85-133: Design Project Report

Mia Vitti (110009254), Dana Taki (105213248), Riwash Tuladhar (110011428),

and Hardik Rajeshkumar Patel (110024552)

Design Group- 3

Dr. Daniela Pusca

Ran Cai

University of Windsor

Date: 2019/11/26

Table of Contents

List of Figures

List of Tables

Introduction

The purpose of this assignment is to understand the five stages of the design process. With the task of designing a 3D printer, our team under ‘Rapidesign” implemented this process in order to achieve a final product. Beginning with phases one and two (needs assessment and problem formulation), we were tasked with creating a 3D printer that met specific technical requirements. These included the design containing all components for a common-use 3D printer, allowing for easy modification of structure to accommodate for different parts, being for home use, price not exceeding CAD 300, sold in Canada and the U.S., and being safe for all users. After given the assignment, we immediately researched the topic in order to gain enough understanding of the 3D printer to establish functional requirements and constraints. These were power efficiency, printing quality, portable, durable, set-up, printing speed, safety, software, external connections, customer services, troubleshooting, and price. Using a house of quality, we performed a competitive evaluation to determine in which areas competitor products are lacking in. From this, we determined to have our design improve upon assembly, printing quality, safety, price and external connections.

In phase three of the design process, abstraction and synthesis, based upon the customer requirements to be improved upon, each team member created an ideation sketch of a 3D as a solution for the design problem. We then evaluated each design using a decision matrix in order to determine the strengths and weaknesses of each sketch. From this, we took the strengths of each design and incorporated them into one in order to achieve a final design solution. Next, in phase four, analysis, we deconstructed our 3D printer into its major systems in order to explain how our product meets the customer requirements. To do this, we constructed a systems table and system design specifications (SDS) documents outlining the functions of each and how the systems interrelate. After this step, we were finally able to establish our final design. We first created a rough sketch of how we wanted the product to look, to which we constructed an isometric view based off of this sketch. Using component design specification (CDS) documents, we deconstructed the essential features of the product in order to illustrate better and convey our intended ideas. Furthermore, phase five of the design process, implementation, was not a requirement as the focus of this assignment was more on the first four steps in the process. By executing the design process, our team was able to produce an effective 3D printer design and understand what in proposing a new product to the market.

Conceptual Design (Milestone 1 and Milestone 2)

The design of this printer has made it a suitable competitor with other 3D printer manufacturers. Rapidesign has made efforts to face the most relevant customer concerns. These concerns are power efficiency, printing quality, size, durability, set-up, printing speed, safety, software, system update, external connections, customer services, prices, and troubleshooting. While this printer may possess superior qualities either in software or hardware, it is important to recognize that it does have relative disadvantages. As the house of quality will demonstrate, the Rapidesign 3D printer will work to combat the areas in which designs from competitors are not implemented as effectively. This printer was, that makes it inviting to the general public. The objective of this assessment was to analyze and compare the customer requirements with the technical requirements of a product. By doing this, the minds behind the Rapidesign 3D printer were able to determine, with greater precision, which areas of interest are underrepresented in the competitor's product. As a result, Rapidesign is able to strengthen our design in areas found to be generally weak, giving the product a superior advantage against our competitors.

House of Quality

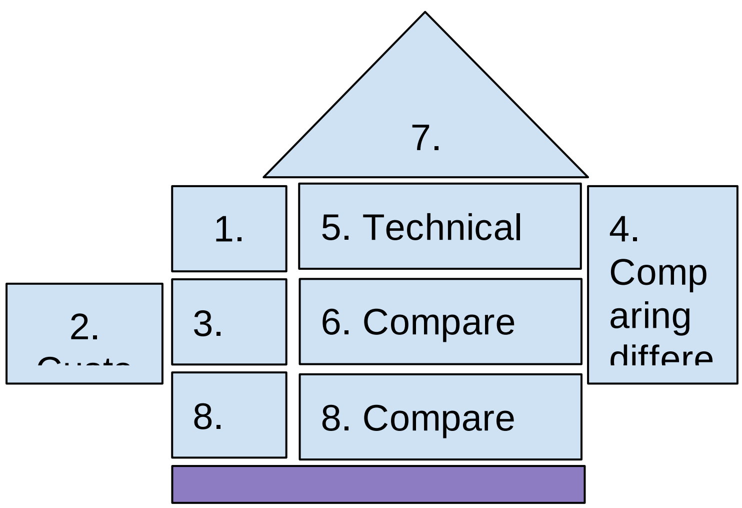


Figure 1. House of Quality

The house of quality is used to identify what your client is looking for and how those needs are addressed by the requirements of the product. They also work to analyze how prevalent these requirements based on a ranking system and how well they are represented in a company's product based on used resources. It also allows the correlation between customer and technical requirements to be made. By looking at the class notes, there are eight main steps (rooms) in order to create a House of Quality:

1. Identify who your target clientele or audience is for your product. For this project, our target customer is house owners in Canada and the US.
2. Look at what needs to be taken into account when designing your product (requirements)
3. Compare the listed requirements with what your target clientele wants in order to narrow down their importance with a ranking system starting at one of the most important (customer requirements). This list is exhibited in column one of table 1.
4. From step 3, different companies are then ranked on how well their products currently fulfill each of the customer requirements based on a scale from one to four:
    a. 1: the design of the product does not meet the requirements
    b. 2: the design of the product somewhat meets the requirements
    c. 3: the design of the product mostly meets the requirements
    d. 4: the design of the product completely meets the requirement

For this project, we chose UP! Plus 2 3D Printer and Afinibot A3SU Single Extruder 3D Printer Kit.

5. Based on the customer requirements, create technical requirements in which values may be measured and compared. The technical requirements also help to examine how the customer requirements can be actualized
6. Identify the relationship between the customer requirements and functional requirements based on either a scale from one to three or one to nine. This is to determine how much of an impact these requirements will have on each other.
    a. 1 (1): weak relationship
    b. 2 (3): medium relationship
    c. 3 (9): Strong relationship
7. Determine how strong of a correlation exists between the functional requirements using the scale:
    a. 1: weak relationship
    b. 3: medium relationship
    c. 9: a strong relationship
8. Identify how other companies have met the technical requirements with quantitative data. By doing this you are able to determine where the competition's design is weak and thus create a target for your design to improve upon

However, for the purpose of this assignment only rooms 1 through 4 will be focussed on and analyzed.

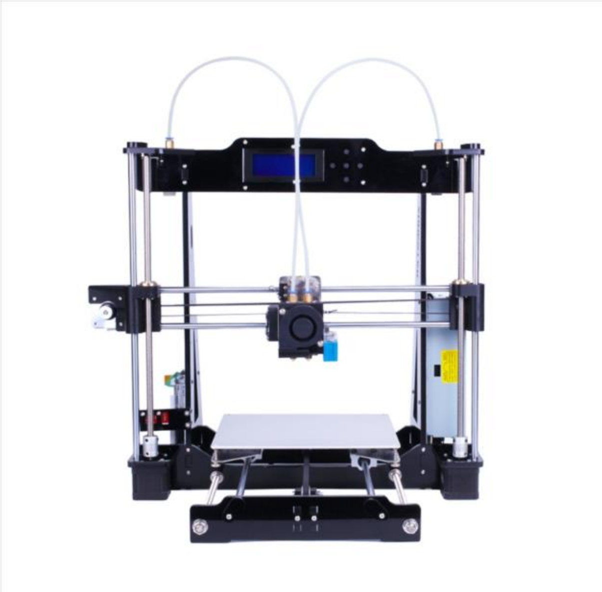
Competitive Evaluation

Product: 3D Printer "Rapid Design"

Version: One
Date: 2019-11-06

Table 1: House of Quality Chart Exhibiting Rooms One Through Four.

