Concept Selection

1.6.1 House of Quality Outcome Discussion

A House of Quality was constructed using customer requirements and engineering characteristics. The customer requirements came directly from the customer needs synthesized previously. Those customer requirements were as follows, satisfy temperatures, easy process, preference control, individual temperature control, prediction and compatibility. The importance weight factor was then applied to these requirements through a binary comparison. The binary comparison took compares and weighs the customer needs against each other and is shown in Table #. Requirements with higher importance weight factors totals were found to be of more importance to the customer and as a result held a higher value. The highest customer requirement found was to be the temperature in the room are satisfied. The least important factor was found to be the compatibility of the system produced, given the scope and timeframe of this project.

Table 1. *Binary Comparison*

Binary Comparison

Item	Satisfy Temperatures	Easy Process	Preference Control	Individual Temp Control	Prediction	Compatibility	Total	Rank
Satisfy Temperatures	-	1	1	1	1	1	5	1
Easy Process	0	-	0	0	1	1	2	4
Preference Control	0	1	-	1	1	1	4	2
Individual Temp Control	0	1	0	-	1	1	3	3
Prediction	0	0	0	0	-	1	1	5
Compatibility	0	0	0	0	0	-	0	6
Total	0	3	1	2	4	5	5	-

The customer requirements were then compared to the engineering characteristics. The closer related a requirement was with an engineering characteristic, the higher the “score” would

be for that category. The rating was a 1, 3, or 9. These values were chosen to exaggerate the outcome of the relations. The engineering characteristics that were compared to the customer requirements came from the targets of the system which came from the functional decomposition of the system. The engineering characteristics were as follows: Material Rigidity, Time to change temperatures, Installation time, Connection time, User interface, Reliability. The house of quality is shown below. The first chart uses the weight factors determined from the binary comparison, then to ensure consistency, the weight factors determined in the AHP were then used. After finding all the customer requirement relations with the engineering characteristics, the total score of each characteristic was found. These were then totaled to find the total raw score of 356 for the first chart (Table 2) and 25.32 for the second (Table 3). From each raw score the relative weight and subsequent rank order was found. The results from the two different comparisons had different percentages in the relative weight, however still yielded the same rank outcome. It was determined it will be important to have a well thought out user interface for this project. It will be of less importance to ensure material rigidity, and therefore less time will be spent on this when developing designs.

Table 2. *Engineering Characteristics*

		Engineering Characteristics					
Improvement Direction		↑	↓	↓	↓	↓	↑
Units		MPa	sec	min	sec	n/a	years
Customer Requirements	Weight Factor	Material Rigidity	Time to change temperature	Installation time	Connection time	User interface	Reliability
Satisfy Temperatures	5	1	9	3	9	9	1
Easy Process	2	1	3	9	9	9	3
Preference Control	4	1	3	1	1	9	3
Individual Temp Control	3	3	9	1	1	1	1
Prediction	1	1	1	1	1	3	1
Compatibility	0	3	1	9	1	9	1
Raw Score	356	21	91	41	71	105	27
Relative Weight %		5.898876404	25.56179775	11.51685393	19.94382022	29.49438202	7.584269663
Rank Order		**6**	**2**	**4**	**3**	**1**	**5**

Table 3. *Engineering Characteristics*

		Engineering Characteristics					
Improvement Direction		↑	↓	↓	↓	↓	↑
Units		MPa	sec	min	sec	n/a	years
Customer Requirements	Weight Factor	Material Rigidity	Time to change temperature	Installation time	Connection time	User interface	Reliability
Satisfy Temperatures	0.43974	1	9	3	9	9	1
Easy Process	0.14002	1	3	9	9	9	3
Preference Control	0.19431	1	3	1	1	9	3
Individual Temp Control	0.12214	3	9	1	1	1	1
Prediction	0.06295	1	1	1	1	3	1
Compatibility	0.04084	3	1	9	1	9	1
Raw Score	25.31874283	1.32595735	6.163678458	3.326399042	5.597267253	7.277621081	1.627819643
Relative Weight %		5.237058409	24.34433306	13.13808933	22.10720845	28.74400649	6.429306754
Rank Order		**6**	**2**	**4**	**3**	**1**	**5**

1.6.2 Pugh Chart

After the house of quality was created and the rank order was established, the next step to the concept selection was comparing the top ten medium and high-fidelity concepts generated. To compare them the group makes use of Pugh Charts; the purpose of these charts is to be able

to compare the different concepts with a common concept or ‘datum’ and then compare the results between themselves. To achieve this, each concept is given a plus or a minus depending on whether is better or worse compared to the datum at the different criteria. The first datum chosen is the thermostat as the most basic and current working system, Table # shows the comparisons made. The two with the highest plusses and the least minuses were RFID VAV SL and RFID SQL, from these two RFID VAV SL was chosen as the new datum to compare to. Table # shows the second Pugh chart with the new datum; there it was compared against all other concepts to ensure consistency and to check if this characteristic was in fact the best among the others. As it can be seen from the results of each table the concept that performed the best against our customer requirements was RFID VAV SL.

