.251154	11.76091918
1.353891	12.82364534
0.218501	11.60275934
0.31517	10.79602664
0.499253	10.90267173
0.891649	12.17518588
0.449691	10.97690699
2.591936	11.94950877
1.187615	12.12298478

Table 14: Consistency Check

Average Consistency	11.7
Consistency Index	0.190
Consistency Ratio	0.128

Table 15: Consistency Comparison

Please note the consistency ratio is not below the desired 0.1 value. However this was the lowest the score would go without compromising the integrity of our rating. Team 519 could get the score to go lower, but not without changing our ratings for certain criteria.

Criteria	Consistency Ratio
Start and Stop Flow on Demand	0.757
Mix Fluids	0.169
Maintain a laminar flow	0.014
Fits different types of bottles	0.149
Holds Mixers	0.156
Withstand handling	0.107
Display machine status	0.160
Check for I.C.s	0.118
Order to Mech Process	0.118
Store Menu Options	0.123

Table 16: Criteria Consistency Ratios

Most of the CR values are around the desired value of less than 0.1. The two outliers are 'Start and Stop Flow on Demand' and 'Maintain a Laminar Flow.' This is because both of them are almost not discernible with overview of the concepts we have right now.

The Final Rating Matrix is shown below.

Selection Criteria	HF #1	HF #3	MF #5	MF #6
Start and Stop Flow on Demand	0.167	0.245	0.094	0.326
Mix Fluids	0.089	0.457	0.243	0.144
Maintain a laminar flow	0.184	0.149	0.039	0.184
Fits different types of bottles	0.101	0.292	0.096	0.184
Holds Mixers	0.167	0.310	0.035	0.348
Withstand handling	0.132	0.361	0.046	0.326
Display machine status	0.170	0.292	0.040	0.149
Check for I.C.s	0.180	0.149	0.039	0.326
Order to Mech Process	0.167	0.257	0.039	0.381
Store Menu Options	0.167	0.257	0.039	0.326

Table 17: Final Rating Matrix

After this, the Alternative Value Rating is calculated using the Final Rating Matrix and the Consistency Ratios.

Concepts	Alt Value
HF #1	0.288
HF #3	0.522
MF #5	0.158
MF #6	0.538

Table 18: Alternate Value Rating

This is the final rating of our concepts. Showing that Medium Fidelity #6 is the best concept, narrowly edging out High Fidelity #3 for the concept selection. Rated first to last is MF #6, HF #3, HF #1, and finally, MF #5. High Fidelity #3 will be our alternate design because it is so close in rating compared to Medium Fidelity #6.

Final Selection: As a reminder, Medium Fidelity #6 is: *A machine that has the capacity of four beverages. The beverages will be placed into the machine upside down. The bottles will dispense liquid that will be pumped through the machine and mixed. The machine will be compact and fit on top of a kitchen countertop. Additionally, the machine will be compact enough to be stored away inside of kitchen cabinets. The machine will be powered through a standard US wall outlet.* This concept will look similar to the picture below.

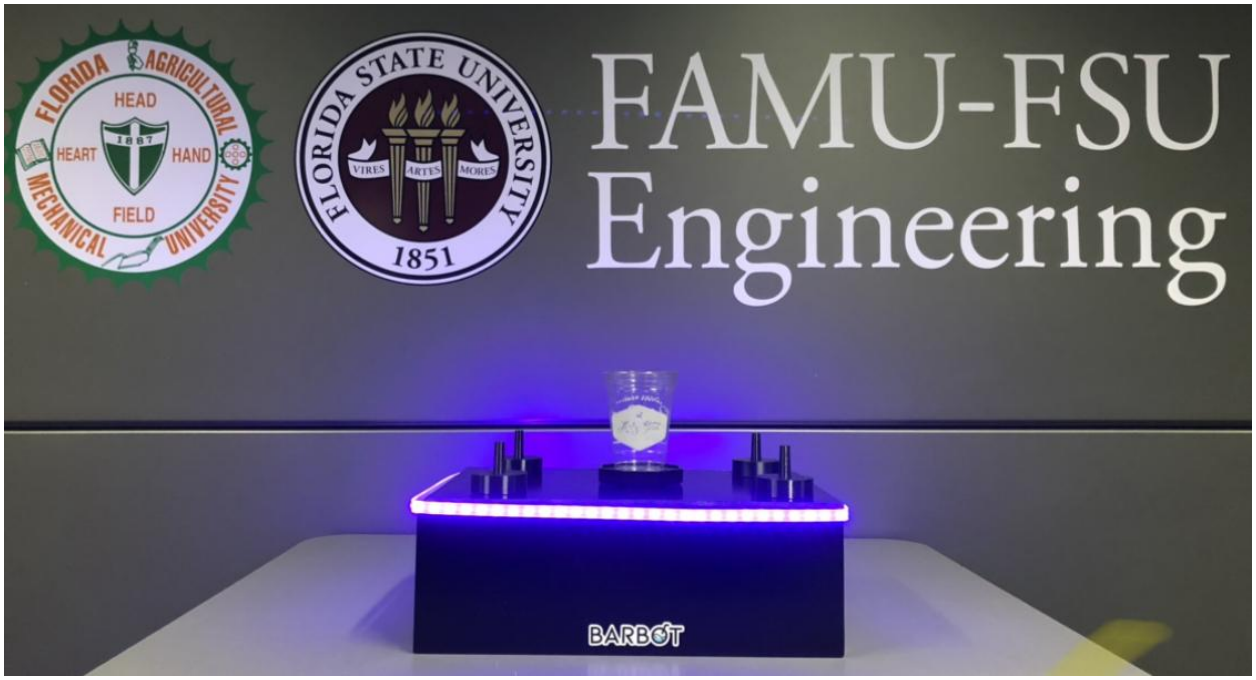

Figure 8: Fall Prototype Progression

This design will have a nozzle added to the back that will be connected thru the base. This design was selected because it is built specifically to solve the customer needs. It has a compact size, it's durable, it’s simple and easy to use. Also, it could be powered by a USB C outlet and has room for a battery pack.

1.8 Spring Project Plan

Win.