Customer Requirements	**Importance Weighting** (Ratings)	**(Competitor 1)** UP! Plus 2 3D Printer (Black)	**(Competitor 2)** Afinibot A3SU Single Extruder 3D Printer Kit	**For Our Design** (intent)
1. Functional Performance Issues				
1.1. Power Efficient	4	**4**	**4**	**-**
1.2. Printing Quality	2	**1**	**3**	+
2. Engineering Issues				
2.1. Portable	9	**3**	**2**	**?**
2.2. Durability	6	**4**	**3**	**-**
2.3. Set-up	8	**4**	**2**	+
2.4. Printing speed	3	**2**	**3**	+
2.5. Safety	7	**4**	**2**	+
2.6. Softwares	5	**3**	**4**	**-**
3. Consumer Issues				
3.2. External Connections	12	2	2	+
3.3. Customer Services	10	**3**	**2**	**?**
3.4.Troubleshooting	11	**3**	**1**	**?**
3.5. Prices	1	**1**	**3**	+



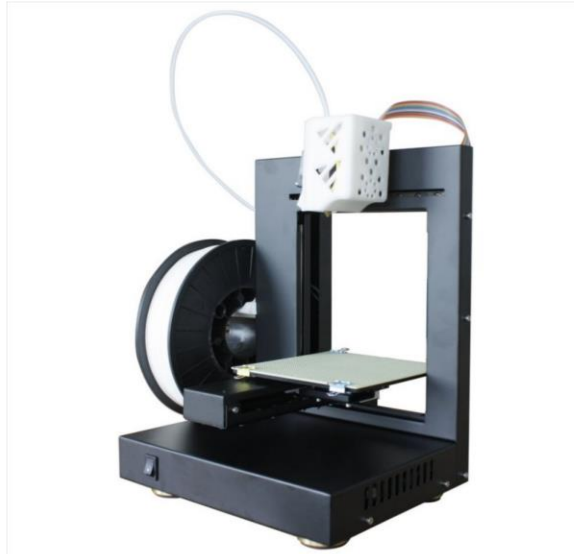


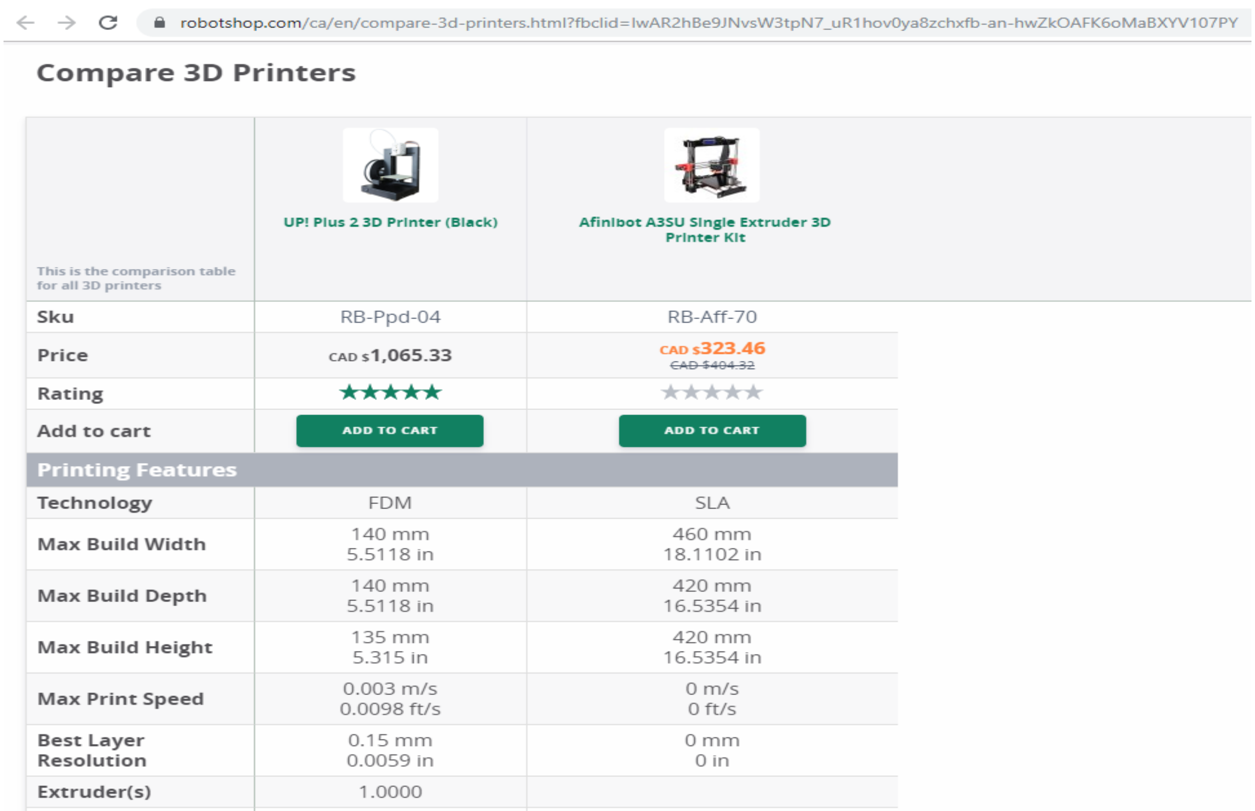
Figure 2. Afinibot A3SU Single Extruder 3D Printer Kit. https://www.robotshop.com/ca/en/afinibot-a3d-dual-extruder-3d-printer-kit.html. Accessed November 6, 2019	Figure 3. UP! Plus 2 3D Printer (Black) **https://www.robotshop.com/ca/en/up-plus-2-3d-printer-black.html**. Accessed November 6, 2019

Table 2: Reasons for Evaluation Ranking

Requirement	**(Competitor 1)** UP! Plus 2 3D Printer (Black)	**(Competitor 2)** Afinibot A3SU Single Extruder 3D Printer Kit
Power-efficient	Requires 120 V	Requires 120V
Printing Quality	Has a smaller nozzle for improved quality	Has the standard nozzle size (0.4mm)
Portability	Is smaller	Is larger
Durability	Made of metal and acrylic	Made of steel
Set-up	Already assembled	Requires basic assembly
Printing Speed	30mm^3/s	150mm/s
Safety	Include heat resistant gloves	Only Apply Standard Safety Measures.
Softwares	Compatible with more software than competitor	Compatible with less software than competitor

External Connections	Is able to connect more types of input devices	Able to connect to multiple input devices but not as many as competitors
Customer Service	Has multiple ways to contact the company (email, phone)	Only has email as a source of contact
Troubleshooting	Has FAQs that pertain to problems that can occur in the product	Has FAQs but they do not pertain to problems that occur in the product
Price	$1,065.33	$323.46

Pictures



robotshop.com/ca/en/compare-3d-printers.html?fbclid=IwAR2hBe9JNvsW3tpN7_uR1hov0ya8zchxfb-an-hwZkOAFK6oMaBXYV107PY

Compare 3D Printers

This is the comparison table for all 3D printers	UP! Plus 2 3D Printer (Black)	Afinibot A3SU Single Extruder 3D Printer Kit
Sku	RB-Ppd-04	RB-Aff-70
Price	CAD $1,065.33	CAD $323.46 ~~CAD $404.32~~
Rating	★★★★★	★★★★★
Add to cart	ADD TO CART	ADD TO CART
Printing Features		
Technology	FDM	SLA
Max Build Width	140 mm 5.5118 in	460 mm 18.1102 in
Max Build Depth	140 mm 5.5118 in	420 mm 16.5354 in
Max Build Height	135 mm 5.315 in	420 mm 16.5354 in
Max Print Speed	0.003 m/s 0.0098 ft/s	0 m/s 0 ft/s
Best Layer Resolution	0.15 mm 0.0059 in	0 mm 0 in
Extruder(s)	1.0000	

Figure 4: Product information for competitor designs related to general product information and printing features.

.https://www.robotshop.com/ca/en/compare-3d-printers.html?fbclid=IwAR1ENoINkr1DJUd_QIsqSYhWApWS1nc50Hci6jx2w2wgr8b49G4XRupPXSk Accessed November 6, 2019

Compare 3D Printers

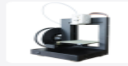
This is the comparison table for all 3D printers	 UP! Plus 2 3D Printer (Black)	 Afinibot A3SU Single Extruder 3D Printer Kit
Notes	Windows (XP+), Mac OS	
SD Card	No	Yes
USB Flash Drive	No	No
Wi-Fi	No	No
Ethernet	No	No
USB [#]	Type B	
LCD and Display		
Technology	N/A	No
Touchscreen	No	
Power		
Input V (Min)	110.0000	110.0000
Input V (Max)	220.0000	240.0000
General Specifications		
Length	260 mm 10.2362 in	480 mm 18.8976 in

Figure.5: Product information for competitor designs related display, power, and some general sp ecification. .ttps://www.robotshop.com/ca/en/compare-3d-printers.html?fbclid=IwAR1ENoINkr1DJUd_QIsqSYhWApWS1nc50Hci6jx2w2wgr8b49G4XRupPXSk Accessed November 6, 2019

robotshop.com/ca/en/compare-3d-printers.html?fbclid=IwAR2hBe9JNvsW3tpN7_uR1hov0ya8zchxfb-an-hwZkOAFK6oMaBXYV107PY

Compare 3D Printers

This is the comparison table for all 3D printers	 UP! Plus 2 3D Printer (Black)	 Afinibot A3SU Single Extruder 3D Printer Kit
Nozzle(s)	1.0000	0.4000
Part Adhesion	N/A	No
Spool and Filament		
1.75mm Filament	Yes	Yes
3mm Filament	No	No
Print Material ABS	Yes	Yes
Print Material PLA	Yes	Yes
Print Material RESIN	No	No
Spool Holder	Opened	No
Connectivity		
Windows	Yes	Yes
Mac OS	Yes	Yes
Linux	No	Yes
Notes	Windows (XP+), Mac OS	

Figure.6: Product information for competitor designs related to filaments and connectivity. https://www.robotshop.com/ca/en/compare-3d-printers.html?fbclid=IwAR1ENoINkr1DJUd_QIsqSYhWApWS1nc50Hci6jx2w2wgr8b49G4XRupPXSk Accessed November 6, 2019

After the competitive analysis in milestone one, it has been deemed that printing quality, assembly of machine, printing speed, safety measures, external connectors, and the price, via product materials, are the requirements we can improve upon in our design. Each team member was tasked with creating their own ideation sketch that meets and implements these requirements. Once these ideation sketches were created, we then performed an evaluation to see how well each design improved the above-mentioned criteria. This was done using a Decision Matrix. After the design evaluation was conducted, we looked at the weak and strong aspects of each design. After the strong ideas were identified, we combined them in order to construct a finalized product design for our 3D printer.

