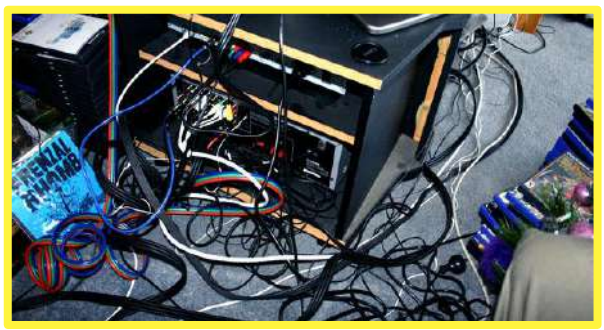
Criterion A: Analysis of a Design Opportunity

Outline and Explanation of the Problem:
Tangled cables and wires pose a bigger threat than mere inconvenience; certain electronic devices' performance can be hindered by large cable tangles, and in some cases made unsafe. The Discovery College IT department plays a pivotal role in daily school life for both students and teachers given the requirement for everyone to own a laptop—even the Year 2 students use Apple iPad's. Every electronic device runs at least 110 volts of electricity when plugged into the wall through a length of wire. If that wire is loosened, damaged, or frayed, it can expose the live electric current. On top of this causing unwanted power loss damage to the electronics, there is potential for an electrical short or even risk of a fire.

Design Opportunity:
A suitable solution to this problem would be to implement a storage system for electronic devices in the IT department. This could be in the form of a cabinet, or even something as simple as labeled drawers. Divider slabs could also be implemented to existing drawers and cabinets within the department. The method of storage would need to be adjustable to the user in order to adapt to a constant flow of new parts and electronics. If a cabinet with drawers were to be implemented, it would have to be multipurpose to allow storage of computers, storage of random bits and pieces, and possibly holes that would allow convenient charging with wrapped cables.



My Client

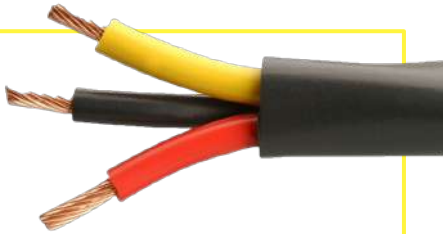
Interview with Client George Tibbits (head of the IT department at Discovery College):

Myself: What problems do the IT department generally face on a daily basis?

Client: Well, as you can see by just looking around, there is a real problem here with messes. All the loaner computers, spare parts, stored machines and especially all the wires running around.

Myself: And how do these issues negatively affect the IT department?

Client: Really all this mess does is slow down anything we do here. Fixing computers takes a longer time since we need to spend an excess amount of time looking for components, and a lot of money that could be used on upgrading and making technical progress is wasted on buying new laptop chargers that keep snapping from being twisted and tangled or on parts that get lost.



Interview Continued:

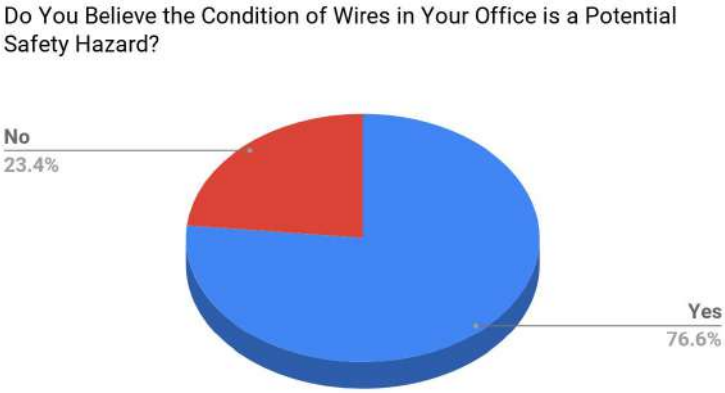
Myself: Have you made any attempt so far to solve this problem yourself?

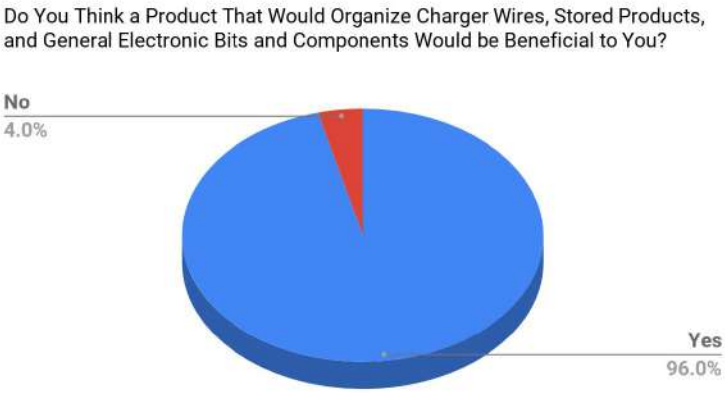
Client: Yes we have multiple times, but any attempt we've made here seems to escalate the problem further. Instead of bits and components lying around individually, we just have a big pile in one of the desk drawers that's an absolute nightmare to go through. At this point we've kind of just accepted and gotten used to the mess.

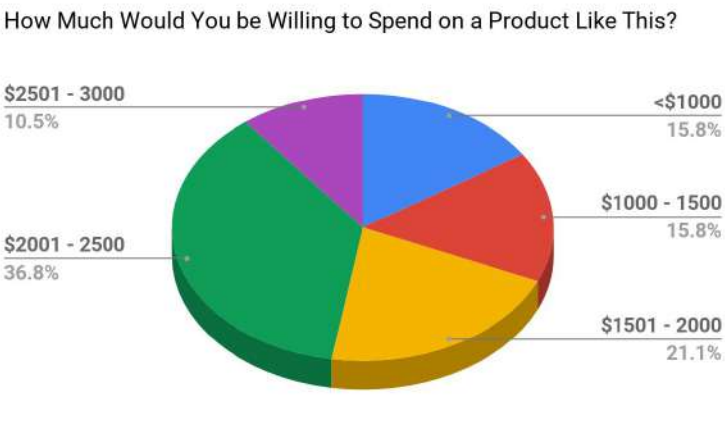
Myself: Would you benefit from a sort of cable management and equipment sorting product?

Client: Well yes, very much so actually. It would be especially useful if it could fit on one of the desks here so we can have clear, uncluttered desktops to work on.

Results from Questionnaire:







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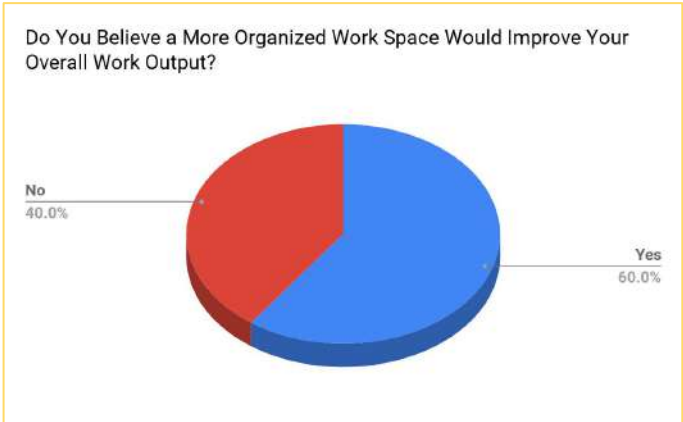


Questionnaire Evaluation:

The members of the Discovery College ICT staff who filled out my questionnaire really highlighted the necessity of a solution to this problem. 76.6% of the staff stated potential concerns for their own safety in their working environment, which was surprisingly high. Moreover, 60% of the staff believe a cleaner working environment would benefit their work output. The design opportunity was validated with 96% of the staff saying the product I proposed would be beneficial to them, which was much greater than anticipated. Finally, the people who filled out my questionnaire stated an ideal price would be between $1,000 - $3,000 HKD.

"Clutter Negatively Affects Your Productivity and Your Wellbeing"

(https://www.officeworks.com.au/workwise/workspace-and-wellbeing/clutter-negatively-affects-your-productivity)

This article talks about the increase in mental energy when working in a cluttered workspace which can lead to emotional and mental distress when working. This causes issues with focusing, stress, and productivity in employees working in such conditions.

Evidence of the Problem:

I visited the client's working space and I was able to gain a better idea of the actual severity of the problem, and begun to think of the solution required. The current product and loaner computer storage system relies on cubby holes and spare drawers around the office. Incorporating something similar into my design would work effectively as most of the products seen stored in the drawers are in cuboid boxes. The current electronic bits and components storage is actually on someone's deskspace. It takes up the majority of the desk and operates via a sort of 'cubby-hole' system, which is currently ineffective as parts can constantly not be found. However, developing upon this system could solve the problem with the addition of labeled or color-coded lids to the cubbys. As for the workspaces, electronic bits and components are just sprawled out everywhere and really give an understanding to the reasoning behind the results I received from my questionnaire.

Current Electronic Bits and Components Storage

- Current sorting system for bits and components
- Mess of junk interfering with employee workspace, causes distraction

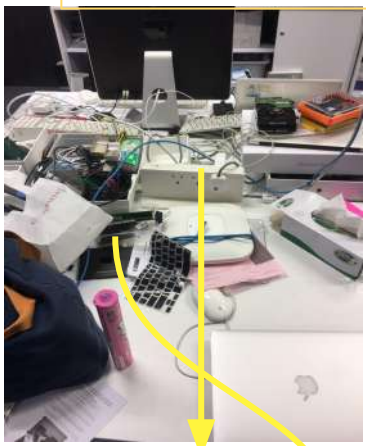
Current Laptop Charger System

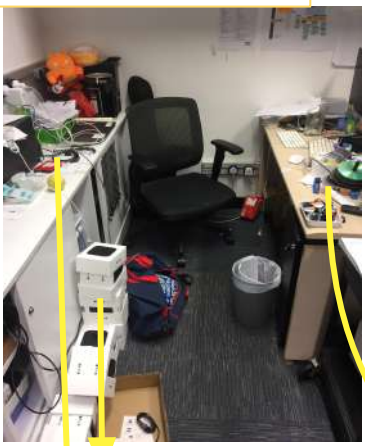
- Boxes containing spare products are stored wherever there is space
- Charging system for loaner computers requires chargers to go to the top of the cubby from behind

Current Product and Loaner Computer Storage System

- Cubby hole storage for loaner computers, highly unorganized and creates delay in productivity
- Employee's deskspace
- Boxes containing spare products
- Laptop charging station, not terrible at the moment but charging more than 2 laptops at once will pose an issue

Examples of Current Employee Workspaces





- Tangled computer wires, potential fire hazard if left the same
- Boxes containing spare products
- Spare electronic bits and components taking up deskspace, promoting unorganization and distraction

Existing Products:

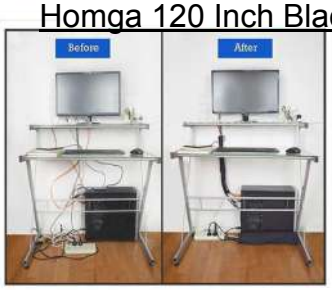
To the left are examples of typical wire and computer sorting products that are already on the market. The product on the top is a cart that can carry several laptops and be able to charge them within the cart without a tangle of wires. However, this product is much too big for the office and this will also most likely be the case for most IT offices around the rest of China. As for the two wire-focused products, they seem to effectively sort out the issue of tangled wires and I could definitely incorporate these as an aspect of my own design, which could also incorporate some of the ideas from the laptop cart. I found none of these products or anything similar in my client's working space.

Analysis of Competitor's Products:

Learniture 12-Outlet Laptop/Tablet Charging Cart:
https://www.amazon.com/dp/B01AJ1VV8Y?aaxitk=fJk-UYm5.mRqdr7prNTk0w&pd_rd_i=B01AJ1VV8Y&pf_rd_m=ATVPDKIKX0DER&pf_rd_p=3534726502&pf_rd_s=desktop-sx-top-slot&pf_rd_t=301&pf_rd_i=laptop+storage+trolley&hsa_cr_id=7116887580601

The product contains many features I plan to have in my own. A built in electrical assembly allows charging of up to 12 devices at a time, ventilated steel framing to keep the interior protected prevent overheating, locking doors, and adjustable shelves. However, the product is around 1 metre tall, which is much too big to integrate with the current storage system of laptops in the IT room. Along with this, the fully assembled product costs $5,000 HKD which is completely out of the ideal price range specified by my customers in my questionnaire.

Homga 120 Inch Black and White Flexible Neoprene Cable Organizer:



https://www.amazon.com/Management-Organizer-Adjustable-Flexible-Neoprene/dp/B01E3QPTRK/ref=sr_1_9?s=electronics&ie=UTF8&qid=1525051333&sr=1-9&keywords=cable+organizer

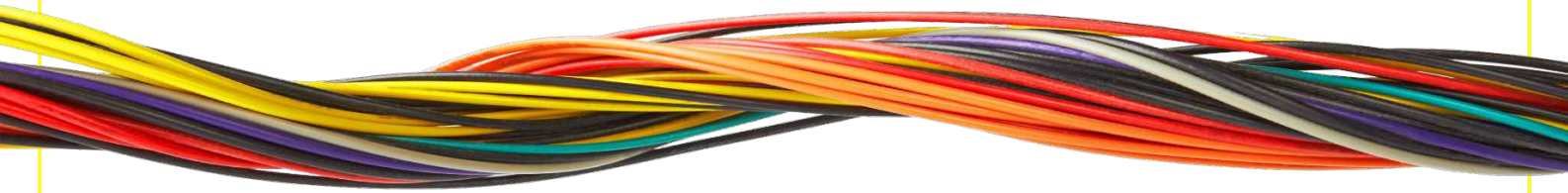
This product is the most cost efficient cable organizer I could find, and provides a simple solution that makes a big difference. At a mere $78, the product is made from highly flexible and durable neoprene which allows it to protect cables from foot traffic and other disturbances without tear. The product provides a total of 3 metres of cable organizers which can be cut at any length to match the lengths of the wires it will contain, and can have holes cut in the sides to let cables out at any position. While this may solve one aspect of my problem, this product is designed for home use and simply isn't enough to satisfy the DC IT department since too many wires is only a portion of the problem.

DMoose Wooden Cable Management Box Organizer:
https://www.amazon.com/DMoose-Cable-Management-Organizer-Entertainment/dp/B01KJ371RW/ref=sr_1_1?s=electronics&ie=UTF8&qid=1525053215&sr=1-1&keywords=outlet+organizer

The product is simple to use but isn't worth its price even at $315. It only serves one function and will not be enough for my client since all the product essentially does is cover one outlet extender for the sake of removing visual clutter. However, it's easily constructible with the resources I have at hand and is very simple to set up and operate.

Research Plan:

The next steps of designing a solution that incorporates aspects from all the designs I've analysed will require several surveys. The best possible solution will require both primary and secondary research which will help finalize the finer details of the product. The primary data will be collected from my client and the other members of the IT department I originally sent my questionnaire to. Talking to my Design and Technology teacher will also give me insight on the feasibility of some of these solutions and whether or not the resources are available to me to bring them to life. This research approach will grant me both quantitative and qualitative data.



Primary Qualitative:

Survey of Which Product was Preferred:

Before revealing each of their prices, I asked my client which one of the existing products I analyzed he preferred along with his favorite and least favorite aspects of them. My client instantly recognized the first product (the Learniture 12-Outlet Laptop/Tablet Charging Cart) and said the IT department had already considered using this product but chose not to because of its impractical storage capacity to size ratio. The laptops are stored horizontally on the shelves which only allow for two laptops a shelf and increases the number of shelves and therefore the space the product takes up in an office where space is limited. My client's favourite product was the Homga 120 Inch Black and White Flexible Neoprene Cable Organizer because of its large practical potential, its simplicity and its convenience of use. The DIY approach of the product is ideal to him because of the lack of restraints it grants. You have the roll of neoprene material ready to use, and can simply cut it to fit the exact cable situation you need it for. The DMoose Wooden Cable Management Box Organizer was less favorable due to its single use (meaning multiple would have to be purchased to make a noticeable impact) and focus on aesthetic tidiness in the office rather than practical tidiness.

The main points I gathered from this are that the product I create needs to be customizable and have practical storage.