Table 4. *Pugh Chart for Connections*

Pugh Chart											
Engineering Characteristics	Thermostat	RFID VAV SL	RFID VAV FCS	RFID VAV SQL	BT VAV SL	BT VAV FCS	BT VAV SQL	WiFi VAV SL	WiFi VAV FCS	WiFi VAV SQL	Online Sign Up
Satisfy Temperatures		+	+	+	+	+	+	+	+	+	+

Easy Process		+	+	+	-	-	-	=	=	=	-
Preference Control		+	=	+	+	=	+	+	=	+	+
Individual Temp Control		-	-	-	-	-	-	=	=	=	=
Prediction		+	+	+	+	+	+	+	+	+	+
Compatibility		+	+	+	+	+	+	+	+	+	N/A
Pluses		5	4	5	4	3	4	4	3	4	3
Minus		1	1	1	2	2	2	0	0	0	1

Table 5. *Pugh Chart for Data Management*

Pugh Chart										
Engineering Characteristics	RFID VAV SL	RFID VAV FCS	RFID VAV SQL	BTVAV SL	BT VAV FCS	BT VAV SQL	WiFi VAV SL	WiFi VAV FCS	WiFi VAV SQL	Online Sign Up
Satisfy Temperatures		=	=	=	=	=	=	=	=	=
Easy Process		=	=	-	-	-	=	=	=	-
Preference Control		=	+	+	=	+	+	=	=	+
Individual Temp Control		-	-	-	-	-	=	=	=	=
Prediction		=	=	=	=	=	=	=	=	+
Compatibility		=	=	=	=	=	=	=	=	N/A
Pluses		0	1	1	0	1	1	0	0	2
Minus		1	1	2	2	2	0	0	0	1

1.6.3 AHP

The AHP, or Analytic hierarchy process, is a selection table that allows the group to visualize which criteria needs to be prioritized against others according to the needs and requirements of the customer. Table # shows the AHP for 6 different criteria that were derived from the customer's needs. Each criterion is compared on a scale of 1 to 9, were 1 is equally important and 9 is the most important. The ranking system is a simple ladder from 1 to 6, where 1 is the first and most important criteria and 6 is least important one. To read the table effectively, each row represents the criteria and the column to what it is compared to. Each cell is the inverse of its opposite cell, for example, Satisfy Temperature has a value of 5 for Prediction; and Prediction has a value of 0.20 for Satisfy Temperature. The ranking of each criteria is done based on the horizontal results of each one. This chart also helped corroborate the results from the Binary Comparison table and allowed the calculation of the Weight factors for the Pugh Charts

Table 6. *AHP Chart*

AHP

Item	Satisfy Temperatures	Easy Process	Preference Control	Individual Temp Control	Prediction	Compatibility	Total	Rank
Satisfy Temperatures	1.00000	7.00000	7.00000	6.00000	5.00000	5.00000	31.00000	1
Easy Process	0.14286	1.00000	0.20000	5.00000	4.00000	4.00000	14.34286	4
Preference Control	0.14286	5.00000	1.00000	4.00000	6.00000	2.00000	18.14286	2
Individual Temp Control	0.16667	0.20000	0.25000	1.00000	5.00000	7.00000	13.61667	3
Prediction	0.20000	0.25000	0.16667	0.20000	1.00000	4.00000	5.81667	5
Compatibility	0.20000	0.25000	0.50000	0.14286	0.25000	1.00000	2.34286	6
Total	1.85238	13.70000	9.11667	16.34286	21.25000	23.00000	85.26190	-

1.6.4 Final Design Selection

The final design chosen was the Radio Frequency Identification, variable air volume, structure query language system. RFID was chosen over Bluetooth due to the connection times, and having an easier user experience. The VAV system was chosen due to its simplicity, there are more complex HVAC systems, that are more precise with control, but due to the scope of this project VAV will not only be sufficient but manageable. The SQL was chosen to process data also due to simplicity and effectiveness. It should be noted that it was not the highest performer in our Pugh chart, however was still chosen.