By allowing each member to constructively design their own images of what the 3D printer should look like, new perspectives and innovative ideas were able to prosper. The combination and analysis of each individual idea, sparkled new concepts, thus leading to a finalized product that the team as a whole was content with. Normally at the industrial design level, the Decision Matrix is conducted several times in order to construct a solid, plausible design. However, for the purposes of this assignment, only one stage of evaluation analysis was conducted before finalizing the design. Despite only one level of analysis orchestrated, we were still able to receive a good understanding of the objective graduate attribute 4b. As a cohesive group, we were able to effectively apply formal design evaluation tools to select and implement which team member's design proposed the best solution for the problem at hand.

Ideation Sketches

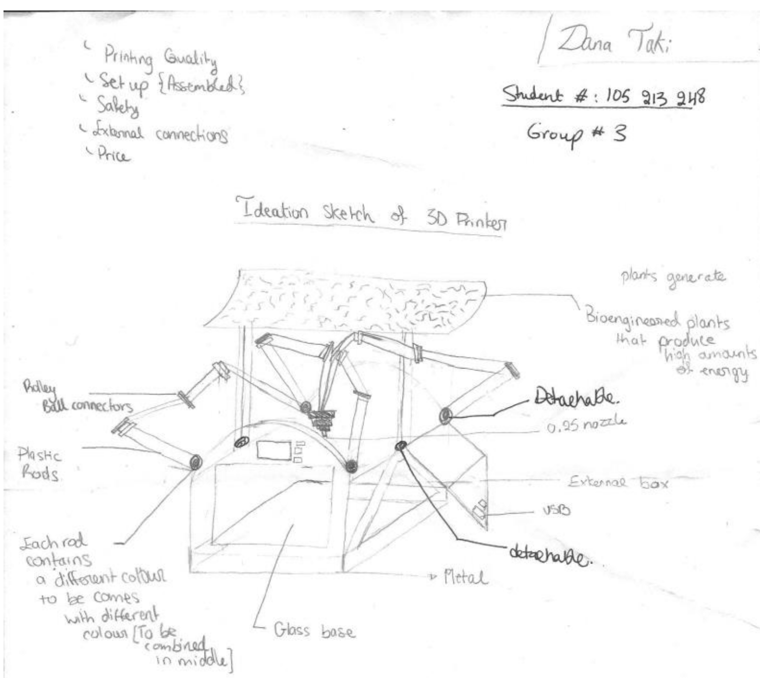


Figure 7: Dana's Ideation Sketch for a 3D Printer

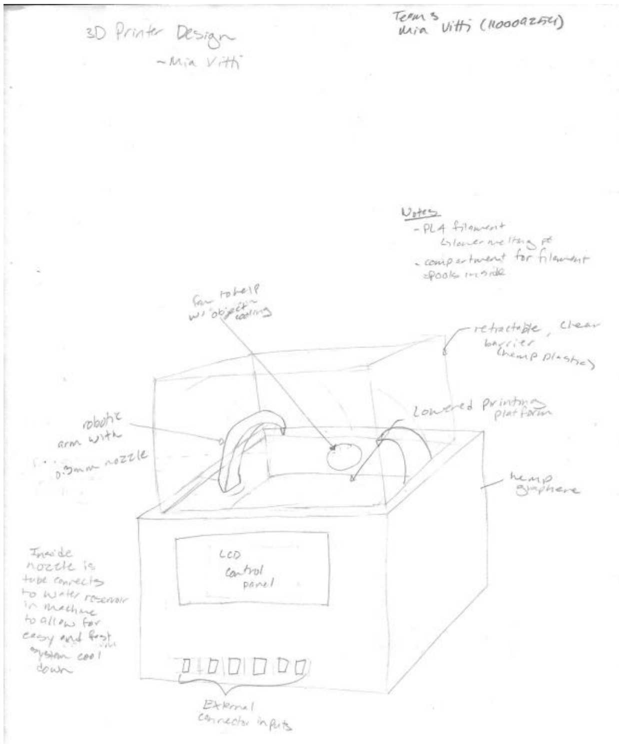


Figure 8: Mia's Ideation Sketch for a 3D Printer

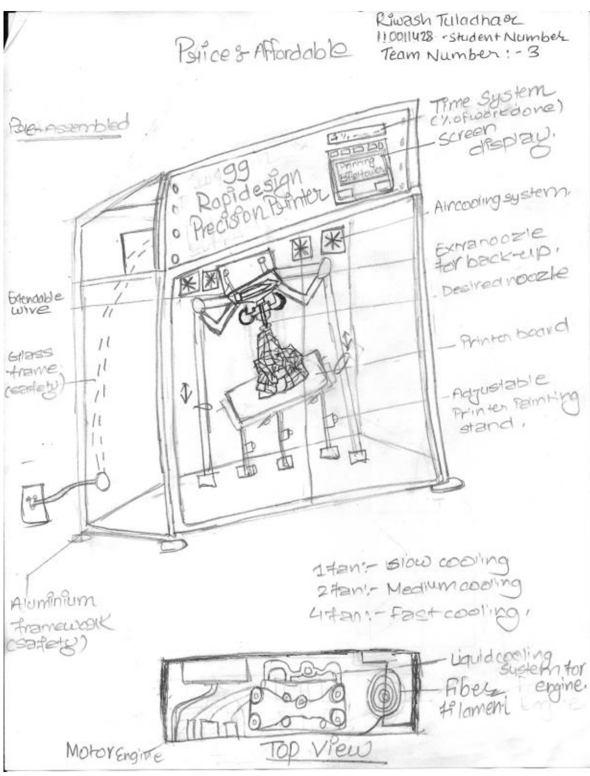


Figure 9: Riwash's Ideation Sketch for a 3D Printer

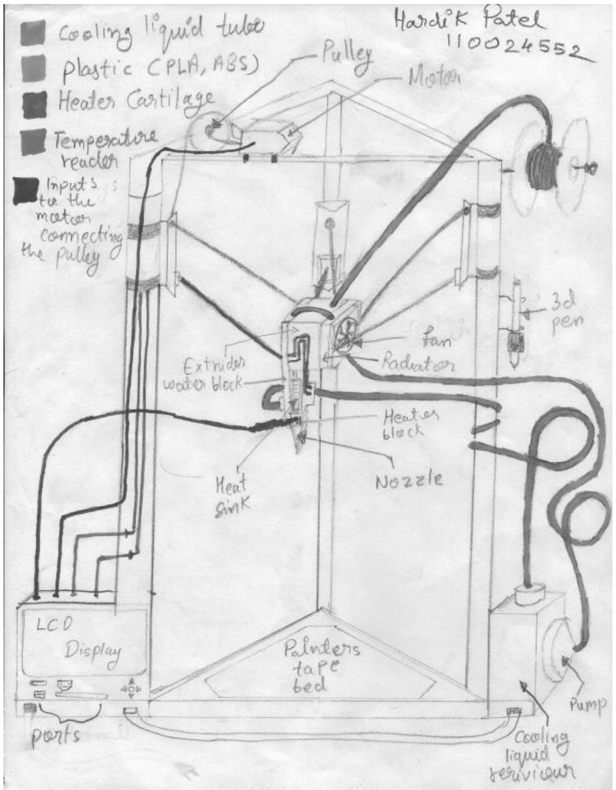


Figure 10: Hardik's Ideation Sketch for a 3D Printer

Decision Matrix

As per the functional requirements, we obtained through the competitive evaluation table of Milestone 1, we finalized that Printing Quality, Set-up, Printing Speed, Safety and the Price of the Product were the areas we needed to emphasize and improve upon. While doing so, each team member was allowed to express their visual ideas and improvements to finalize the product's design. The ideation sketches of each member are scanned above. Thus, after completion of each sketch, the versatile ideas were truly worth seeing. While some had an idea of photosynthesis, the other was keen to add a wireless or Bluetooth system for printing. One took safety in her account, the other preferred adjustable nozzle for the advancement of the printing quality. Thus, in order to find the "preferred" design, we proceeded to the evaluation criteria table. This table basically indicates the satisfaction of the metrics through the team's overall view on specific parts of the design. While taking reasonable reasons and factors of design objectives in mind, the evaluation was performed systematically and with precision. In the table, there is a total of 7 ranks. The rank was graded ascendingly in terms of the percentile of 100,90,75,50,25,10 and 0 respectively, which evaluates that 100 indicates the highest order of satisfactory while 0 shows that the specific ideation drawn by that particular member has not met the requirement at all. To sum up, the measurement table 1 for evaluation of each decision matrix has been provided below.