Survey of Similar Individuals:

I also interviewed some of the members of the IT staff who originally filled out my questionnaire, and their responses were mostly the same regarding the first two products. However, most of them saw the purpose of the third product to be more valuable than my client did. This shows that not only the aesthetics of the product itself should be considered in my design, but also how it aesthetically impacts the rest of the office.

Primary Quantitative:

IT Office Aesthetic Qualities and Style:

My client's office consists of white walls, desks, cupboards, and shelves. That means my product should be more colorful in order to 'spice up' (as my client put it) the rest of the office, with simple colors to match the white, providing a clean and sleek look and feel. A lighter neutral colour such as brown or beige would also work well. The carpet is a dark grey color and will work with everything previously mentioned aesthetically.

Cubby, Drawer, and Desk Measurements, Colours, and Shapes:

Each desk space in my client's office has a surface area of 1.4m x 1.2m and consists of a white table-top with silver and black legs, along with a hole in the middle that wires currently go through. There are a total of 14 white cubby holes, each one with dimensions of 0.31 m x 0.23 m and a depth of 0.33m. Lastly, a long desk on the side of the room which is available space for me to potentially use has dimensions of 2.0m x 0.67m, with interior drawers that are 0.54m x 0.94m. Everything listed here has a cuboid shape, so that is the shape my product will need to be in order to maximize storage potential.

Secondary Qualitative:

Available Materials:

I spoke with one of our school's design technicians who informed me on two available materials that I can use when building my product. These are MDF. and pine. MDF. would definitely be the cheaper option to use, but its lack of a wood grain takes a toll on its aesthetic viability. However, with a simple primary colored design this wouldn't be a problem. As seen in the third competitor's product I analysed, I could also use a mix of wood and acrylic as there are many uses and options available to me with the resource.

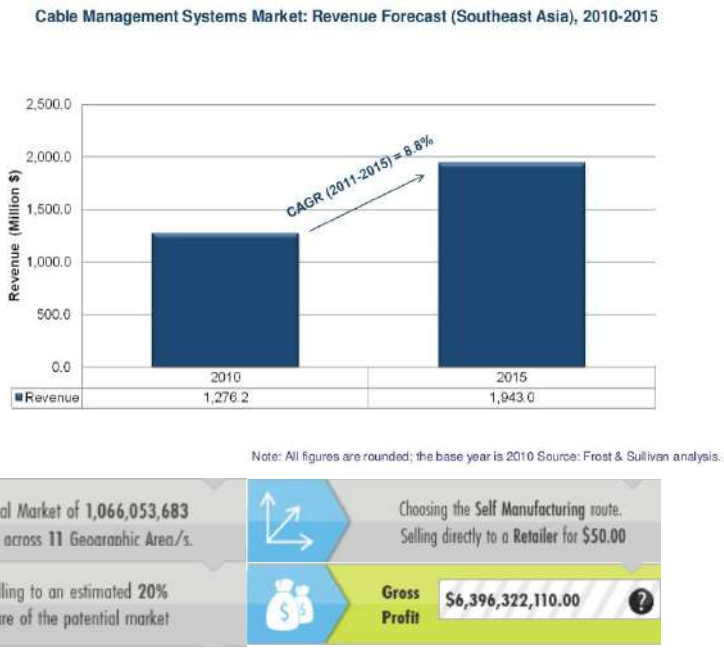
Available Equipment and Processes:

The equipment available for me in my school's design tech room that would be relevant to my product includes basic woodworking tools, a spray painting booth, the pillar drills, a strip heater (if any molding of acrylic is required), and a laser cutter (if a custom motif is desired). I already have prior knowledge of many basic woodworking processes such as housing joints, and any new concepts to me can either be taught by or handled by one of the design technicians.

Secondary Quantitative:

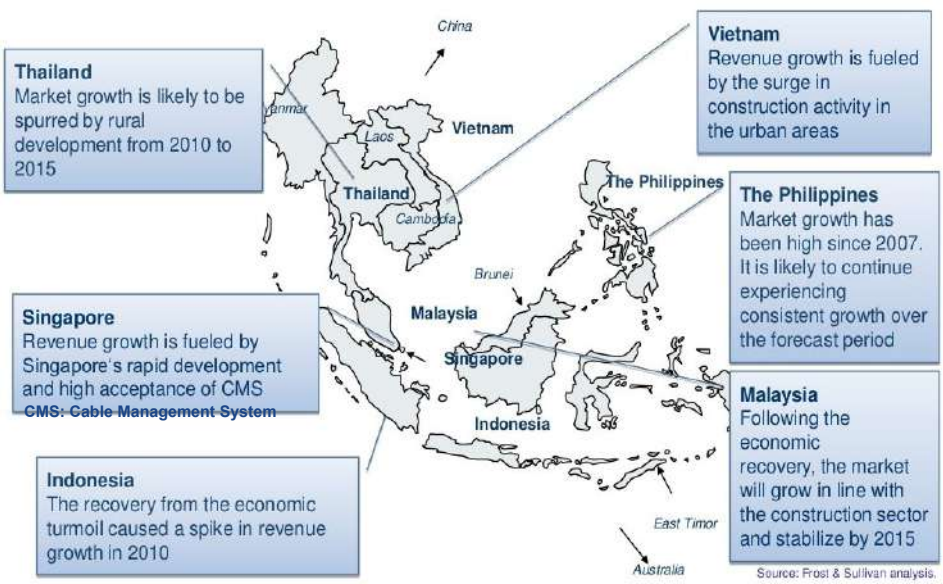
Required Measurements for Viable Storage:

All of the loaner computers I would be dealing with via my product are 13.3 inch (0.33m) Apple MacBook Pros which are 17mm thick. Therefore, the shelving rack in my product will have to meet these measurements and safely store the laptops up on their sides. MacBook Pros are also known to produce high amounts of heat while charging. If my product is to store and charge these laptops simultaneously, it will need to have proper ventilation to prevent overheating as this poses as a fire hazard.



Market Research:

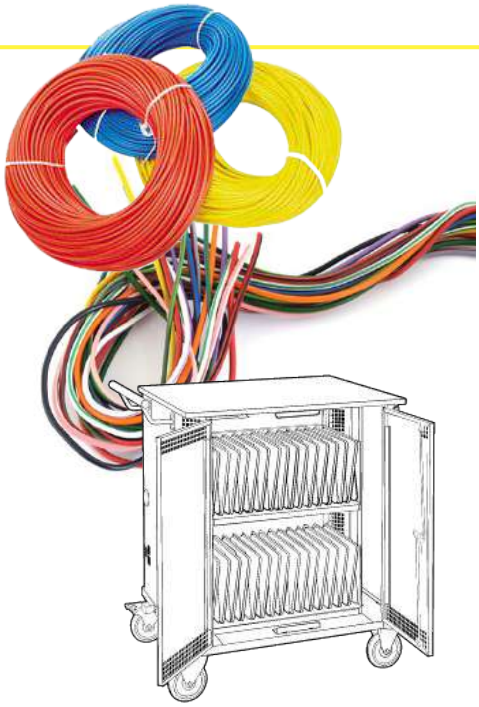
I found that my product could potentially have a large target market beyond just my client's problem. A quick use of the Invention Calculator gave me an idea of the maximum potential profitability of my product in 11 geographic areas and overall it looked to be in my favour. According to the graph above, the compound annual growth rate of the cable management system market in Southeast Asia alone increased by 8.8% in just 5 years. On top of this, the company Reportbuyer estimates the cable management market growth to have a CAGR of 12.3% between 2016 and 2022. To my surprise, the highest market share was in Singapore which was 21.1% of the cable management market. This is actually due to the rapid growth in construction and development sector of Singapore in recent years.



An estimated $97.7 trillion is spent in the global construction industry within the next decade. However, all of this data is just for cable management systems alone. My product will incorporate a cable management system along with being able to store electronic devices and spare electronic bits and components. While there are several existing products that meet this category, few cost below $4,000 HKD. This means that there is a large gap in the market for my product.

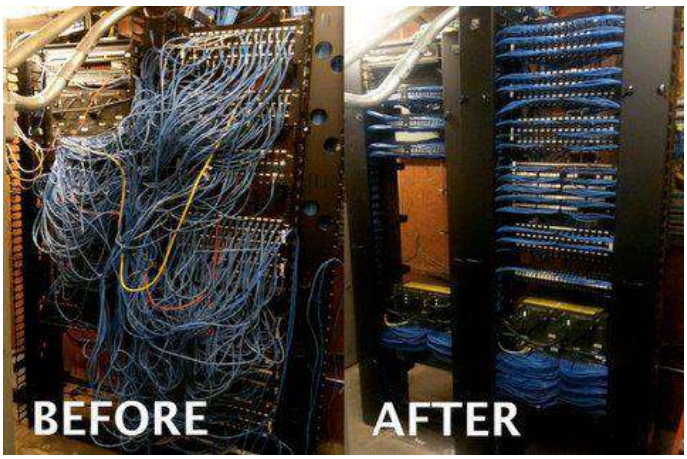
Design Brief:

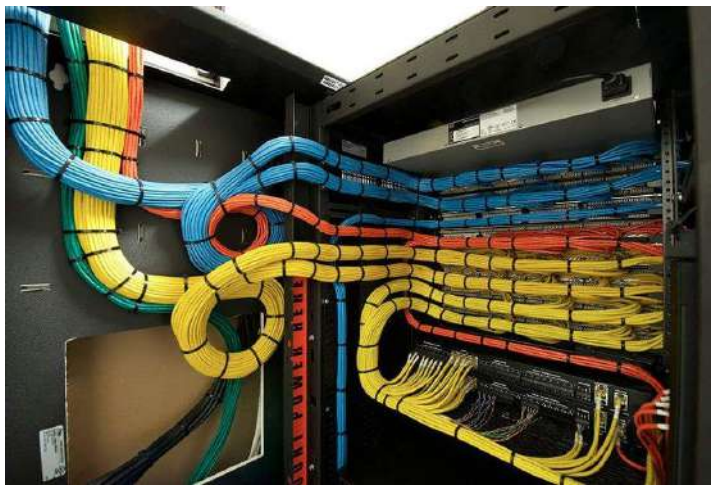
I will design and build a one-off working prototype of a multipurpose storage unit for my client. The purpose of this is to ensure loaner computers and other electronic products can be conveniently stored and simultaneously charged via installed wire compartments within the unit. The prototype will fit in and be integrated with the current storage arrangement in the office. This will help reduce clutter in the office since that is a major concern of my client, along with streamlining the storing and charging of loaner computers to ensure they are available to students in need as often as possible. The cabinet will also feature miniature drawers that serve the purpose of storing, sorting, and making electronic bits and components lying around as easy to work with as possible. I also aim to keep the selling price of the product at or below $3,000 HKD as indicated by my client. It needs to be secure and sturdy to prevent the damage of interior content, and feature extensive ventilation to prevent overheating and reduce fire hazards.



Feasibility of Product:

My product does not require complex processes or equipment to build and therefore I believe it is feasible. The exterior of the product will be wooden, to match the aesthetic of the rest of my client's office space and to decrease the complexity of manufacture as much as possible. The interior laptop holders will be made of acrylic to ensure sturdy and tight storage that maximizes the space potential of the interior. The wiring of laptop chargers will be inserted through the back of the product to eliminate all visual clutter. The product will rely on hinges for the bigger doors and possibly metal slides for the storage drawers, both of which are available for me to use. Ideally the product will have locking doors, however this aspect may not be feasible. All the materials I plan to use such as MDF and acrylic are widely available to me in Discovery College's design tech room. The components include hinges, metal slides, and a metal lock. The functionality of my product can easily be tested by repeatedly opening and closing the drawers and doors, then applying different levels of pressure to them opened. This will test the sturdiness of the doors and drawers along with the weight capacity of the drawers. Weaving a laptop charger into my product from behind and putting my own laptop on a rack to see if everything aligns correctly will be my method of testing the interior function. To test my product in my client's situation I can simply carry it down 5 floors to the IT department.





User Research:

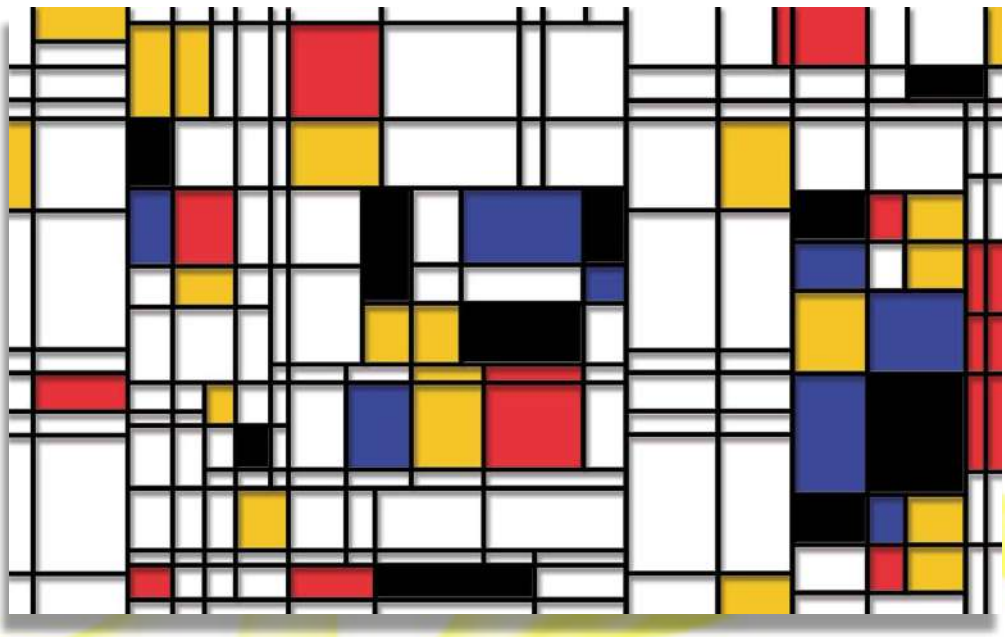
When surveying other potential users and my client, it was apparent that the size of the product is a major concern. In its current form, the IT room is a relatively small office space, and the amount of space already lost to storage and wire treatment is extensive. This leaves room for concern from my client and the other potential users as to whether or not their office could actually fit a product I design. As a result, I will keep the current storage situation of the IT office in mind when designing my product. It will need to take up the same amount of space or even less space than the current storage system. My client liked several features on existing products such as the customizability and flexibility of the wire organizers. This means that my client wouldn't have to rearrange all of the wires to fit the mold of a set wire organizer, and could instead simply set the wire organizer to fit the wire situation. Another popular feature was the simultaneous storage and charging aspect of the laptop cart. Hence I will integrate both of these functions mentioned by my client into my product.

Marketing Specification	Description
Target Market 	My product must primarily consider the needs of my client over the needs of the target market. Nevertheless, an IT office falls under the commercial market segmentation which took up 31.3% of the market demand of cable management system products in my target geographical areas (China and South-East Asia) as of 2015 according to Frost & Sullivan. The other segments being compared to were the industrial, residential and governmental segments. However, one thing every segment has in common is a need for the product to be discreet but still liven up the room, as one of the goals of the product is to reduce visual clutter. Reliability of the product is another necessity due to the psychological feeling of security it brings. If the product successfully removes visual clutter, the threat of a fire combusting from the wires is supposed to be reduced. If my product is not reliable than proper preparations for a fire might be lowered as a false sense of security is established by the user.
Target Audience 	Currently the target audience is limited to my client, who is a school IT worker. However, on top of all IT workers both associated and unassociated with a school around the world, a storage cabinet for electrical devices that also serves as a wire sorter can have a significant use in many offices and even homes. For example, storing laptops and charging cables overnight in this cabinet would promote organization in a home environment, which would speed up any morning routines that require packing these items. The prototype will be of use to my client as it will organize his working space and he will no longer need to worry about spending more time than necessary looking for something through piles of unorganised items. My client is the head of the IT department at my school, and therefore is very busy and simply doesn't have the time to spare sorting through everything in his office.
Market Analysis 	The other members of the IT department at my school that I interviewed said that they thought my product would be extremely useful to have in their office. Most similar multi-functional electronic organizer cabinets retail for around $5,000 HKD, which is far beyond the ideal price given to me in my questionnaire. This means my product will need to be manufactured at a significantly lower price, as my questionnaire revealed the ideal price to be around $2,500. The primary use of MDF and acrylic in my product will keep the quality high and the cost low, and will allow me to effectively use a market penetration pricing strategy. The invention calculator I used previously backs this up. If the product is efficient and easy to use, then ideally my client will recommend it to other IT offices he knows.
User Need 	The product must be easy to integrate into the office and set up. It should be reliable, consistently sturdy, fully functional and customizable to meet the user's requirements. The product also aims to eliminate as much visual clutter as possible, which means the user will need the product to be a simple, appropriate and fitting colour to the rest of the work environment While still diversifying itself from all the other white furniture. Apple's MacBook Pro typically generates a lot of heat while charging, so in order to reduce a fire hazard and create a safer working environment the product should have effective ventilation to prevent overheating. The point of entry from behind where the charger wire will go inside to charge the laptops should be as simple as possible to navigate, as well as being positioned to not cause the bending and tearing of charging cables. The product needs to have both small and large storage drawers for different electronic bits and components to give the most user friendly approach.
Competition 	The competition in this market is large. There are many established products developed by brands that have had a market presence for several years. These brands have already developed brand loyalty and trust from consumers, so it will be a challenge to win over consumers when or if my prototype makes it to market. In order to overcome this, my prototype will have unique selling points that raise it above competition. These include the use of a market penetration pricing strategy that encourages more people to buy my product and increases the size of the target market, a wider range of built in applications that combines several different features found on competitor products that have never before been put together, and discreet yet aesthetic appeal. Ensuring my product has a wider range and appeal of features while managing to undercut competitor prices will make my product more aesthetically and financially appealing.

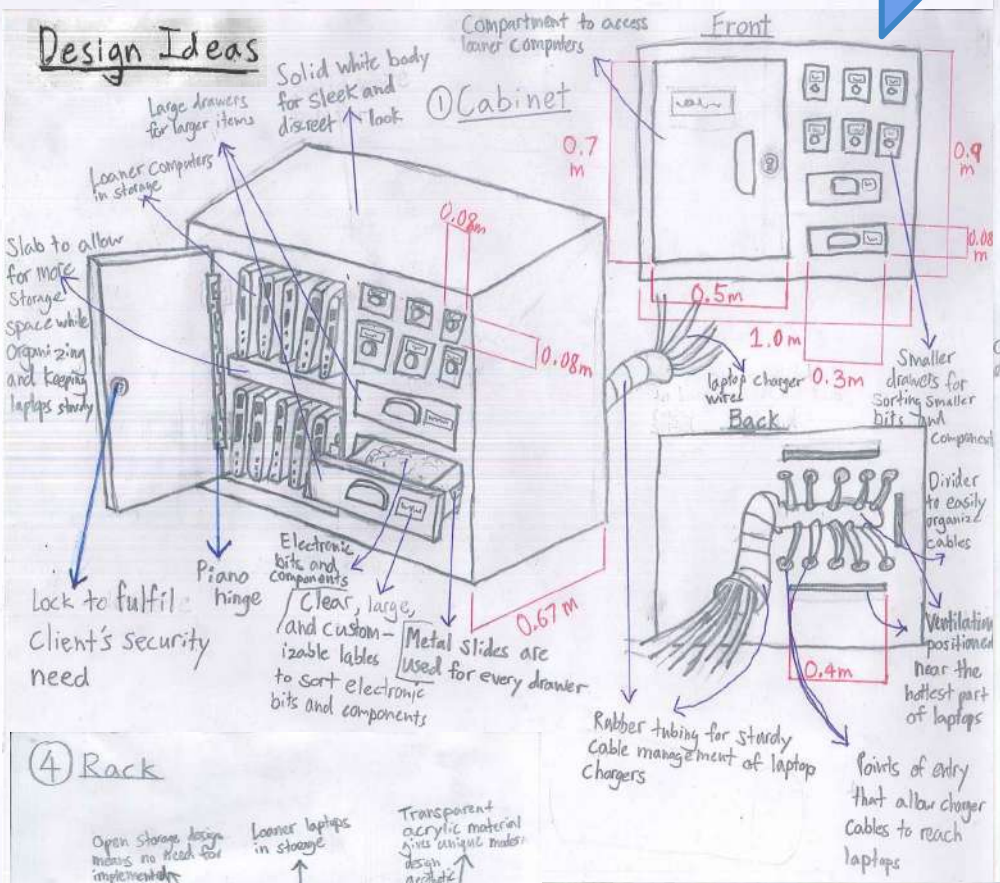
Design Specification	Justification
1. Function/ Performance Requirements and Constraints 	My product functions as a storage unit for loaner computers and spare electronic bits and components. It will be able to charge the laptops while they are stored inside, and its different sized drawers will allow for easy sorting and obtainment the spare electronic bits lying around my client's office. The product will operate via hinges for the laptop storage compartment, and possibly metal slides for the sorting drawers. It will have different holes of entry from behind to prevent the charging wires from getting tangled. The product must increase the overall organizational performance of the office.
2. Aesthetic Requirements 	The aesthetics of the product will be suited as to look pleasing in my client's office. A clean and discrete yet colorful look will help it liven up but still match the rest of the room. The wire entrance from behind will completely out of sight. The drawers and doors will open and close with a tight fit, and all uses of wood will be initially sanded with 60p sandpaper to remove any blemishes in the wood, followed by 120p to smooth out the prototype so it can feel like a high quality product. The outside of the product will follow a Mondrian(pg 10) art style, done with water-based paint to maintain the wood grain through the color. Gloss will be applied to back up this clean look, with no ridges or sharp corners anywhere on the outer body. The main testing procedure for aesthetics will essentially be the client's approval and whether or not it successfully blends in to his office.
3. Cost Constraints 	The total cost of the prototype will be no greater than $3,000 HKD, as that is the absolute maximum amount my client is willing to spend, however the ideal price would be $2,500 since that is the most widely accepted amount as seen in my questionnaire. In order to assure high quality while also keeping manufacturing costs low, I will use machinery, materials and components that are widely available to me when constructing my prototype.
4. Customer Requirements 	The product will have large and small storage drawers for spare electronic bits and components, along with easily and efficiently storing loaner computers while being able to charge them. The process of using the product will be as efficient and streamlined as possible. The charger wires will be managed via a cable management system that removes them from visual clutter. My client doesn't want anymore space to be taken up than what is currently being taken up by the loaner computers, so the prototype will aesthetically fit in with the office and into this space requirement. To test this, I will place the prototype in my client's office and see whether or not this is the case. I may then time how long it takes myself and my client separately to make effective use the product.
5. Environmental Requirements 	The product will be painted with water-soluble paint over environmentally friendly and sustainable timber. To minimise any negative environmental impact I will ensure the product is entirely recyclable or reusable by the design technology department and reduce as much waste and scrap materials as possible during manufacture.
6. Size Constraints 	My product will be placed on the side desk of my client's office, which has dimensions of 2.0 m x 0.67 m and is much more space than I'll need. In order to remain discrete, my product will be longer than it is wider and will be no larger than 1.0 m x 0.67 m. However, the minimum height of the product will be 0.33m since that is the height of the loaner computers when stored on their side. The charging cables will be implemented through holes in the back of the product to allow it to be pushed against the wall as much as possible. The testing procedure I will use throughout the designing process will be to measure the product to make sure it consistently meets these requirements.

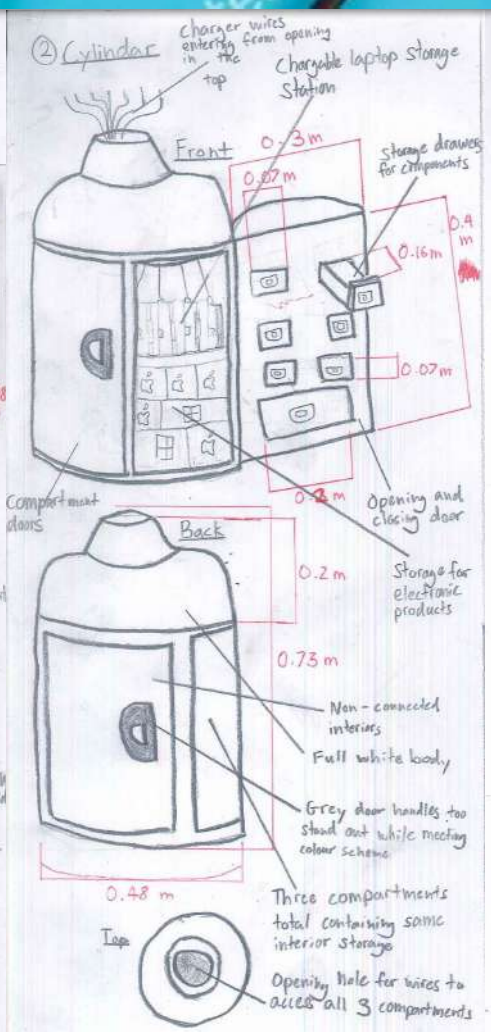
Design Specification Continued	Justification
7. Safety Considerations	The prototype will be vigorous and robust in order to handle the weight of the products placed inside without cracking, being damaged, or damaging said products. The prototype will be thoroughly sanded to remove all sharp edges and instead feature smooth, rounded corners. The interior will have proper ventilation holes to remove and threat of a fire hazard that could potentially be caused by the laptops overheating whilst charging inside the prototype.
8. Materials Requirements	The manufacturing of my prototype will require several materials that are readily available to me. For the wooden exterior, doors, and drawers, I will need MDF or plywood painted to fit the Mondrian multicolored style. I will need an acrylic rack on the inside to hold the laptops that can be taken out and customized at the will of my client. The hinges, slides, and lock will be metal to ensure reliable usage. All the materials listed here are feasible because they are readily available to me via the Design Technology department.
9. Manufacturing Requirements	The manufacturing equipment and techniques needed to assemble my prototype that assure a high standard of quality are all available. I will use standard woodworking tools to make the wooden carcass of my product, the pillar drill to create the points of entry for the charging cables and drawers, a scroll saw to cut the acrylic I need, a strip heater to bend said acrylic to my needs, and various paint supplies from the art department. I will use Fusion 360 to use CAD to design my product beforehand, which will ensure no mistakes lead to wasted materials when manufacturing my prototype.

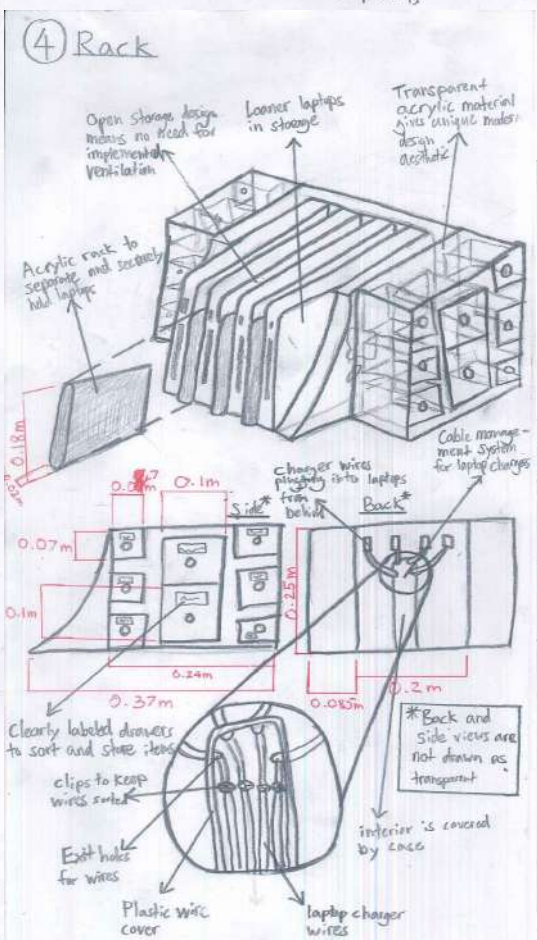
The Mondrian art style: a niche consisting of bold, primary colors contrasting each other in an abstract way