Table 3: Evaluation Criteria for Decision Matrix

Rank (%)	Description
100	Complete Satisfaction; Objective satisfied in all aspects
90	Extensive Satisfaction; Objective Satisfied in all important aspects
75	Considerable Satisfaction; Objective satisfied in most aspects
50	Moderate Satisfaction; A middle point between complete and no satisfaction
25	Minor Satisfaction; Objective satisfied in some but less than half of all aspects
10	Minimal Satisfaction; Objective is minimally satisfied
0	No Satisfaction; Objective is not satisfied

After collectively reviewing each team member's freehand, objective-based and descriptive sketches, the process further advanced to decide how much has respective members taken the design concept into their design process. As mentioned, the 4 engineering metrics that were to be taken into order was Price, Assembly, Safety, Printing Quality, and External Connection. Likewise, each of them had different weighting scale due to their level of importance for the whole team member. Price, out of all had the strongest rating due to the fact that we considered it to be the topmost basis for consumers to purchase our product. To clarify more on it, the discussion to complete the table is elaborated below,

Table 4: Decision Matrix

Engineering Metrics	**Weighting**	**Design 1 (Riwash)**		**Design 2 (Dana)**		**Design 3 (Hardik)**		**Design 4 (Mia)**	
		Rating	**Weighted Score**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**
Price	0.30	75%	22.5	25%	7.5	50%	15	75%	22.5
Assembly	0.10	75%	7.5	75%	7.5	90%	9	90%	9
Safety	0.20	90%	18	50%	10	50%	10	90%	18
Printing Quality	0.25	100%	25	50%	12.5	90%	22.5	50%	12.5
External Connection	0.15	75%	11.25	75%	11.25	100%	15	75%	11.25

Raw Score	84.25	48.75	71.5	73.25
Relative Rank	1	4	3	2

Discussions

Price: Price is the primary filter that customers use, and therefore is one of the most important criteria for any product. Here, we gave a higher rating to the printer design given by Mia and Riwash because their printers are made up of relatively cheaper but quality material when compared to the others. Mia has hemp plastic for her printer which is cheap, plus environment-friendly whereas, Riwash has aluminum for his printer, which is cheap, lesser corrosive as well as lightweight.

Assembly: Our printer comes for household use only, so the goal we have is to keep it as simple and easy to use as possible. Hardik's and Mia's design displayed simplicity. Mia's printer comes pre-assembled and everything is well organized inside a Primark shoe box. Hardik's design also provides buyers with a pre-assembled printer, with everything well organized, and filaments can be changed by a few simple steps.

Safety: Safety in any product is important, and since we have our printer for household use, safety is the number one priority. Mia and Riwash added simple but strong safety measures. Both of their printers are closed inside a see-through glass box which provides a layer of security from the high temperatures at which a printer works.

External Connections: The number of ports is also what computer geeks love to count. Here, Hardik's printer comes with the most number of useful ports. The printer has a strong port selection, including a USB Type-A port, a thunderbolt 3 port, a full-sized HDMI connector, a microSD card slot, and an SSD card slot. So, the buyer has a good amount of options to get connected and start with the printing process.

Systems Design (Milestone 3)

The purpose of this milestone is to finalize the intrinsic features of our product design. After evaluating each group member's 3D printer design in milestone two, we were able to identify where the areas of improvement need to be in our final design. Once we identified what features of which design we were keeping in our design, we now have to sort the features and parts of our design into different systems. This is done using a System Table, which depicts the different systems present in the design and determines whether they satisfy a specific function or not. The functions we focussed on originated from the customer requirements and functional requirements established in milestones one and two. After the systems were recognized in the design, a series of system design specifications (SDS) documents are developed. This further analyses the functions of the system. SDS documents focus on what functions each system provides and specifically how that system works to perform that function, allowing a better understanding of the overall product. For our 3D printer design, we determined the systems to be structural, cooling, heating, and internal connections. A thorough understanding of all the mechanisms in our product enables us to then produce detailed drawings of the parts of each system.

System Table

A system is an essential component of the design body which performs functions collectively to allow the product to accomplish its objective. The table below summarises the system involved in our printer and the functional performance each contributes in order for the printer to achieve its goal.

Table 5: System Table of Our 3D Printer

Function	**Systems**			
	Structural	**Cooling**	**Heating**	**Internal Connections**
Allow for Smoother Assembly	✓			
Maintains Safety of Operator	✓	✓	✓	✓
Increasing Printing Quality			✓	
Allow for Better External Connections	✓			✓
Increases power efficiency			✓	✓

Maintain product integrity	✓	✓		✓
Aesthetics	✓	✓		

Table 6: System Design Specification for the Structural System

System: Structural	**Author: Riwash Tuladhar Version: 1 Date: 2019/11/13**
Related Systems:	**Heating, Cooling, Internal connections**
Function	**Explanation**
Allow for Smoother Assembly	The 3D printer is pre-assembled. The only connection required is to connect the filament to the extruder.
Maintains Safety of Operator	The framework consists of glass and aluminum cover. While glass is used to insert the model, the aluminum acts as a hardcover for overall support.
Allow for Better External Connections	It includes connection to USB drives, thunderbolt 3 port, a full-sized HDMI connector, a microSD card slot, and an SSD card slot.
Maintains Product Integrity	Aluminum is UV resistance, has a comparatively lower corrosive rate in terms of rusting and very high life span of 50 years.
Aesthetics	5/4 inch LCD display allowing comfort screening, Logo will be open concepts and fancy script, varieties of color like Blue, Black, Gray, and other lighter paints.

Table 7: System Design Specification for the Heating System

System: Heating	**Author: Riwash Tuladhar Version: 1 Date: 2019/11/13**
Related Systems:	**Cooling, Structural, Internal Connections**
Function	**Explanation**
Maintains Safety	Insulation layer over the heater board and heat sink will avoid burning

of Operator	of the skin if someone touches it abruptly.
Increasing Printing Quality	It allows the filament to maintain ideal temperature during the printing process to provide finer results.
Maintains Product Integrity	A constant heat allows smoother melting of the filament to allow a lesser chance of clogging of the extruder.

Table 8: System Design Specification for the Cooling System

System: Cooling	**Author: Riwash Tuladhar Version: 1 Date: 2019/11/13**
Related Systems:	**Heating, Structural, Internal Connections**
Function	**Explanation**
Maintains Safety of Operator	Prevents overheating of the system.
Increasing Printing Quality	The system sustains the life span of the filaments and mechanically functioning parts. Thus, the quality of the printing will remain for a longer period.
Increases power efficiency	The controlled regulation of water allows other systems to consume less energy and supports wear and tear of connections to make the printer power efficient.
Maintain product integrity	As water is used for cooling purposes, it can be regulated throughout as many times as one desires.
Aesthetics	The tube for cooling will be blue or red in color, which symbolizes tranquility, joy, and energy.

Table 9: System Design Specification for the Internal Connections System

System: Internal Connections	**Author: Riwash Tuladhar Version: 1 Date: 2019/11/13**
Related Systems:	**Heating, Structural, Cooling**
Function	**Explanation**

Maintains Safety of Operator	Wiring within the printer has been insulated to prevent heating issues.
Allow for Better External Connections	Makes compatibility of device effective and capable of connecting with different outputs.
Increases power efficiency	Internal connection box comes with transformer, which converts small quantities of electricity to larger quantities, increasing overall efficiency.

Discussions

Structural System: The team has decided to go with aluminum as the primary material for our printer as aluminum checks out important customer requirements. Aluminum is currently cheap in the market and is considered a strong metal for manufacturing this provides buyers with a lower price and higher durability of our item. Aluminum also has a high melting point, so in case of any malfunction of the heater board, the structural system would not be affected. The only constraint that we currently have is that any damage to the structural system can directly have its effects on the majority of other systems. Other components of this system include motors that allow the extruder and the heater to move more smoothly and allow better printing quality. Overall this system satisfies three major customer requirements that include, price, printing quality and durability.