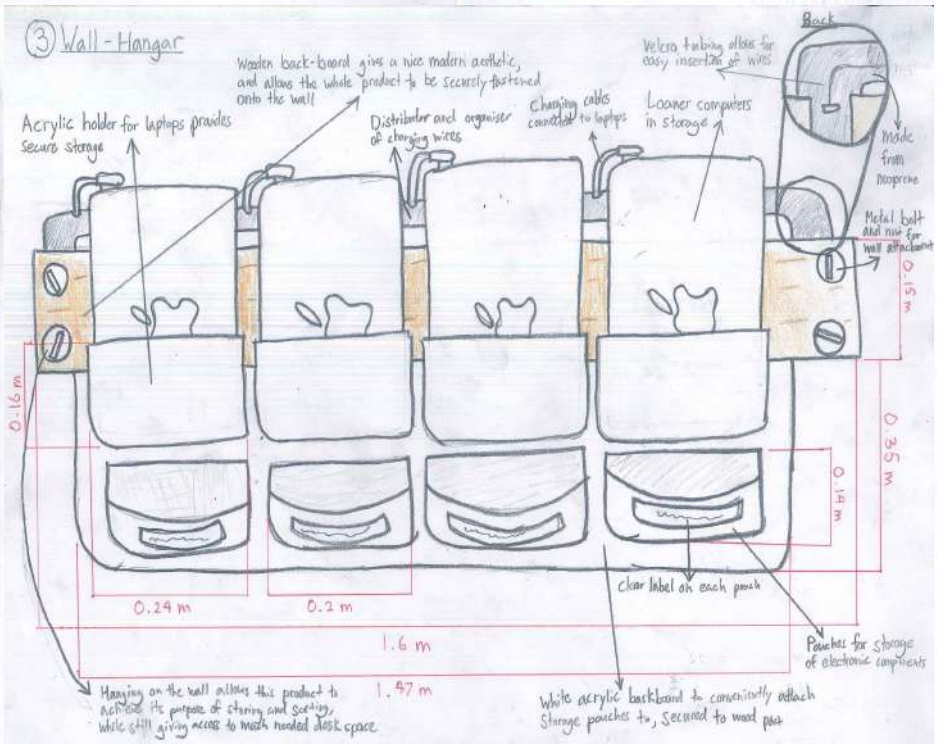


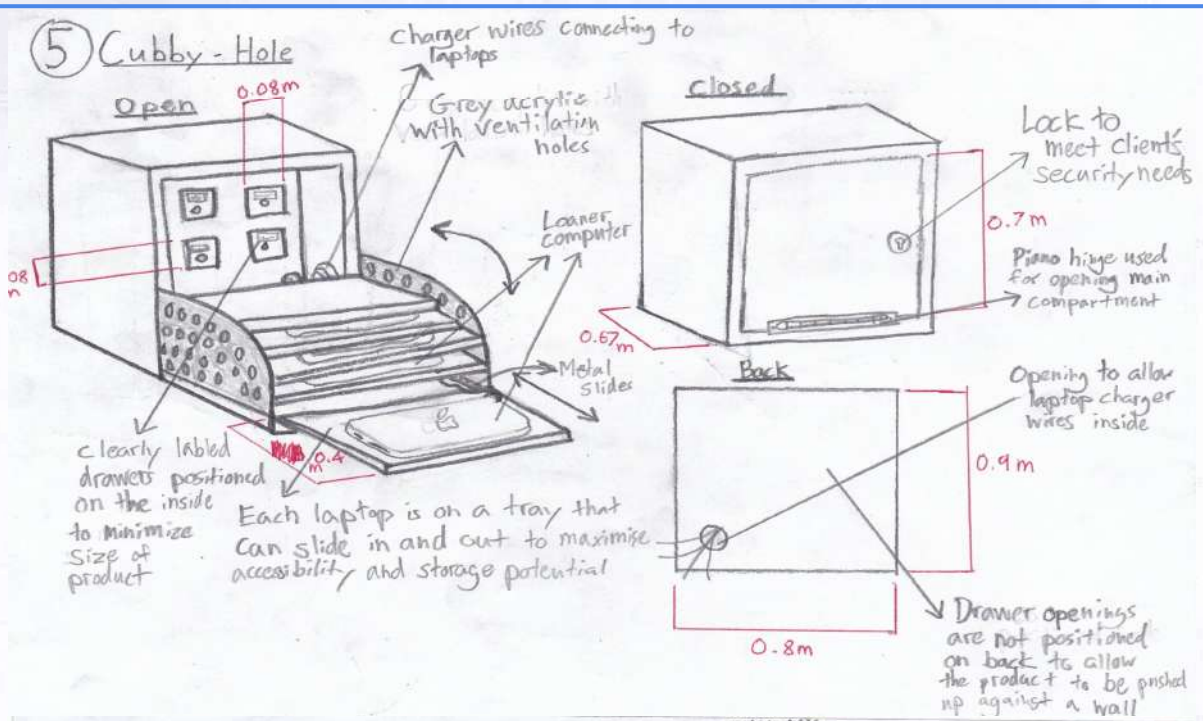
Criterion B: Conceptual Design

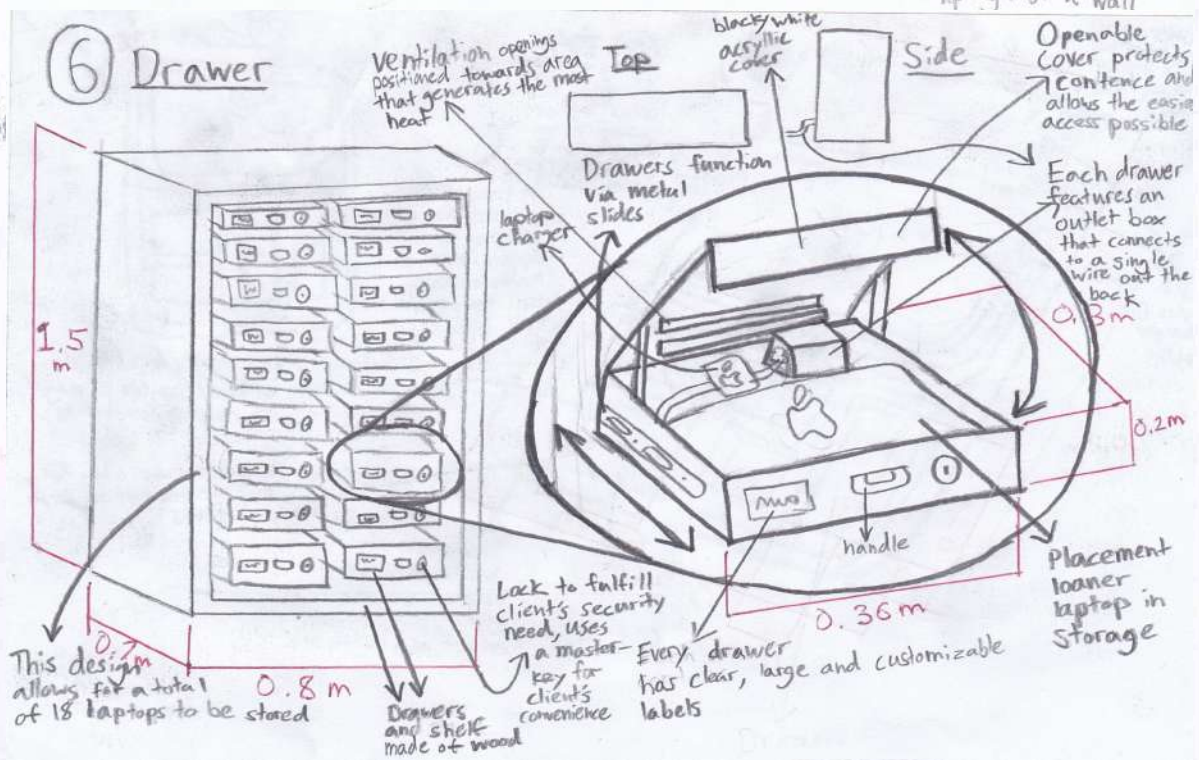


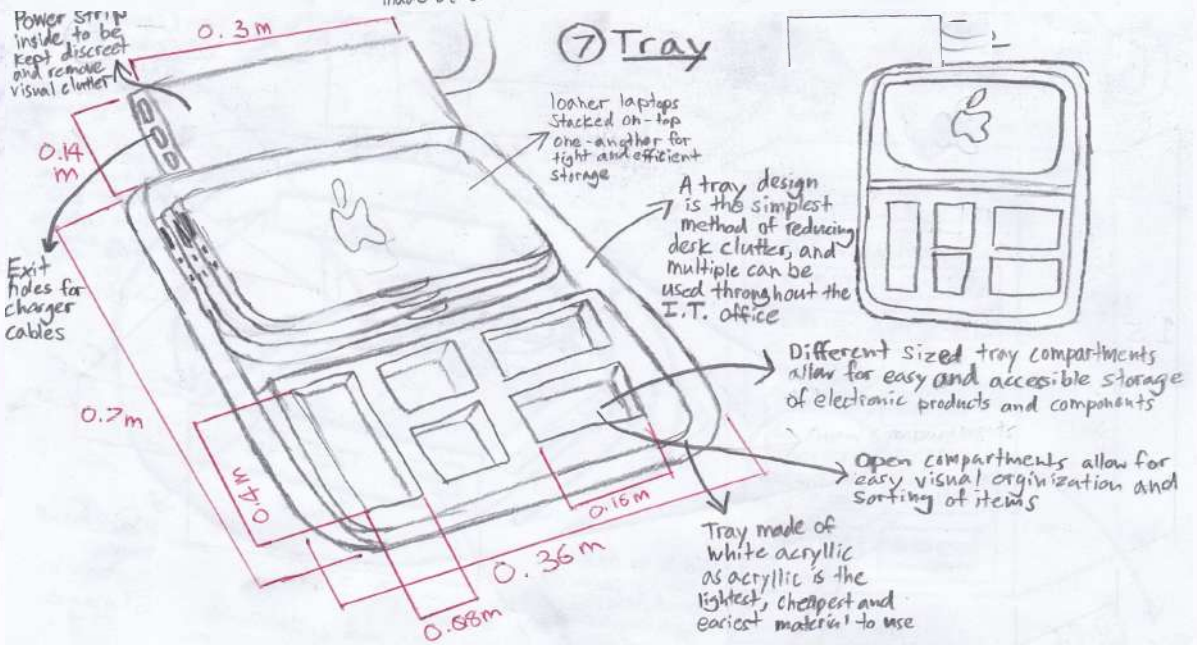







5 Cubby - Hole
Open
0.08m
Charger wires connecting to laptops
Grey acrylic with ventilation holes
Loaner computer
Metal slides
0.08m
0.4m
Closed
Lock to meet clients security needs
0.7m
Piano hinge used for opening main compartment
0.67m
Back
Opening to allow laptop charger wires inside
0.9m
0.8m
Drawer openings are not positioned on back to allow the product to be pushed up against a wall
clearly labled drawers positioned on the inside to minimize size of product
Each laptop is on a tray that can slide in and out to maximize accessibility and storage potential

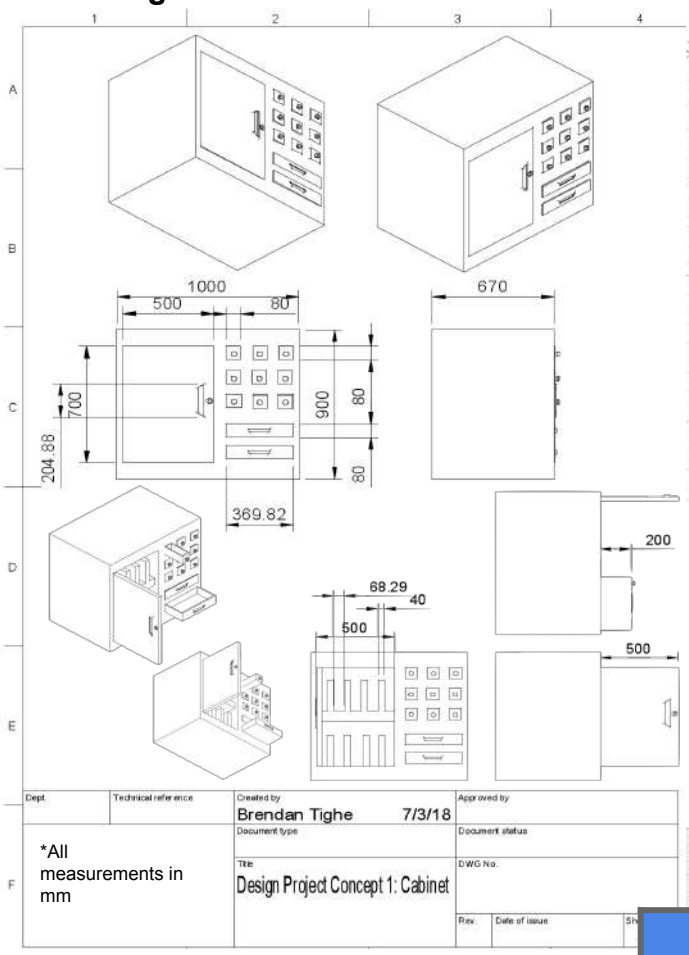

6 Drawer
Ventilation openings positioned towards area that generates the most heat
Top
black/white acrylic cover
Side
Openable cover protects contence and allows the easie access possible
Drawers function via metal slides
laptop charger
Each drawer features an outlet box that connects to a single wire out the back
0.3m
1.5m
0.2m
handle
Placement loaner laptop in storage
Lock to fulfill clients security need, uses a master key for clients convenience
0.36m
0.7m
This design allows for a total of 18 laptops to be stored
0.8m
Drawers and shelf made of wood
Every drawer has clear, large and customizable labels

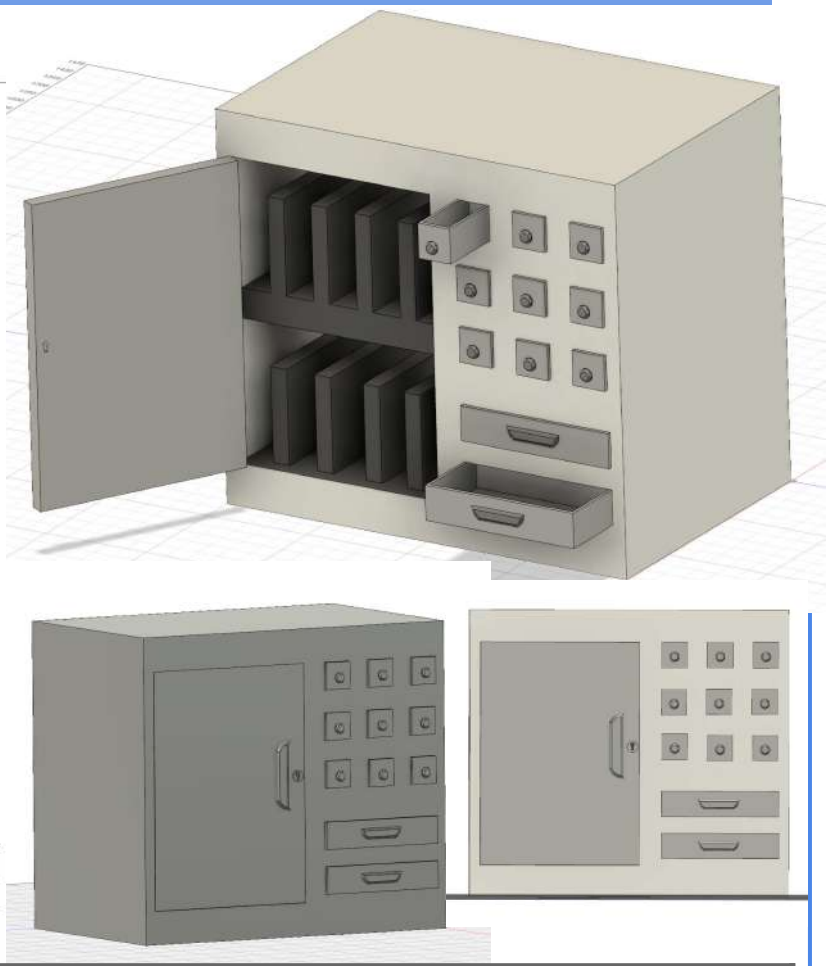

Power strip inside to be kept discreet and remove visual clutter
0.3m
7 Tray
loaner laptops stacked on-top one-another for tight and efficient storage
0.14m
A tray design is the simplest method of reducing desk clutter, and multiple can be used throughout the I.T. office
Exit holes for charger cables
Different sized tray compartments allow for easy and accesible storage of electronic products and components
0.7m
0.47m
0.16m
Open compartments allow for easy visual organization and sorting of items
0.36m
Tray made of white acryllic as acryllic is the lightest, cheapest and easiest material to use
0.08m

Initial Product Evaluation (refer to pages 8-10 for details on specifications)							
Design Idea	1	2	3	4	5	6	7
Marketing Spec.							
Target Market	10	8	7	10	10	10	8
Competition	8	9	10	8	9	9	6
Target Audience	10	10	9	10	10	10	9
User Needs	10	9	8	9	8	10	7
Market Analysis	10	8	10	10	8	10	7
Design Spec.							
Aesthetics	7	8	10	10	10	8	7
Cost	-	-	-	-	-	-	-
Customer	10	8	7	9	9	7	5
Environment	-	-	-	-	-	-	-
Safety	10	10	10	10	10	10	7
Size	10	9	10	9	10	4	10
Function	10	9	6	9	9	10	8
Manufacturing	10	8	10	10	8	4	10
Materials	-	-	-	-	-	-	-
Client Feedback	"Looks really good, nice design and fits the job well. I only wish there could be more than 6 little drawers to allow more sorting options." 9/10	"Very interesting design. Function wise it's perfect but I'm not sure where in the office we could fit that, and the cylinder design seems impractical compared to the others." 8/10	"Very simple looking design, I like the look, however it isn't exactly the product we're looking for as it doesn't seem it can do much compared to the others. For example, it can only hold 4 laptops so we would definitely need at least 2 or 3." 6/10	"Awesome looking. Very sleek and modern and meets what we need, however, maybe adding a base would secure the laptops further." 9/10	"Looks very practical and efficient, but it seems to take up a good amount of space when fully opened. There also looks to not be much storage space for little electronic bits." 8/10	"Awesome design. Exactly what we are looking for in the function and look, but is definitely too big for the office and I imagine it would be expensive having an outlet be in each drawer." 8/10	"I like the simplicity, and it seems we could easily implement these on every desk, but seems a little lackluster compared to the other designs in terms of security and efficiency." 5/10
Total (/120)	114	106	103	113	109	100	89

Conclusion:
After analysing my concepts in relation to the marketing and design specifications, and after talking to my client about 3 potential best designs, I have chosen to continue pursuing design ideas 1 (Cabinet), 4 (Rack) and 5 (Cubby-Hole). My next step is to improve upon my chosen designs and to render them using Fusion 360 to create highly realistic CAD models. These will then be assessed by my client and myself, and the final design idea will be chosen.

Modelling of Ideas:





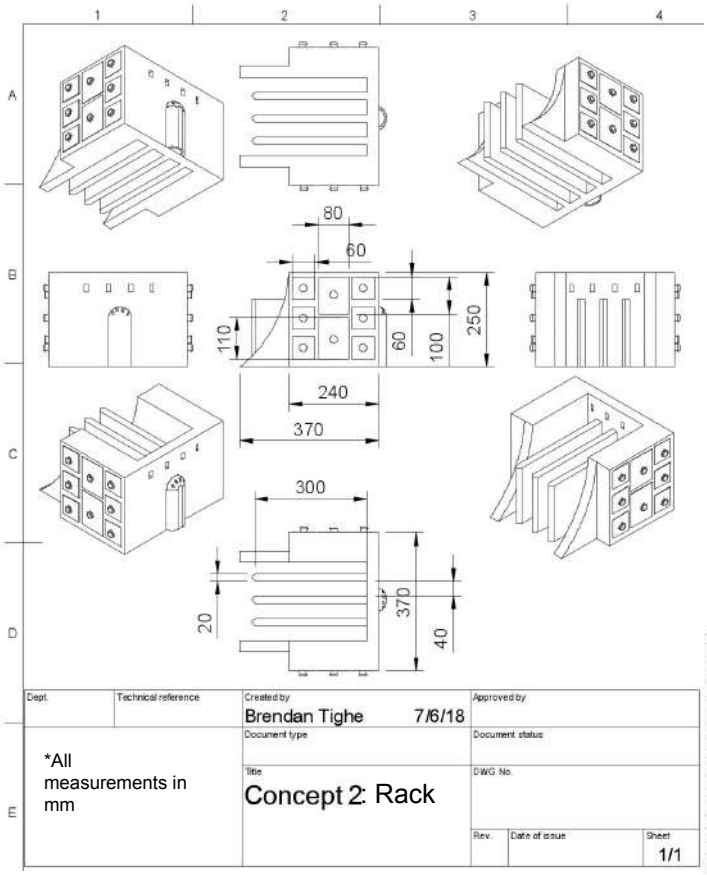
Design Concept 1: Cabinet

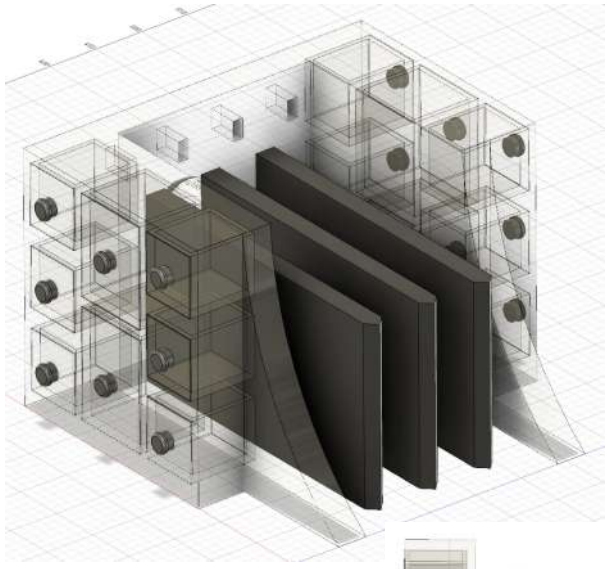
The development of this design was relatively straightforward and I had to change little from my concept drawing. The picture on the top right shows the interior where the laptops will be held. The black acrylic slabs are there to divide the laptops which will prevent scratches when being stored. When virtually modelling this concept, I found that the size measurements I gave when I graphically modeled it allowed for up to 9 small drawers rather than 6. The bottom left image showcases the design before colour was applied, and color was added to the bottom right. Humans will be operating this product and as such I have focused on a simpler design that requires little to no thought process for the user. The direction and placement of the door handles gives indication to the direction the door will open by simply looking at it.

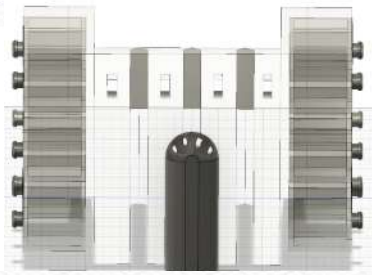
Final 3: Updated Product Evaluation			
Target Market	10	Safety	10
Competition	9	Size	10
Target Audience	10	Function	10
User Needs	10	Manufacturing	10
Market Analysis	10	Materials	-
Aesthetics	9		
Cost	-		
Customer	10		
Environment	-		

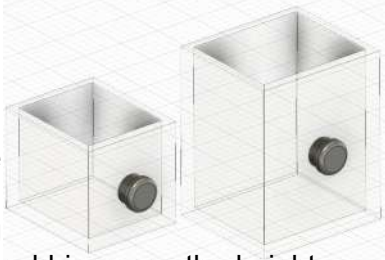
Client Feedback:
"Outstanding design. We could easily fit this in the corner of our long desk and I can tell we will instantly take full advantage of this if it were put in the office because of its multi-sized drawers. But I do wish there were more drawers and the Mondrian art style was incorporated though."
9/10

Design Concept 2: Rack







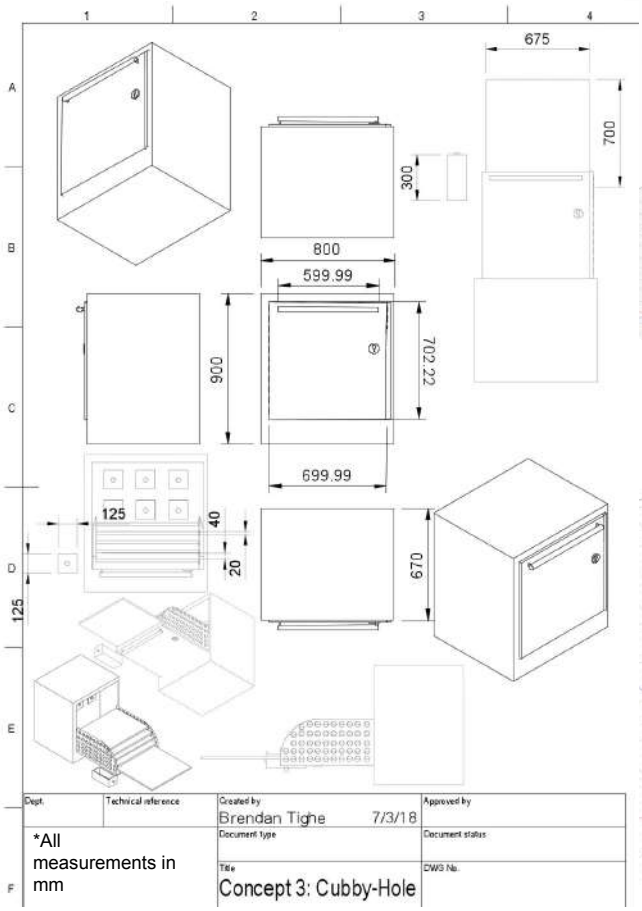


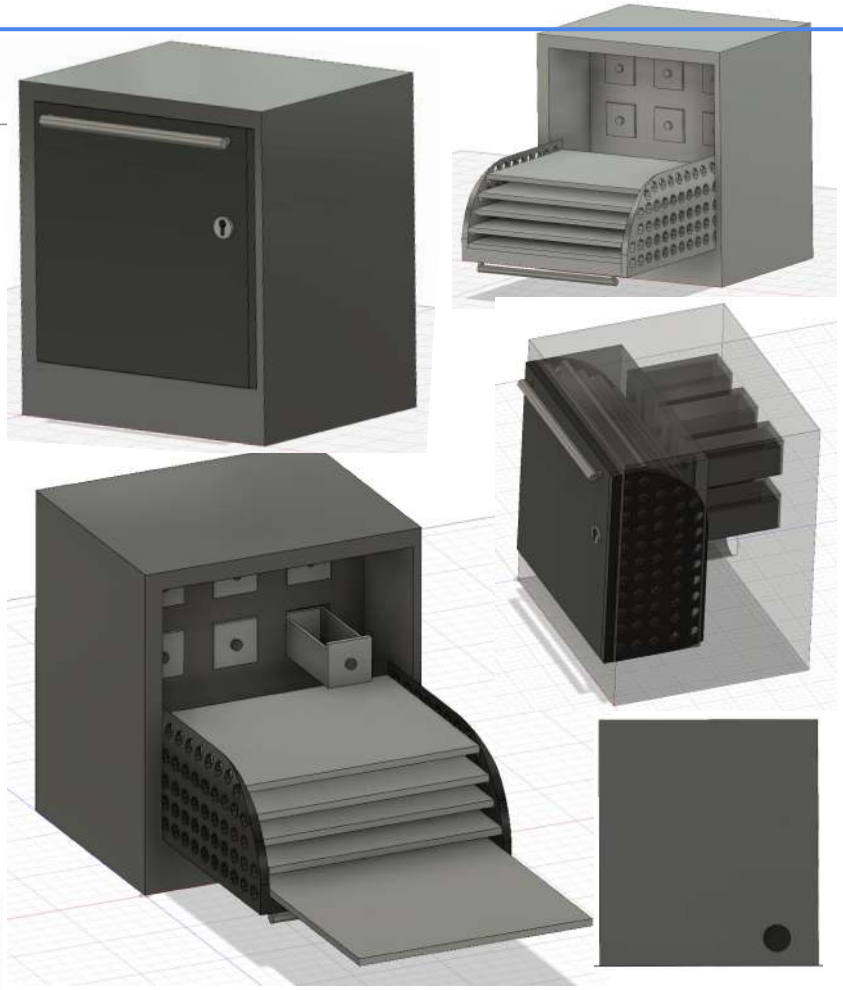
The development of this design brought up many details that I didn't think to include in my concept drawing. For example, this design doesn't have a base, and I therefore needed to consider the implications of adding one versus simply attaching the divider slabs to the back. I decided to go with the latter since adding a base would increase the height and the weight of the product and wasn't a necessity. The image in the top right shows the finished product coloured as it would be. Both my client and myself are quite fond of the see-through acrylic which adds to the aesthetic appeal immensely. The photo directly below is from the back where you can see the cable management system featured in this product. I considered many different designs but ultimately decided on this one as it is very discreet and convenient for the user to use. The product can store a total of 4 laptops, each one being able to be charged through holes seen in the back.

Final 3: Updated Product Evaluation			
Target Market	10	Environment	-
Competition	10	Safety	10
Target Audience	10	Size	10
User Needs	7	Function	10
Market Analysis	10	Manufacturing	8
Aesthetics	10	Materials	-
Cost	-		
Customer	9		

Client Feedback:
"Wow. By far the best aesthetics. Looks very good and so sleek, although I am concerned about the security of the laptops against theft. The see-through is great but I don't think it would really stand out amongst all the white furniture. It also can't really store that many loaner computers to be entirely useful."
7/10

Design Concept 3: Cubby-Hole





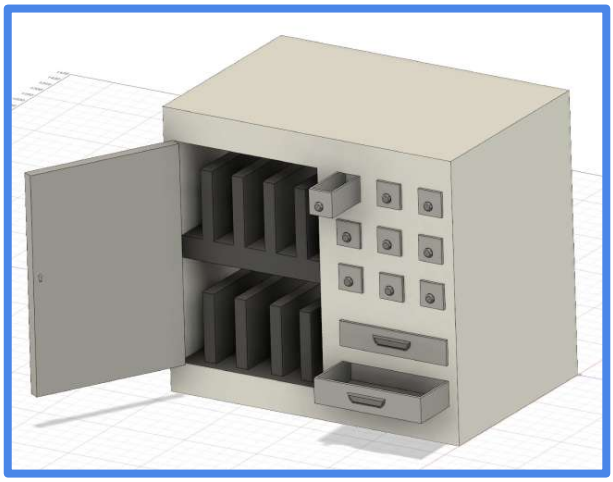
This was by far the most challenging virtual mock-up of the 3 designs. However, I am very pleased with the outcome. The top right image is the design with no colour and the door open, but the laptop tray isn't slid out. I included the image below to visually show how the interior of the product fits together when the door is closed. The door opens horizontally, and each tray can slide out to access each laptop as seen in the bottom left image. Several drawers are featured behind the trays (6 here compared to the 4 I had drawn out), and a lock is included on the door to add security. Finally, the image in the bottom right is the back of the product, where you can see the entrance holes for the laptop charging cables to go through and connect to the laptops in storage.

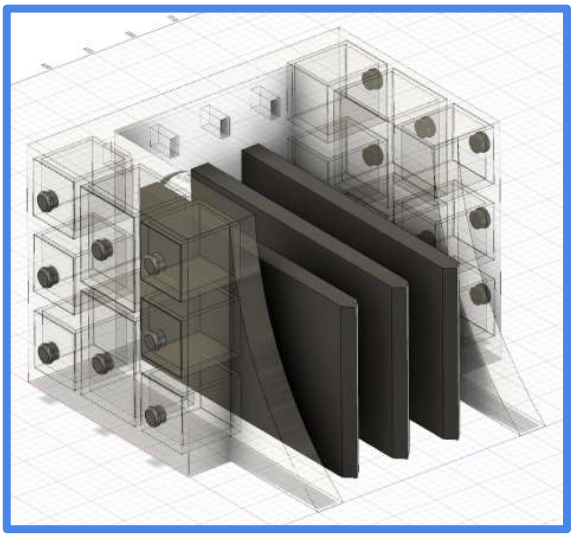
Final 3: Updated Product Evaluation			
Target Market	10	Environment	-
Competition	10	Safety	10
Target Audience	10	Size	6
User Needs	10	Function	9
Market Analysis	8	Manufacturing	8
Aesthetics	10	Materials	-
Cost	-		
Customer	9		

Client Feedback:
"This is a very cool and unique design. I like the 2 additional storage drawers here, but in order to safely store the laptops it seems there is no way to reduce the space it takes up when opened. Again, the Mondrian style and any color at all isn't included which really isn't wat the office needs. It would also be nice to have some larger drawers for more diverse storing options." 8/10

Testing Against the Design Specification:

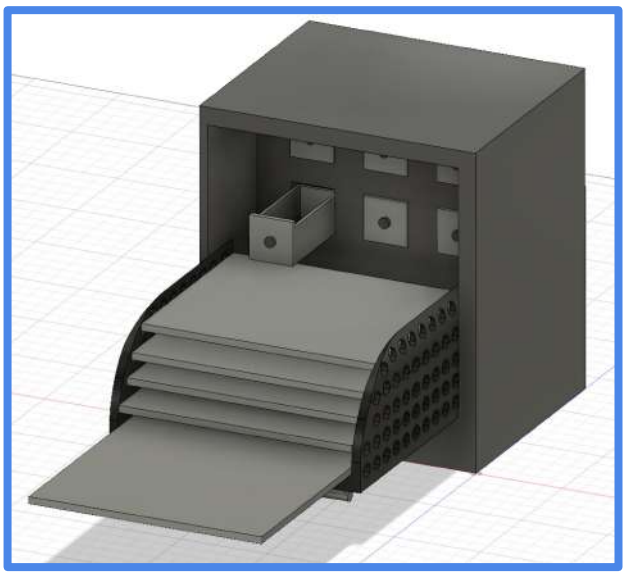
This design definitely captures the modern look. Overall it has mediocre aesthetics but it can easily be improved and pushed further. Using simple, neutral colours such as light and dark grey has allowed this product to easily blend in and match in any IT office, however, maybe a bit too well since my client doesn't like how bland it looks. A faint woodgrain from the plywood achieves in giving the user a feeling of trust and warmth that would be associated with home, and puts comfort in the storing of expensive hardware inside. The height of the cabinet is perfect for the office it was designed for. As for the performance requirements, this idea is very simple, efficient, and will be easy to pull off. It is a multi functioning piece of furniture doubling as both a laptop storage and electronic component sorter. With access to the tech room, manufacturing this product will be a simple and easy process.





This design has the best aesthetics by far. But while the other two put function over form, this design does the opposite. In order to fit the size constraints and obtain symmetry for aesthetic appeal, this design can only hold 4 laptops compared to the higher numbers in the other designs. The transparent look is very unique and could possibly draw unnecessary attention in the IT office, which fails to meet the specification. Function wise this design somewhat meets the specification. It features a cable management system, but it is the most complicated of the 3 designs and is unrealistic for being implemented in the prototype. The purpose of the rack was to allow easy access to the laptops while having a unique look compared to the other designs which are simple cuboids. However, the laptops are also exposed to potential scratches as there is no base. If used in a home or high-end office, this product would be perfect. However, my client specifically values form over function which puts this design behind the other two.

The design of this product has achieved colours that can both contrast and blend well with each other, along with being neutral to blend in and match with other IT office furniture items. While it isn't white, it also isn't Mondrian which is part of the aesthetic specification. The cubby-hole itself is an even box with a simple design to not draw too much attention from the rest of the room. Size wise, this will have trouble opening up in tight spaces, but I believe the measurements I have provided are appropriate while still having storage space on the interior of the cubby-hole. This design meets the performance specification by having a hole in the back to allow for laptops to be charged while stored, however there are only 6 small drawers and no large ones, meaning this design provides the least storage space of the 3 given that it can only store 4 laptops. In terms of manufacturing, this product is definitely doable to craft, however further research into the internal storage will need to be done beforehand.