Heating System: The heating system comprises an extruder that connects the filaments to the main heating component, a heater board, a heat sink, a heat break, a nozzle, heater cartilage, and a temperature sensor. This is where the printing quality really gets defined, lower the size of the nozzle finer will the product be, so we have made sure that our printer has adjustable nozzles that buyers can adjust to get their desired print, our printer’s heating system also has a layer of insulation so that the heat does not escape outside and this layer of insulation also acts as a safety measure if in case the heater board was touched. Temperature is also very important here, it has its own game. If the temperature is too high then the plastic may be too liquidy to maintain proper layers of the solid model and if the temperature is too low then the plastic will not stick. We currently do not have any problems with our heating system as it is spot on with connections to the computer in order to maintain the right temperature for the right material. It solves customer requirements like the printing quality and safety issues.

Cooling System: We have designed a spot-on liquid cooling system for our printer, as liquid cooling is faster, better, reduces the noise and also adds to the aesthetics. This system comprises a reservoir, a pump, a water block, a radiator, colored tubing, and a fan. The liquid we are using here is simple distilled water. This system adds on to the safety as liquid cooling is way faster than fan cooling and for a final touch, it also adds to the aesthetics of our printer, a liquid cooling system with liquid running through the printer look mesmerizing. Our cooling system stands out and it makes sure that our printer always has a benchmark performance. It is power efficient, it is mildly expensive at the beginning but since the water inside can be changed anytime, it cuts out the price when it is viewed on a longer-term. There no such constraints but only that it makes the printer bulkier and the system needs to be used carefully as any leaks can kill the printer. For the final model, we seek more insulation so as to bring the possibility of leakage to an absolute zero.

Internal Connections: Our printer has a vast number of internal connections, it is the most complex system on the device. The system connects all other systems to the main computer where the commands are given. Our electromagnetic signals are passed through an optical fiber, so as to provide a neat and quick transaction of data and fine timed printing. It also includes connections to the thermal sensors so as to control the heat inside the heater board using the liquid cooling system. Our connects are fine and quicker which plays a minor role in giving out better printing quality, The wires have an extra layer of insulation so as to prevent short circuits and blow up the system, so it contributes to safety as well. The constraints we currently have is that the internal connection buffs up the price by bits. To maintain neatness we currently have with a lesser price for our final design of the printer.

To Conclude, throughout this milestone, transforming the original functional requirements into practical functions was not always possible, and proved to be challenging. For example, since the functional requirement “price” was not a function of a printer associated with a specific system, we had to remove it altogether. Some functions were slightly altered to fit the requirements of specific essential systems in our product. Some of our systems did not have many contradictions to one another, for they did not possess too many functions. One contradiction that we came across was that encountered was that assuring the safety of the operator was met has impeded us from developing the printing quality to its fullest potential. To reduce this contradiction, we had to prioritize some functions over others. This milestone helped us become more aware of how the functions of each system can alter the overall outcome of a product.

Component Design (Milestone 4):

After creating the SDS (System design specification), the team members further processed to focus more on each of the systems in order to further analyze how the components of the 3D printer will fit-in together. This is known as the CDS of our design. Creating an abstract model format of what the final product looks like made us more apt to organize our information, structure our mutual ideas, and visualize the relationships between different components. Most importantly, our graphical representation made us capable of a thorough analysis of the proposed structure. The bill of material was a compromise of all the proposed materials in the originally proposed models of each team member. The graphical representation that we came up with represents a refined and advanced conceptual design in its final end state. The objective of this assignment was met since the views created allowed an accurate depiction of how each system is composed. None of the views showed all the details that our printer has completely. The whole product was represented as an isometric view with the purpose of showing a more broad, less detailed composure of the overall product. To do this in a clear and informative manner, different colors were used to represent the different connections in our drawing. For example, the cooling tube is colored blue. This allowed for further clarification of the purpose of each component.

Component Design Specification

After analysing the systems that perform functions which includes heating, cooling, internal connectivities and structures in our Milestone 3 which are to be included in our final project, we then proceeded to refine and conceptualize the design end state. To do so, we forwarded the process to CDS. CDS, in general, (Component Design Specification) is a specified analytical and detailed assembly process of drawing. It helps us to provide clear instructions on the intent, performance and construction of the project. The figures are shown below.