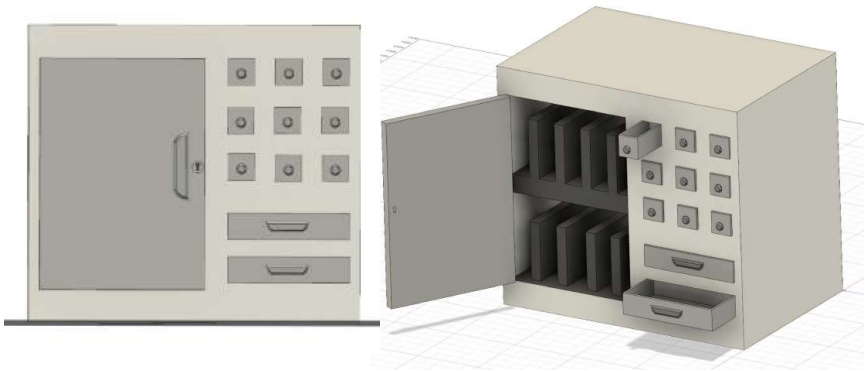


Conclusion:
After re-analyzing and virtually modelling the final 3 design concepts in relation to the marketing and design specifications, and after consulting my client about them to try and determine the best idea to continue with, I have decided to continue pursuing design 1 (Cabinet) as it seemed the best option when both evaluated by myself against the marketing and design specifications and my client's personal needs and wants.

Justification of Chosen Idea:

I chose this idea as my final design because it meets every point of the specification aesthetically, size wise, and performance wise, while being manufacturable with my resources available. For the aesthetics, my client gave me helpful feedback stating I should perhaps consider changing the design of the body to be more unique, lighter, and to increase the number of small storage drawers to allow an even greater amount of sorting options. I found all of these points to be extremely helpful and definitely feel confident in my abilities to implement them into my current design to improve it for the better. This design achieves its intended function by serving as a reliable, consistently sturdy, fully functional, and customizable storage and component sorting cabinet.

This design, however, is more of a general piece of furniture rather than a user-specific design. Meaning **no ergonomic data and little to no user trials will be required** in order to meet the design specifications. My prototypes will most likely need to not be to scale in order to save time and resources, along with extensive designing and constant improvement through CAD.



Drawer/Storage Component Prototyping:

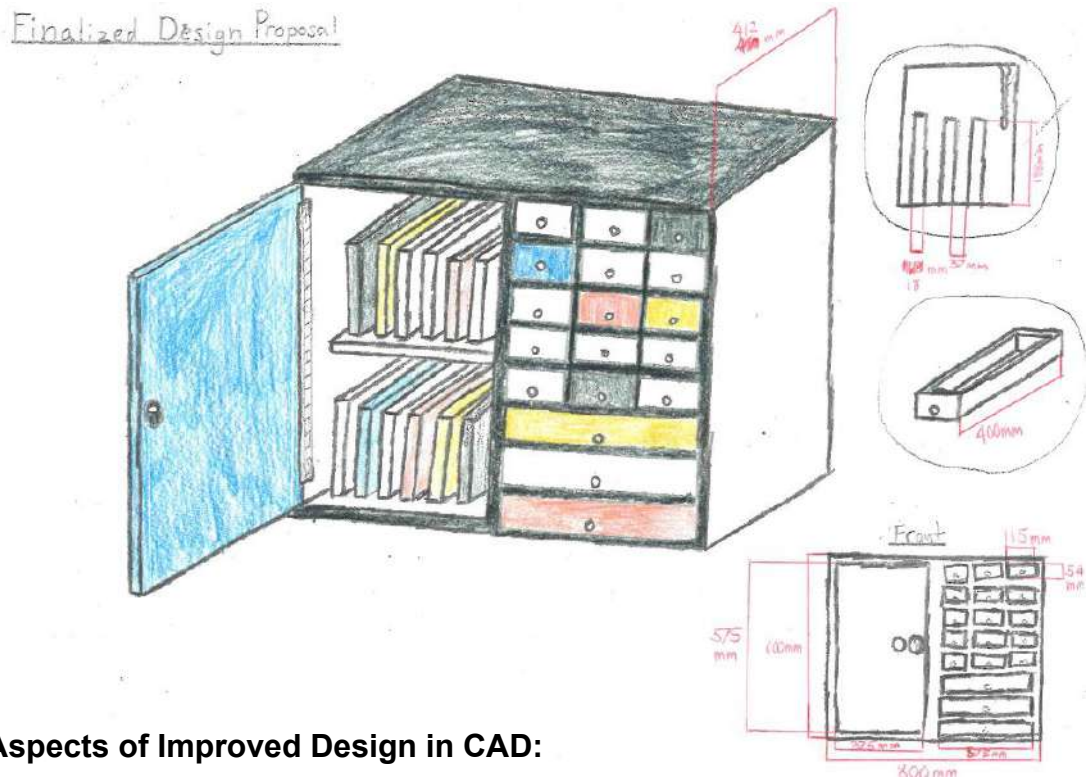
In the above photo, the joint on the left was created by only using wood glue and clamping them together to dry overnight. On the right, I experimented using wood glue for the joint immediately followed by using the nail gun to hold the joints together as they dried. The nailgun method was by far the most efficient as it allowed me to continue to work without having to wait for the joints to dry.

Laptop Storage Component Prototyping:

In the above photos, I experimented with different thicknesses for the dividers between the laptops that were fortunately lended to me by my client. I found 3.7 cm to be the optimal distance between each slab that divides the laptops. The thicker slabs were more secure than the thinner ones when they were both fully attached to the base, and both had laptops leaning on them.

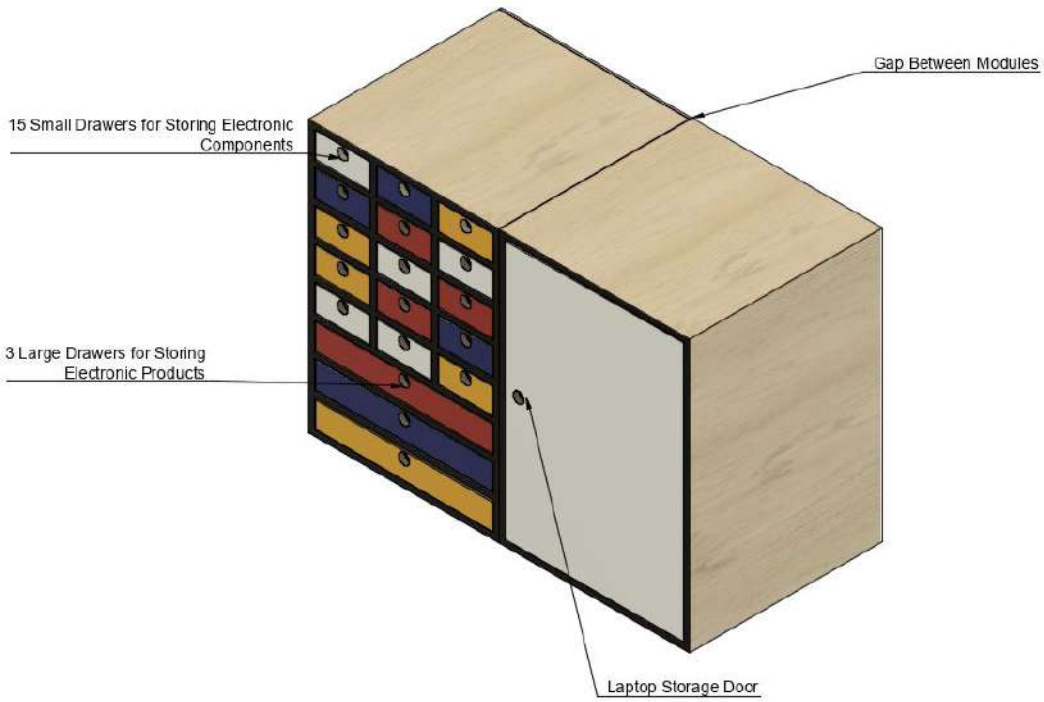
Final Concept Drawing:

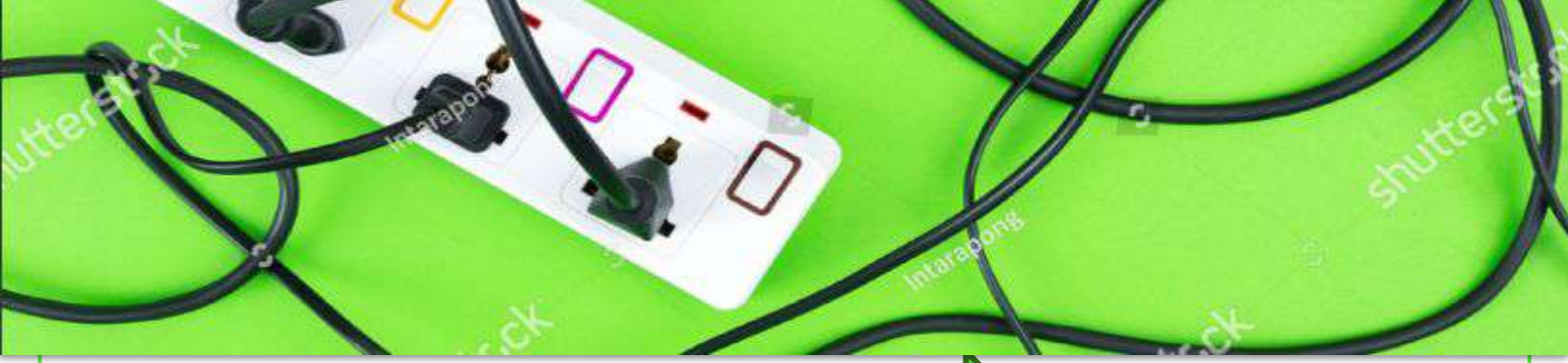
Because my cabinet will be made with 12mm wood, I was able to include a substantial amount of drawers in comparison to my initial CAD concept (15 here vs. 9 originally). I also incorporated the Mondrian aesthetic style my client requested. From here I can create a life-like CAD render before beginning the manufacturing of my cabinet. The drawing assists in visually planning what my cabinet will look like before applying any changes in Fusion 360.



Labeled Aspects of Improved Design in CAD:

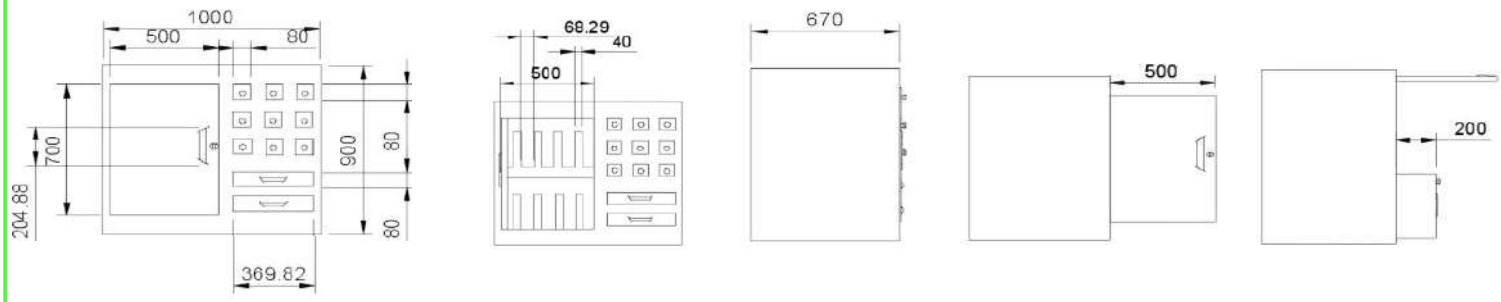
Using Fusion 360 I updated the CAD model of my final design. This is a more refined version of Concept 1. Further changes were made since the drawing above. Firstly, I split the laptop storage and the drawers into two modules that combine together. This was done to make the cabinet more customizable given that each module can be separated and placed around the office. Since my client's office is constantly disorganized this will be a useful feature that makes the cabinet more flexible to changing environments. The laptop storage was also moved to the left-side because I found that people use their dominant hand (most commonly the right hand) when handling expensive machinery such as laptops. This was a small quality of life change that required no significant effort to include, thus it is included.





Step 3: Development of a Detailed Design

Selection of Material and Component Requirements:



Quantity	Component	Dimensions	Materials for Classroom Manufacturing	Justification (Cost/Supply/Physical & Mechanical Properties)
1	Main laptop storage door	700 x 500 mm	Plywood	The layers of veneer that make up plywood are glued together at alternating right angles, which gives it both strength and durability. The cross-graining also reduces the chance of the wood splitting when nailed at the edges along with making the wood warping, cracking, and twisting resistant. I have chosen to use plywood for the material of my storage and drawer doors because the way the wood is made ensures a consistent strength across the entire length of it. In addition to all this, plywood is less expensive than similar boards made of full wood species, and is readily available to me through the Design-Technology department in my school. The measurements I have provided for the storage doors and drawers are to give them a sturdy and reliable feeling when being used that comes from the appropriate weight distribution from these measurements when the drawers slide in and out.
9	Small storage drawers	80 x 80 mm, depth of 200 mm	Plywood	
2	Big storage drawers	370 x 80 mm, depth of 200 mm	Plywood	

Quantity	Component	Dimensions	Materials for Classroom Manufacturing	Justification (Cost/Supply/Physical & Mechanical Properties)
2	Vertical side faces of body	900 x 670 mm	Pine wood	Pine is a lightweight, inexpensive wood that is commonly used for rustic pieces. Pine takes paint well and ages well allowing it to resist shrinking and swelling. I have decided to have the bulk of my cabinet be made out of pine wood because it is regularly available in my Design-Technology department at school. I decided to decrease the thickness of the storage compartment from my CAD drawing because I felt it unnecessarily reduced the maximum storage space inside. All the measurements I have given are to provide a sturdy yet easily usable product.
2	Horizontal top and bottom faces of body	1000 x 670 mm	Pine wood	
2	Vertical front and back faces of body	1000 x 900 mm	Pine wood	

Additional Material Information/Research:

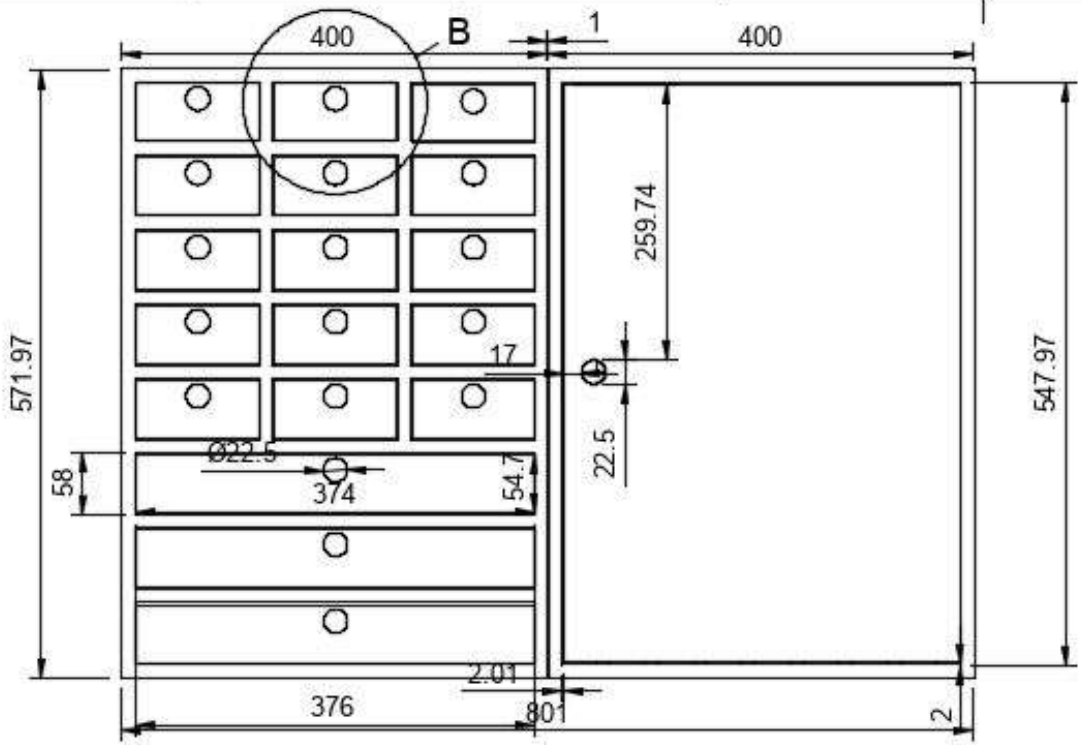
Materials	Properties	Cost
Acrylic 	Stiff, hard, flammable, impact resistant, can be vacuum formed, can be glued, can be injection molded	$130 HKD per m²
MDF (Medium-Density Fibreboard) 	Low durability, heavy, hard, finishes well, not suitable for exterior work, can can be milled	$30-$100 HKD per m²
Neoprene 	Resistance to oxidation and sunlight ageing, abrasion resistance, high resilience, light, can be cut	$25 HKD per m²
Plywood 	Increased stability, high impact resistance, high strength to weight ratio, popular for use in furniture, can be milled	$105 HKD per m²
Pinewood 	Lightweight, resistant to aging and scratching, durable, popular for use in furniture, can be milled	$314 HKD per m²