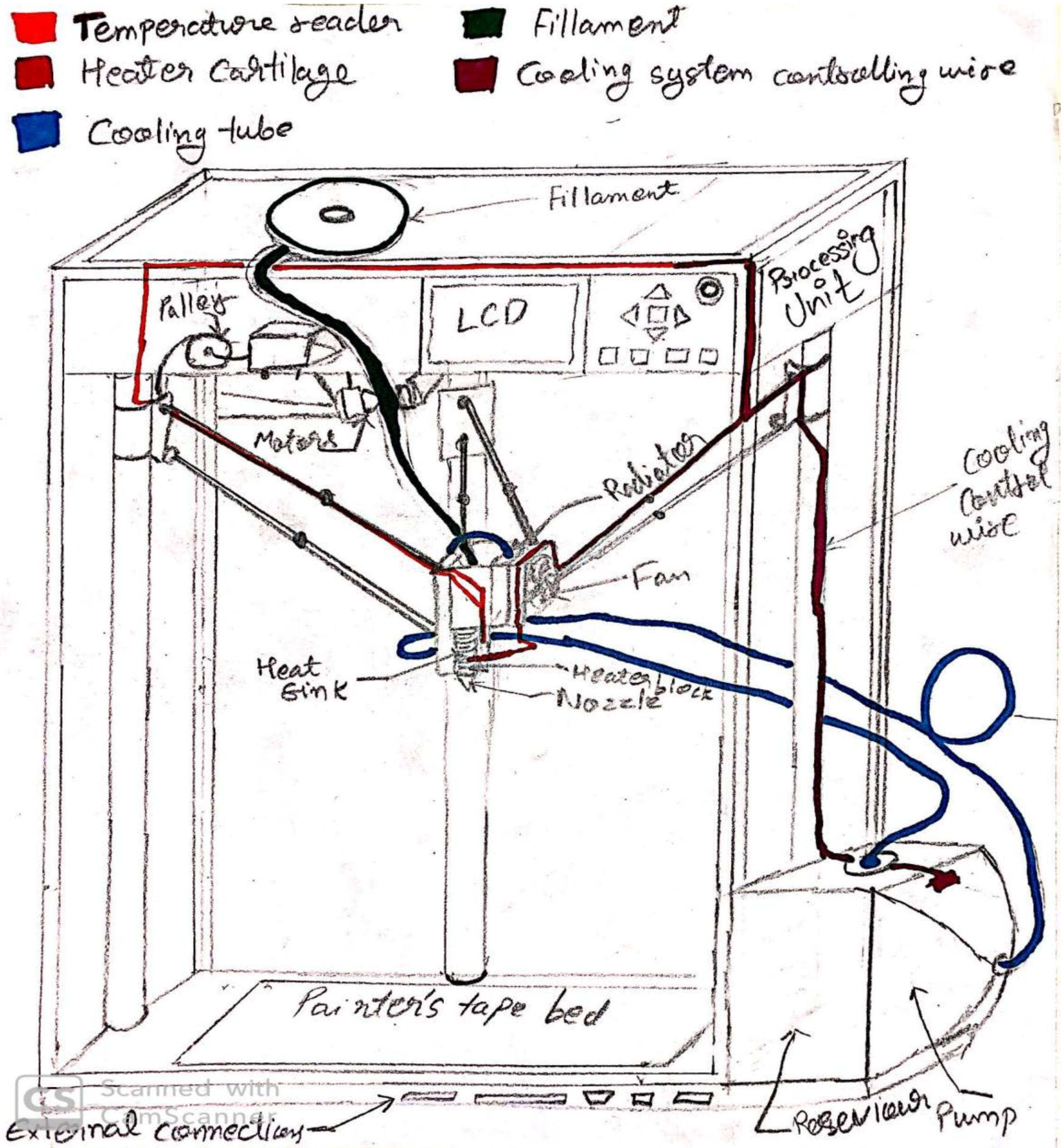


Figure 11: The Final Rough Sketch of the 3D-printer

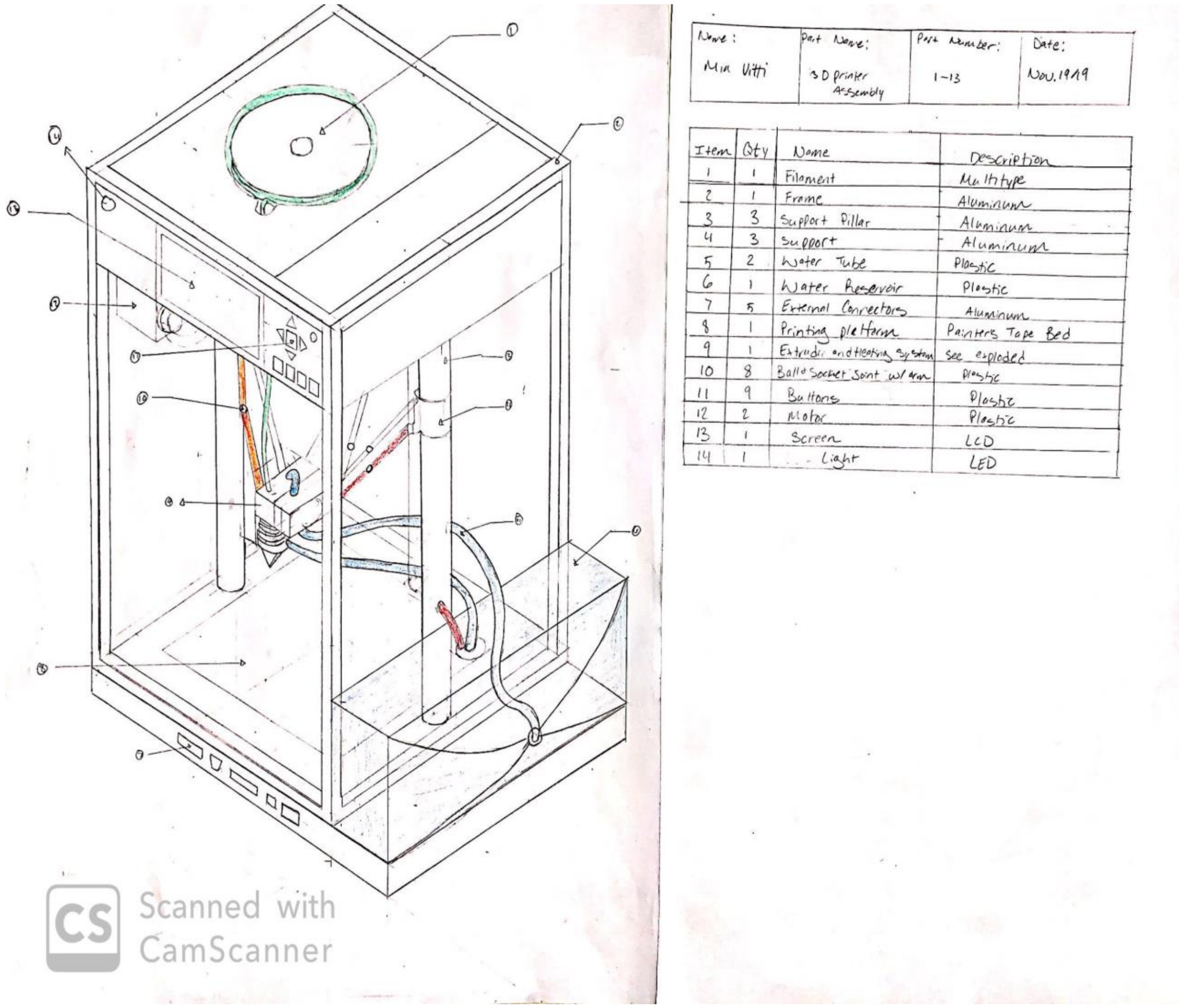


Figure 12:. Isometric view of the Final Design

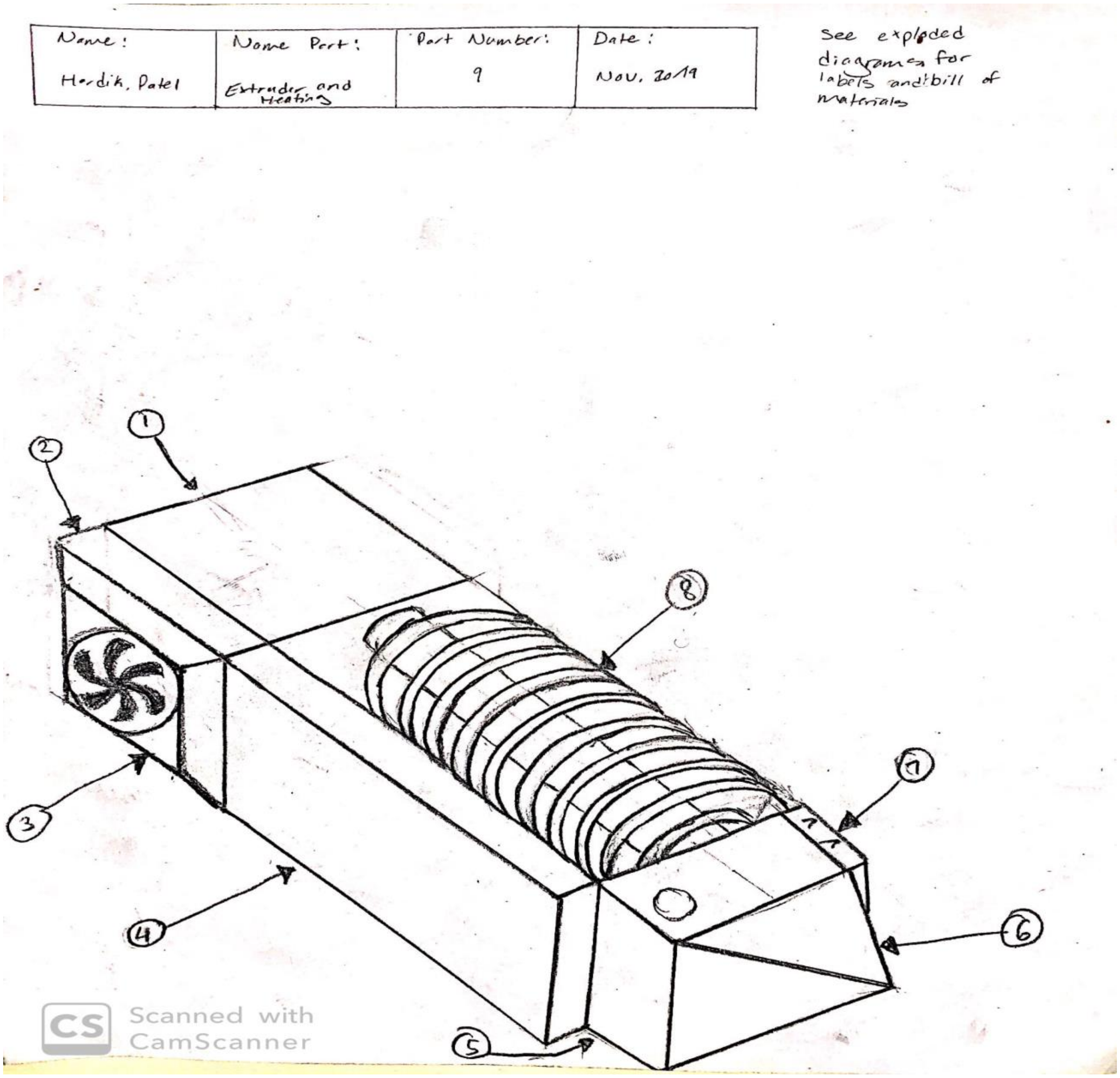


Figure 13: Isometric view of Extruder and Heater

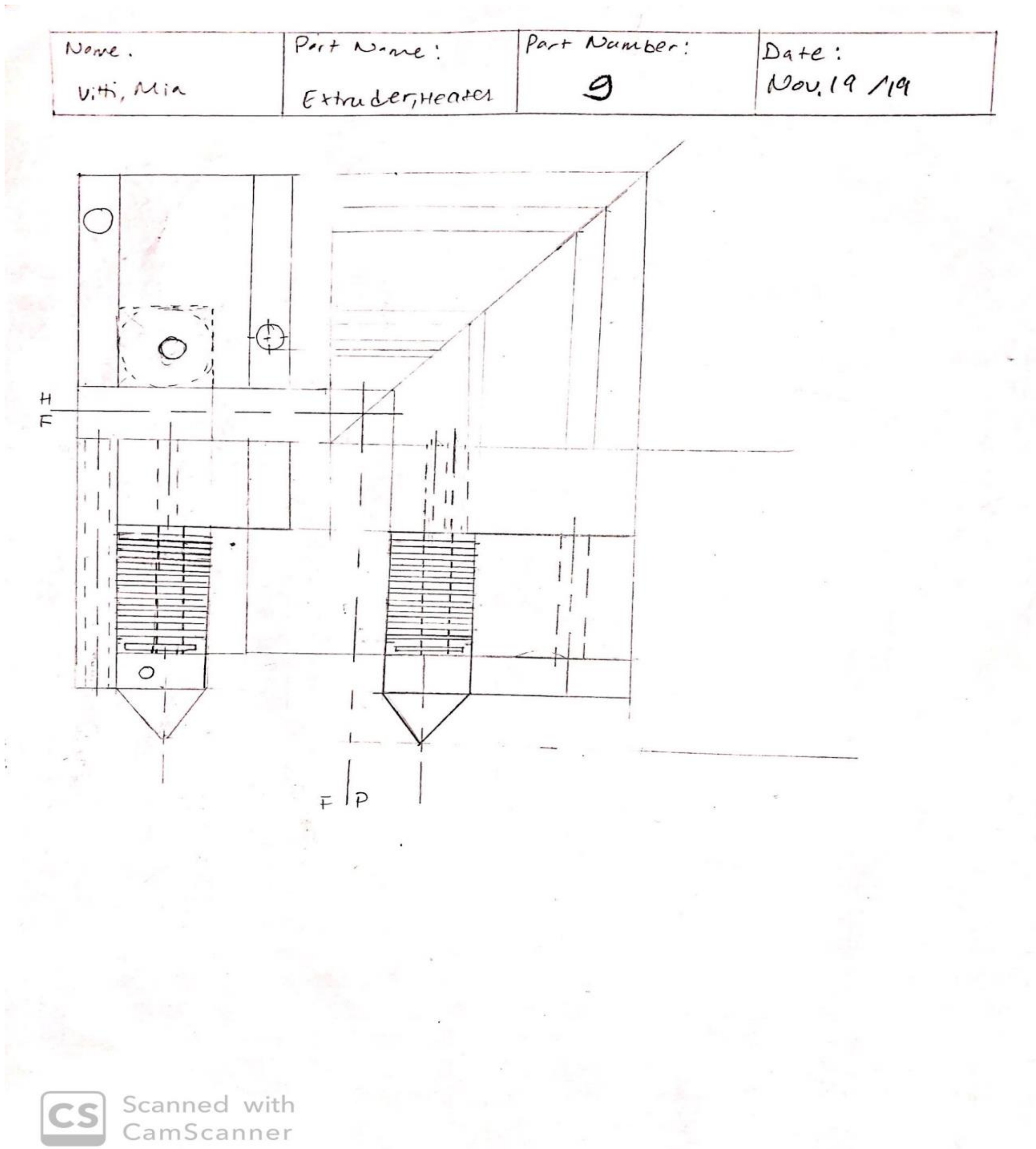


Figure 14. Orthographic projection of the Extruder and Heater

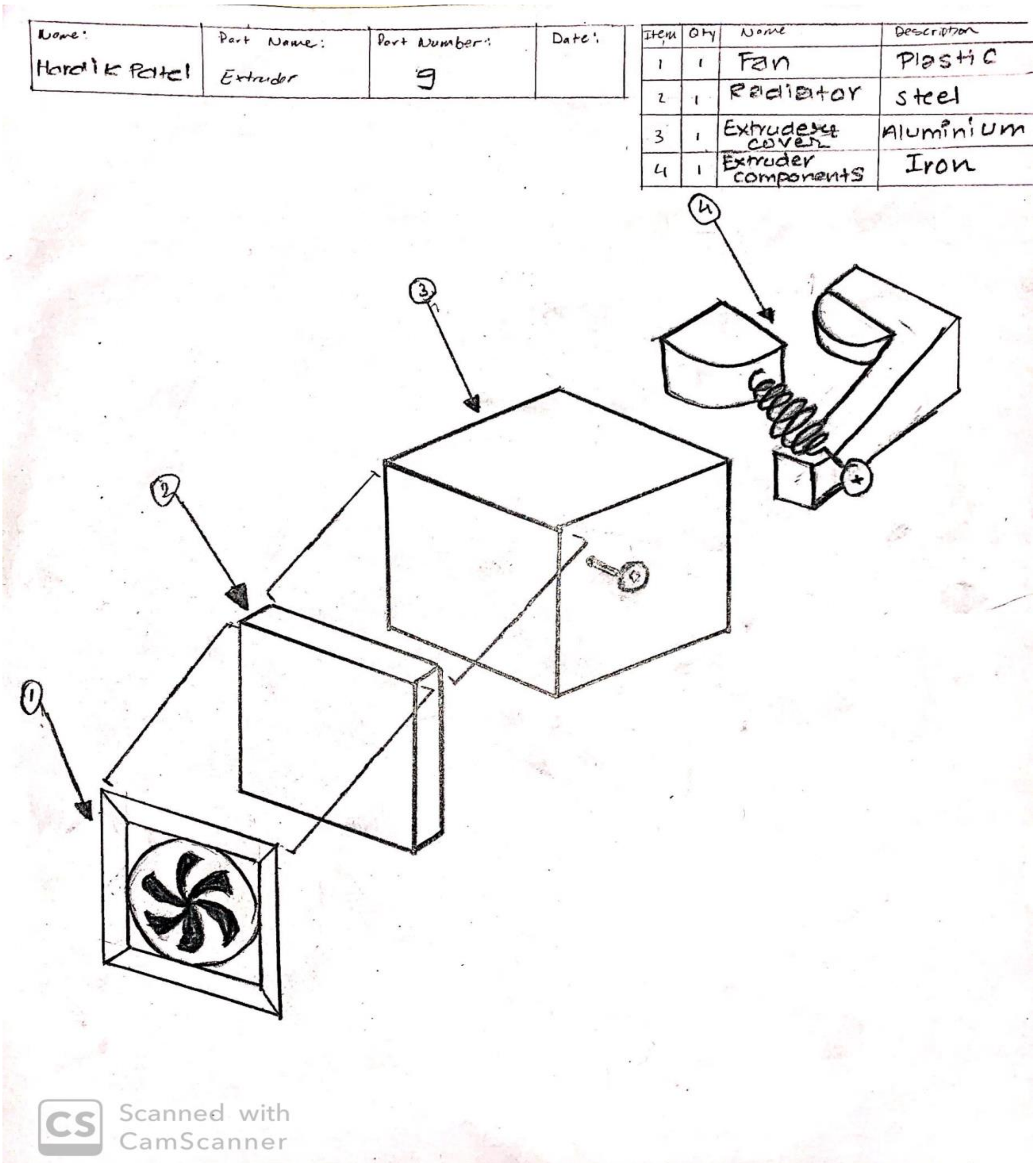


Figure 15. Exploded view of the Extruder

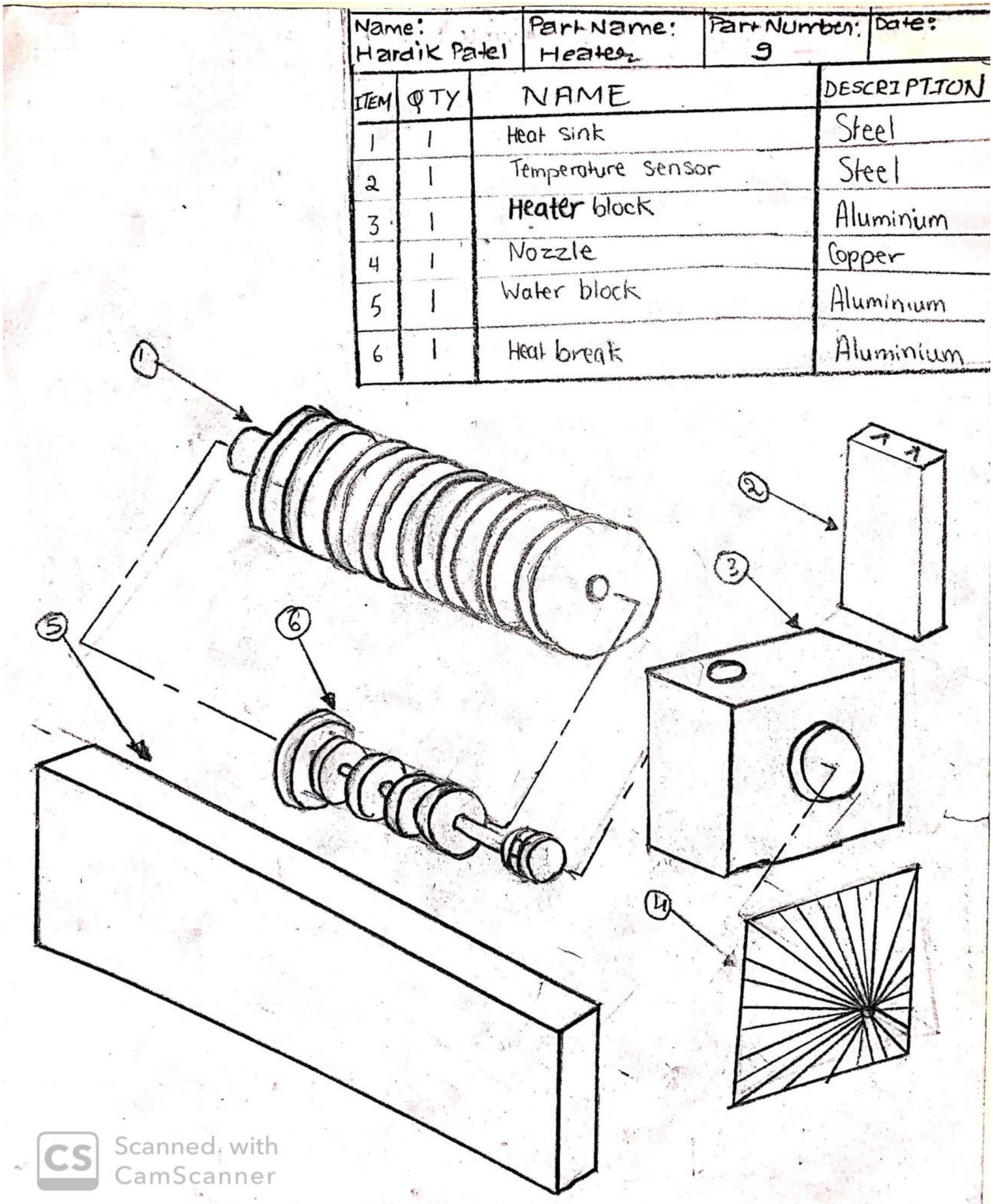


Figure 16. Exploded view of the Heater

Discussions

The above uploaded final components of our design are well-described below.

Figure 11:

This is the basic structure of our 3D printer. We have named it, “ MR. HD. " Our printer focuses on printer quality which includes filament, nozzle, and heating system keeping the price affordable. The external connections are located below, while the LCD upfront so that it's easier for the viewer to control the system. Our processing unit is compacted on the top floor which has filaments, pulleys, motors, and LCD. As shown, our reservoir is attached to the motherboard, which makes the customer easier to control the water flow system. Our printer’s special forces are the liquid cooling system, which will keep up the quality, safety, price optimizable.

Figure 12:

This figure is derived from the basic figure which gives an engineering design called the isometric view of the printer. It explains in detail what are the external features of our printer. As learned from the engineering design class, this has been taken into account for the exact same process, like 30-degree angles and symmetrical. Overall, this figure illustrates the 3D figure of the printer to let the viewer grasp an idea of how exactly could it look and laminates each system we discussed on Milestone 3.

Figure 13:

This figure examines the Heater and Extruder system of our printer. As being the most important component and complex enough to be understood individually, we decided to detail draw the extruder and heater in order for the viewer to understand not just how it works but to have a clear view on how it exactly will be like. The location of the Fan, Heat sink, Temperature sinker, Nozzle, Water block, Radiator, and similar components are well-labeled to let the user know how the printer will be manufactured. These components are also described with what materials they will be made up of. For instance, for maximizing the nozzle’s quality we used copper, a fan of plastic and steel for the radiator to ensure the best possible price and quality of it.

Figure 14:

This figure depicts an orthographic projection of the extruder and its internal heating mechanism. By creating an orthographic projection of this main component within the 3D printer, the outside structure is clearly able to be analyzed and transferred into a model. The extruder is used to direct and control the flow of melted filament into the desired 3D object.

Figure 15:

This figure flashes an exploded view of the extruder mechanism. The exploded view of this major component allows a visual view of the larger internal mechanisms within the extruder. By doing this, the builder or viewer of the model is clearly able to obtain a view of how different parts connect and interrelate with each other. Also in combination with the next figure, illustrates how the extruder works in simultaneity with the heating system to provide a smooth transformation from coiled filament into the desired object. It compromises, a fan, radiator, Extruder cover, and Extruder components

Figure 16:

This figure gives us a detailed exploded view of the heating system on our 3-D printer. The heating system is basically the backbone of our printer, it is made up of six basic components, and each of them plays a vital role in the working of our printer. Apart from the obvious parts like a nozzle and the temperature sensor, the heater break, the heater block, and the heat sink is complex system in this section. The breaks have perform two basic functions; firstly, to connect the heat sink to the heater block and also to melt the plastic coming in. Heater block is basically a metal block with a compartment for a heater cartilage and works like a heater to melt heat up the system. Heat sink does not really play any heating roles, it is more of a durability feature. When the plastic in the heat breaks melt, the heat moves up and thus melting the plastic above the break as well, and since the are far up, any change in the temperature and they solidify, thus jamming the entire system. So for this peculiar reason a long heat sink is installed, it provides a longer path to the filament to cool down and thus cancelling majority of the possibilities of a blockage. Water block is a part of the cooling system and it helps cool the heat sink and the heat breaks. All these add up to make this the most complex mechanical parts of our printer, thereby making it the biggest gem in our crown.

To conclude,

By combining multiple aspects from each team member, the proposed final model provided great solutions to the customer requirements that were focused upon. Our product is superior in terms of the number of external connections options offered. It also includes the option of compatibility with different kinds of filaments. A lot of research was required in order to determine what kinds of metal would better suit the needs of specific functions in our printer. Our product combines the two main types of printers on the market. By integrating a cartesian and delta structure within our product, we are increasing practicality of our system, encouraging buyers to feel accomodated. Finally, our product is relatively cheap considering what all the specs it includes. We created an abstract model format of what the final product looks like in order to dissect each system separately and further analyse its complex parts. This made us more apt to organize our information, structure our mutual ideas, and visualize the relationships between different components.

Conclusion

Throughout the 4 milestones, our collaborative efforts have led to great success. In the course of the design process, our team members were able to identify the needs for improvement, and research for solutions. After taking into consideration the functional and customer requirements that we have chosen to improve upon we performed a competitive evaluation to see how well each design performs. Most importantly, we came to the realization that without the use of specific tools designed for the engineering design process, ameliorating our existing product effectively would be near impossible. We also learned the importance of setting due dates and compartmentalizing such a large project into smaller sections. Implementing good concepts in the final proposed design required a thorough analysis of not only the components of the product but also the interaction of different systems found in the product. However, to improve upon our existing product, the team members should have paid more attention to the types of materials used, and how these materials interact in a system under the pressure of consecutive printing. For example, how does having plastic arms on a metal frame wear down overtime? Another important notion that could be improved is communication. Misunderstandings were a common problem we faced due to not always being able to communicate ideas in person. In the end, our design met all the requirements provided by the client company. First of all, the budget price of $300 was successfully met. This was the most heavily weighted factor, and we made sure to settle for cheaper materials like plastic and brass. The next customer requirement that our design implemented was safety. Our safety features surpass all of the printers we looked at on the market, and we are confident that our design is as safe as possible. Our printer provides methods to ensure that the high temperatures at which a printer operates would cause no harm to the user. The external and internal connections of the printer required much of the research that was conducted, but in the end, our proposed product has a revolutionized port selection.

The graduate attributes we all met successfully throughout each milestone of our project. First, we generated a problem statement and its design objectives. Soon after, we as a team applied formal multi-criteria decision-making tools (House of Quality) to select candidate engineering design solutions for further development. Near the end of the design process, we refined and advanced a single conceptual design to its final end state. This is known as CDS. Finally, communicating our ideas in an effective manner to people outside of our team aided us by recapitulating our efforts, and opening doors to feedback.

References

1. PLA vs. ABS: What's the difference? (n.d.). Retrieved November 11, 2019, from https://www.3dhubs.com/knowledge-base/pla-vs-abs-whats-difference/.

2. Parts of a 3D Printer: List of Major 3D Printing Components. (2018, August 10). Retrieved November 9, 2019, from https://3dinsider.com/3d-printer-parts/.

3. https://www2.mmu.ac.uk/media/mmuacuk/content/documents/information-systems/help-guides/3D-InfoSheet3Dprinting.pdf

4. Your chance to learn more about 3D printing, robotics. (2019, November 4). Retrieved November 10, 2019, from https://www.guelphtoday.com/local-news/your-chance-to-learn-more-about-3d-printing-robotics-1826765.

5. Baguley, R. (2019, November 4). Best 3D Printers 2019. Retrieved November 10, 2019, from https://www.tomsguide.com/us/best-3d-printers,review-2236.html.

6. 3D Printing Canada. (n.d.). Filaments, Resin, 3D Printers & Training. Retrieved November 9, 2019, from https://3dprintingcanada.com/.

7. Fabian. (2018, July 23). 5 Mistakes to Avoid When Designing a 3D Model for 3D Printing. Retrieved November 19, 2019, from https://i.materialise.com/blog/en/5-mistakes-to-avoid-when-designing-a-3d-model-for-3d-printing/