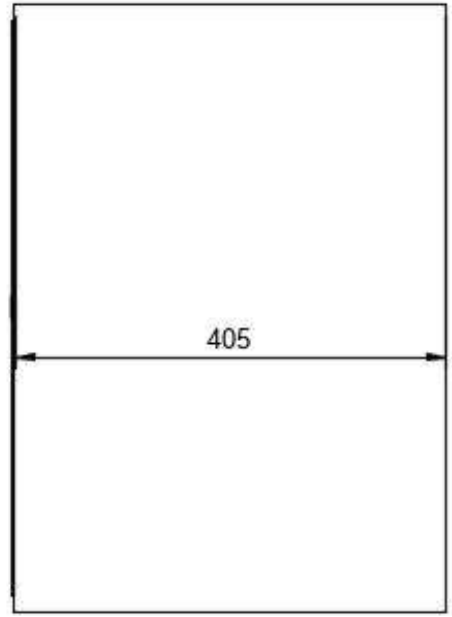
The best material for the manufacture of the cable management system would be neoprene as it is cuttable, this allows it be easily customized to fit the placement of the charging cables and the cabinet itself. MDF, however, would not be suitable for this design due to its low durability compared to that of plywood. Acrylic is stiff, hard and easily shapeable—perfect for handling laptops when they are being stored. Pinewood is commonly used for furniture and is the most optimal material for the body of the product for its cost, along with plywood for the drawers. Alternatively, simple holes could be drilled in to allow cable access to the laptops for no additional cost.

Component	No. of	Cost per 1 unit	Justification
Right-angled hinge	~6	$15 HKD	Having multiple is advantageous for providing support through distributing stress and weight uniformly along the entire length of the big door.
Ball bearing drawer slides (maybe)	11	$100 HKD	Can support heavy loads and full extension functionality allows for the entire drawer to be stable and accessible.

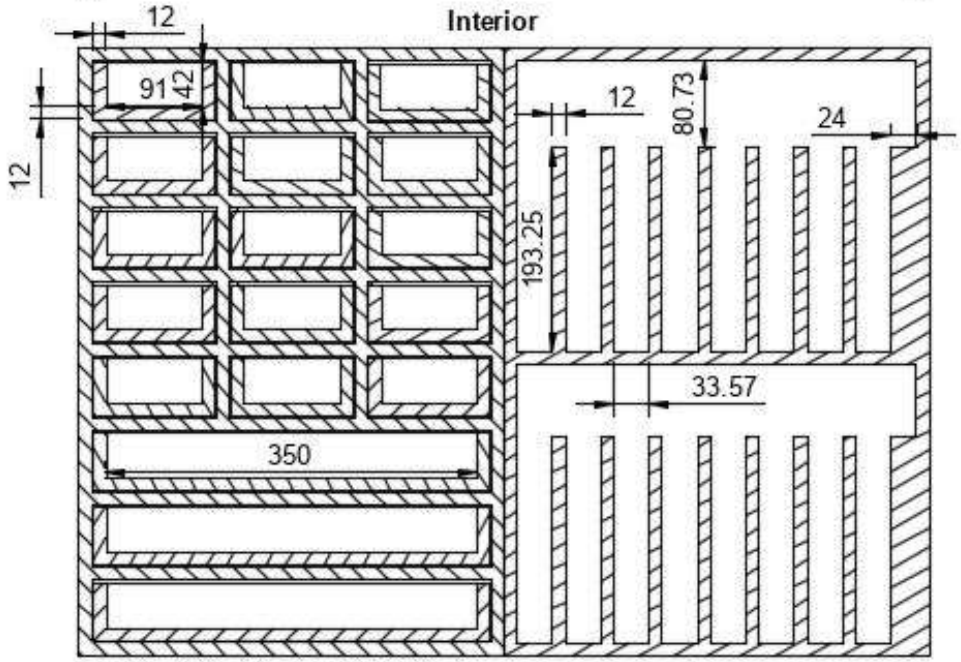
Justification of Potential Manufacturing Techniques:

Quantity	Component	Manufacturing Technique	Justification (Cost/Supply/Physical & Material Choice)
2	Vertical side faces of body	All of these components will be made out of pine wood, and therefore can be cut together. With setup help from a technician, I plan to use the circular saw to rip cut these large pieces of pine to achieve a flat level and surface for each component of my cabinet. Creating rebate joints would be ideal for creating the necessary support structure for the entire unit, however, I don't think I am skilled enough to consistently make them.	Rebate joints are both easy to implement, and reliable methods of bonding together wooden components. Using the circular saw will allow me to easily get the necessary quantities and measurements I need of pinewood, however I will need help from a design-technician to operate it. The circular saw and pinewood I need are readily available in the Design-Tech department and therefore would be cost efficient for me to use.
2	Horizontal top and bottom faces of body		
2	Vertical front and back faces of body		
1	Main laptop storage door	Like the body of the cabinet, the storage doors and drawers will be cut with the circular saw, but this time with plywood. Cross cutting plywood without supporting it across its entire length can cause the saw to bind or the veneer to tear or splinter as the cutoff piece drops; so I will most likely need support when cutting this. To prevent the main laptop storage door from caving in on the cabinet, a small strip of wood around the edges of the storage opening on the inside will need to be implemented. I plan to have the access door function via right-angled hinges, which are in high supply from my technology department.	Since the inside of the laptop storage compartment is hollow, I decided to go with the small strip of wood to maximize the storage capacity rather than indenting the walls of the cabinet. It would also be significantly easier to implement a small strip of wood on the inside than to carve out a resting spot for the storage door on the faces of the cabinet. Right-angled hinges are easy to implement in my design and are a cost effective manufacturing technique.
9	Small storage drawers		
2	Big storage drawers		





Interior



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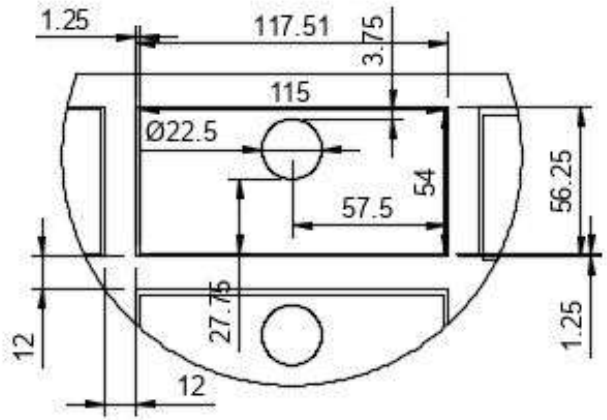
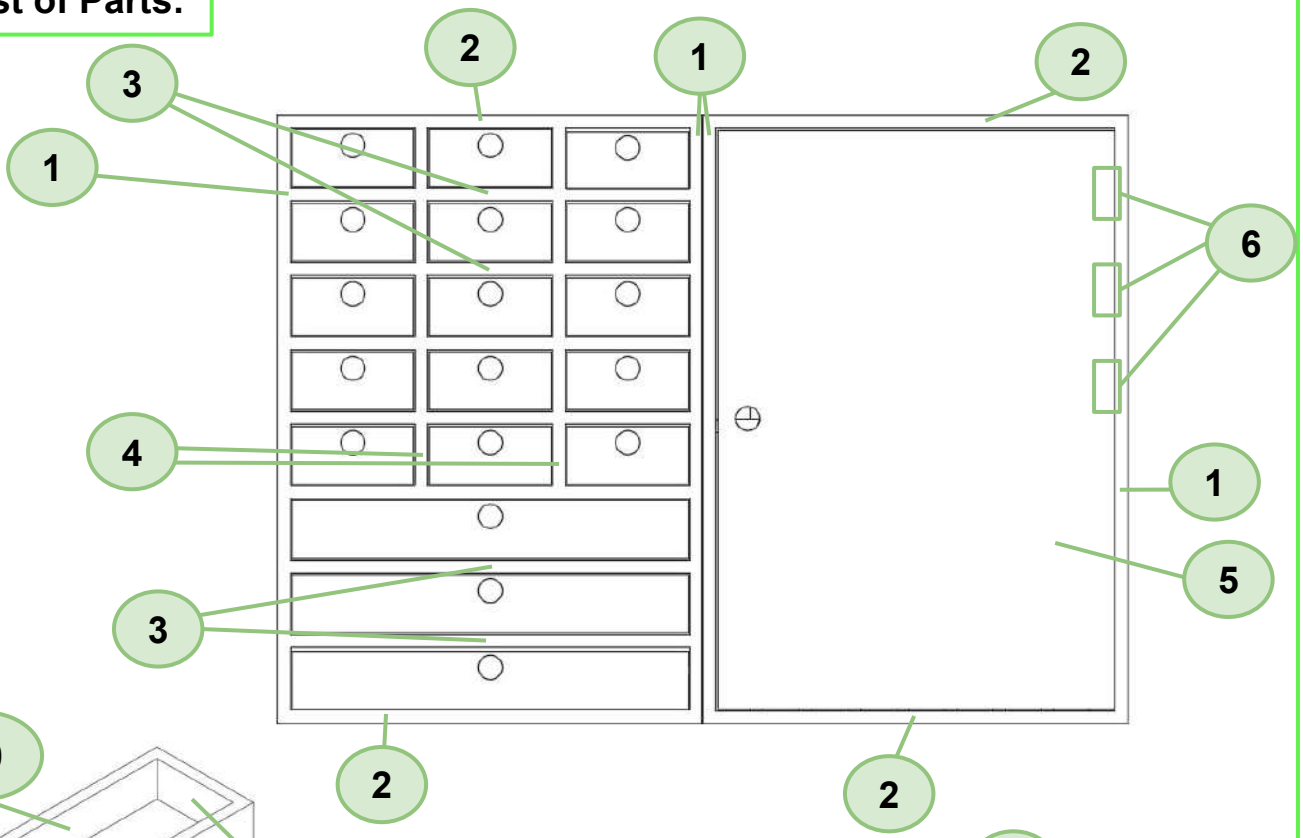
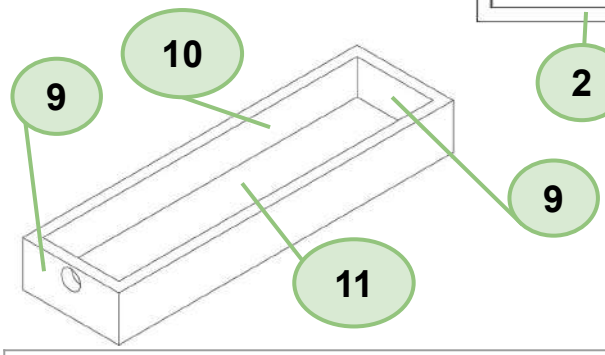
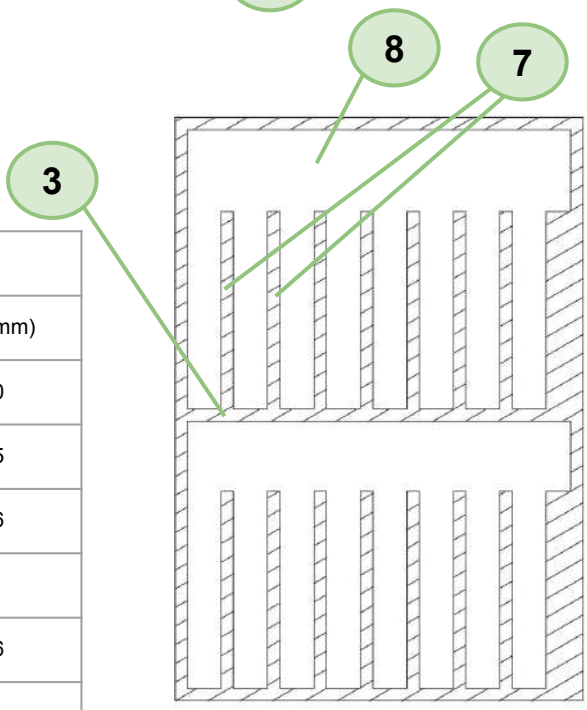


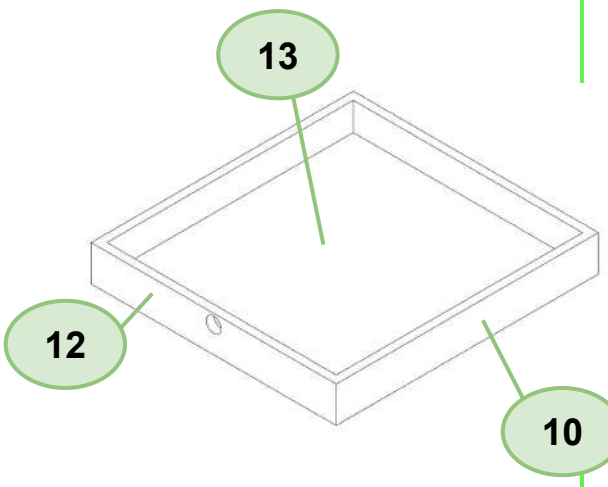
Dept. DC DT	Technical reference	Created by Brendan Tighe 7/3/2019	Approved by
		Document type CAD Orthagraphic	Document status
		Title Laptop Cabinet	DWG No.
			Rev. / Date of issue / Sheet 1/2

Labeled List of Parts:





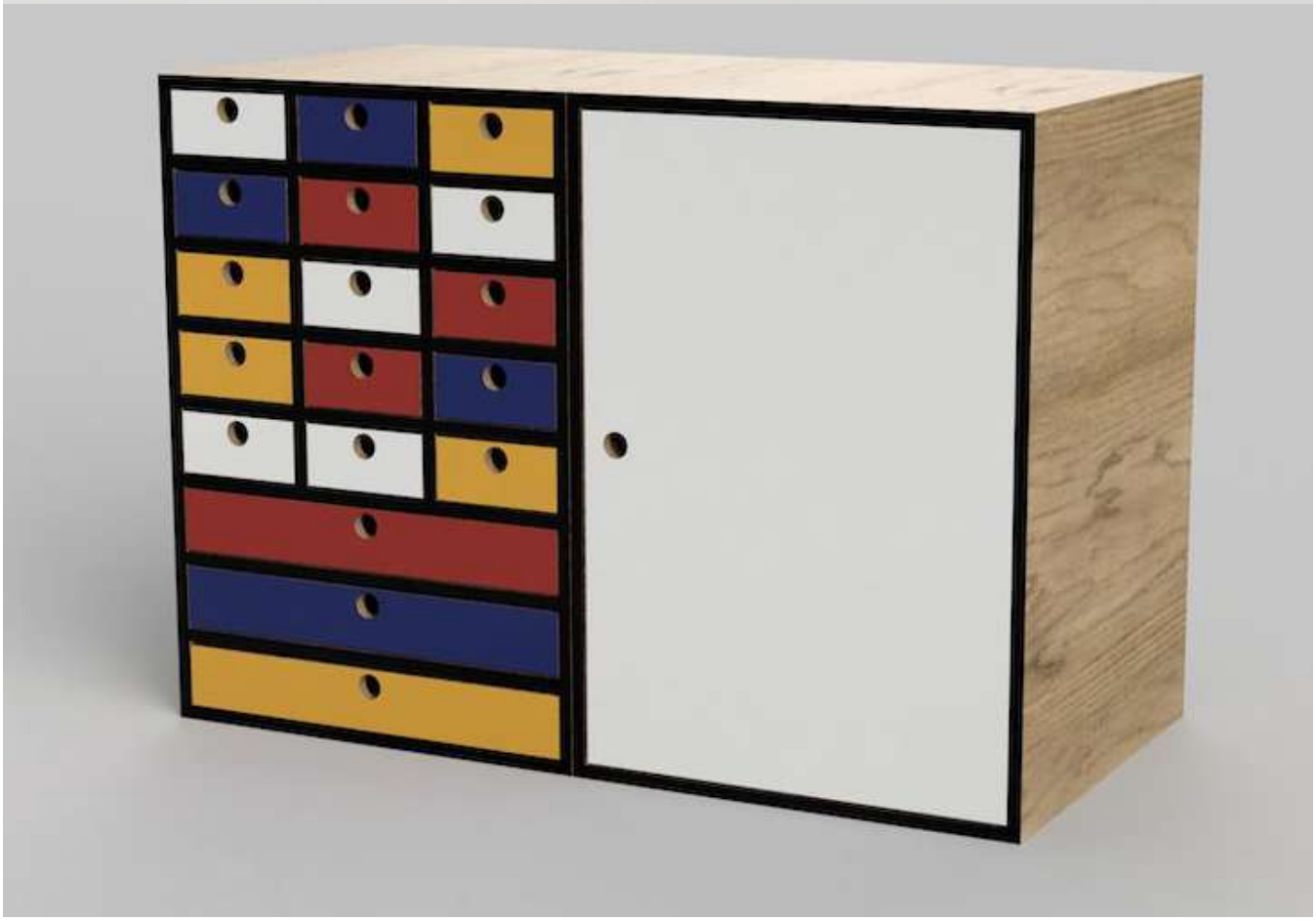




Parts List				
Item	Qty	Part Name	Material	Size (mm)
1	4	Side faces of body	Bamboo**	400 x 600
2	4	Top and bottom faces of body	Bamboo**	400 x 405
3	8	Drawer frame level	Bamboo	400 x 376
4	10	Drawer frame divider slab	Bamboo	400 x 56
5	1	Cabinet door	Bamboo	548 x 376
6	6	Right-angled hinges	Metal	-
7	16	Laptop divider slab	Bamboo	193 x 300
8	2	Back panel	Bamboo**	400 x 600
9	30	Front and back faces of small drawer	Bamboo	54 x 115
10	36	Side faces of drawer	Bamboo	400 x 56
11	15	Bottom face of small drawer	Bamboo	400 x 115
12	6	Front and back faces of large drawer	Bamboo	54 x 374
13	3	Bottom face of large drawer	Bamboo	400 x 374

**See Criterion E

Final CAD Rendering:

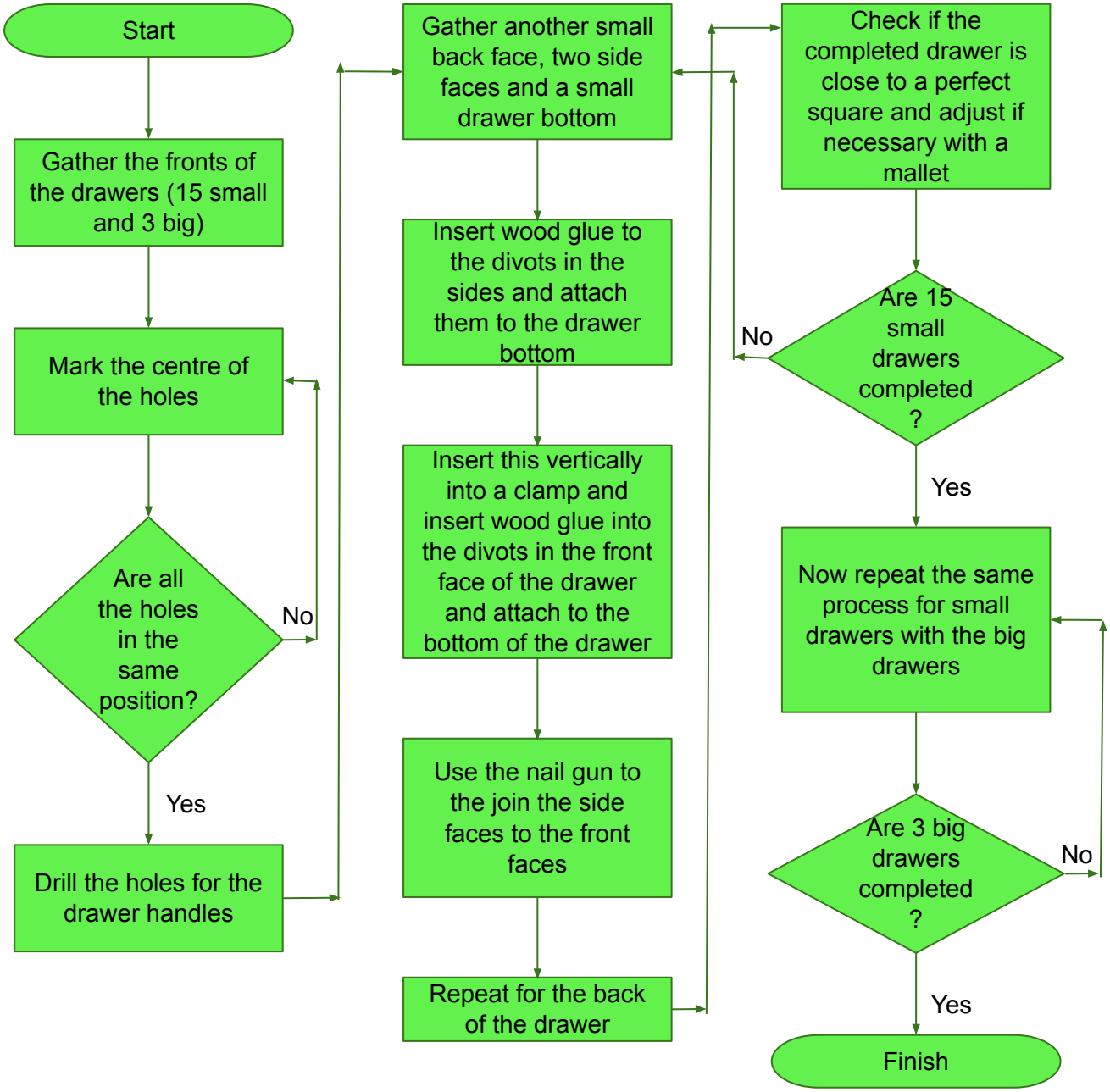


Production Plan:

Module	Stage Number	Task	School Timetable Blocks						Description
			1	2	3	4	5	6	
STORAGE DRAWERS	1	Cut out the all the front, back, side and bottom faces of the small and large drawers. Then cut out the side, top, bottom and back faces of the module's body							Use the circular saw to cut the industrial bamboo sheet into the correct measurements
	2	Assemble the Drawers **							See flow chart on pg. 28
	3	Attach the drawer frame levels to the drawer frame divider slabs							Use wood glue and the nail gun (see risk assessment before so) to do this. Place 3 small drawers upside down on a frame level and put the frame dividers in between them so they are evenly spaced.
	4	Attach the assembled drawer frame upside down on the top face of the body and attach the side faces of the body to the top face and the drawer frame levels							Again, to this with wood glue and the nail gun. Once finished use clamps to hold the drawer frame and its body faces together.
	5	Attach the bottom levels for the large drawers to the two bottom drawer dividers and the two side faces of the body. Then attach the bottom face of the drawer.							Do with wood glue, nails and clamps
	6	Attach the back panel to the frame levels and the body faces							Do with wood glue, nails and clamps
	7	Sand the drawers and all wood used to ensure every drawer slides in-and-out of the frame smoothly							Use the belt sander. The drawers should be tested sliding at every stage of the frame assembly

Module	Stage Number	Task	School Timetable Blocks						Description and Quality Assurance Tips
			7	8	9	10	11	12	
LAPTOP CABINET	8	Cut out the side, top, bottom and back faces of the module's body along with the door and interior laptop dividers							Use the circular saw to cut the industrial bamboo sheet into the correct measurements
	9	Assemble the module's body (excluding the door)							Use wood glue and the nail gun (see risk assessment before so) to do this.
	10	Attach the last remaining drawer frame level (from step 1) inside the cabinet							Use wood glue and nail gun
	11	Insert the laptop divider slabs and use a 33.57mm thick piece of scrap wood to ensure the spacing between each divider is consistent.							Use wood glue and nail gun. Only use the scrap wood for measurement, do not attach it. Remove it before any excess wood glue dries on it. The last divider slab should be touching the right interior wall for the door.
	10	Drill a 22.5mm hole into the door (see orthographic) and use right-angled hinges to attach it to the farthest divider slabs							Use the pillar drilling machine to ensure the hole is in the correct place
FINAL PRODUCT	11	Remove the drawers and paint only the front faces, then paint the front face of the drawer frame. Then paint the door and the cabinet frame							Mix the paint with water and use a rag instead of a brush. These will both ensure the woodgrain is preserved through the coat of paint. Refer to the final rendering for the specific colors

****Manufacture of Drawers:**



Quality Control Checks:

- Ensure every drawer is properly sanded on all sides to allow for a smooth opening and closing
- When constructing the drawers, check for deformities or bumps in the wood that might otherwise prevent a smooth opening and closing
- Accurately measure dimensions and check them in CAD before beginning the manufacturing process.

Risk Assessment:

- Wear safety goggles when using a nail gun as metal pieces may fly into the eyes
- Do not run when carrying tools/equipment
- Always tie away loose hair or clothing so they can't get caught in the machinery
- Get teacher assistance when cutting out wood with the circular saw

Completed Product at Different Production Stages:

Assembled drawers stacked up next to cabinet prototype

Finished product before paint was applied

Finished product

Criterion D: Testing and Evaluation

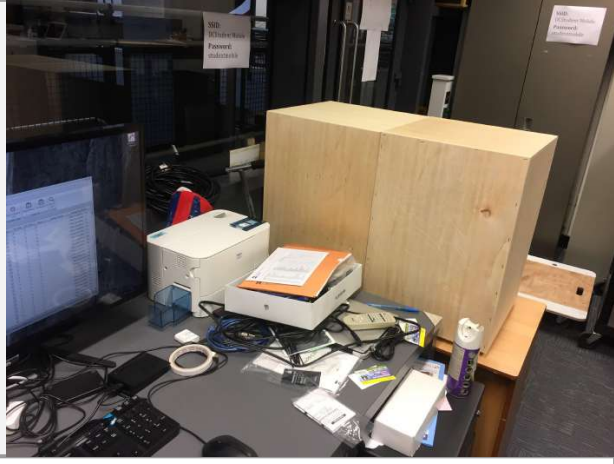
Refer to Pages 8 - 10

Marketing Specification	Description
Target Market	The solution is successful because it was designed for the target market by having a simple and discreet design, removing visual clutter, working reliably and reducing the risk of fire in the office by removing cluttered wires. It is design for IT office workers and these are all common problems in an IT office.
Target Audience	The solution is successful because my client no longer needs to worry about spending more time than necessary looking for something under piles of unorganised items. The simplicity of the cabinet's design promotes organization in a home or office environment. 
Market Analysis	In relation to the market analysis, the solution is a success because it didn't cost more than $5,000 HKD to produce (which was the most expensive product I analysed) or less than $500 (which was the cheapest product I analysed) and so it fits in the price range to sell to the target market. [photo] & annotated fixed and variable cost graph. Is your product viable?
User Need	The solution met the user needs because it's separated modules allows it to be easily integrated into the IT office. Moreover, the cabinet is reliable and sturdy because of the joints it has and the material it's made of. The simple colors make the cabinet 'approachable', because only primary colors are used and the user will be aesthetically drawn to the design.  On the contrary, the product the product isn't entirely successful because it isn't customizable. Each drawer needed to be sanded in a different way in order to fit into the drawer frame, meaning drawers can't be switched around into different frames. The cabinet also doesn't have holes for charging cables to reach the laptops being stored, and because of this no ventilation was required. There are also no labels or locks on the drawers and cabinet door.

Competition	The cabinet is successful because it doesn't cost more than the most expensive product on the market (around $5,000 HKD) and therefore it's predicted to sell successfully. The product has a wider range and appeal of features than the competitors' products that were analyzed on page 4, and it is also more discreet and aesthetically pleasing. Thus my product has a distinct advantage over competing products since my product is more suitable to the target market.

Design Specification	Justification
1. Function/ Performance Requirements and Constraints	The product is successful because it stores up to 16 laptops. The drawers allow for easy sorting and obtainment of spare electronic bits and components. However, the solution isn't entirely successful because there is no way to charge the laptops without leaving the main door open, which takes up too much space. The drawers are also not labeled. 
2. Aesthetic Requirements	The solution is a success because it's aesthetically pleasing: it and has no sharp corners and has is painted with a Mondrian art style that was preferred by my client. However, the cabinet isn't entirely successful in this criterion because there is no laquer or finishing coat applied to the wood which may make the product last for a shorter period of time before wearing down. 
3. Cost Constraints	The cabinet doesn't cost more than the most expensive product on the market ($5,000 HKD) which means it should sell relatively well which is successful in regards to cost constraints. However, the product costed more to make than the preferred price given by my client ($140 HKD). In spite of this my client would still pay the full price for my product
4. Customer Requirements	The solution is a success because it easily and efficiently stores laptops, and the process of using the product is as efficient and streamlined as possible. The cabinet discreetly fits into my client's office and adds a bit of color while doing so. However, there are no labels on the storage drawers and it isn't possible to charge the laptops that are being stored which means there isn't a cable management system in the cabinet. 
5.Environmental Requirements	The cabinet meets all environmental requirements because it was painted with water-soluble paint and was built with recyclable and sustainable timber

6. Size Constraints	The cabinet is a success because it doesn't exceed the maximum size constraints (1.0m x 0.67m) and so it can easily be placed in my client's office. The height of the product is greater than 0.33m and can therefore efficiently store laptops.
7. Safety Considerations	The product is a success in terms of safety considerations because the cabinet is vigorous and robust. It can handle the weight of the products placed inside without cracking, being damaged, or damaging said products. While there are no sharp edges, the corners of the cabinet weren't properly sanded meaning there is room for improvement. Ventilation was not required since the laptops aren't being charged on the inside.
8. Materials Requirements	While I ended up not using all of the materials I initially planned to, the change to bamboo was an excellent decision. The cabinet is still very durable and is thus a success. All of the materials I used were readily available via the Design Technology department in my school.
9.Manufacturing Requirements	The manufacturing process was suitable for the materials that the prototype was made from. Because no acrylic was used, only standard woodworking tools were needed to assemble the final product. CAD was used to design the cabinet beforehand which ensured no mistakes led to wasted materials during the manufacturing process.



Client Feedback:

I took my cabinet down to the IT office to gain feedback from my client, Mr. Tibbits, to see his thoughts on it in its current state and to hear his ideas for potential improvements. I came back after 48 hours to give Mr. Tibbits an adequate amount of time to use the cabinet and to see how it assists in a working day. Below is the transcript for my interaction with Mr. Tibbits following his use of the cabinet. A table with my client's ratings against the specifications is presented subsequently.

Mr. Tibbits, head of the IT department at Discovery College

Interview with Client:

Myself: So how are you liking the cabinet?

My Client: I think it's absolutely fantastic. It has every single thing that this office needed. Aesthetically, it looks great. I really love how it spices up the rest of the room by not being completely white. It's a great size which is wonderful. It isn't too big so that we have nowhere to put it, but it also isn't too small so we can actually get a good use out of it.

Myself: What use has the cabinet had so far?

My Client: The cabinet's been great for storing the loaner computers, however it would be nice if the computers could charge while being stored since the loaner computers are pretty old and run out of battery in a pinch. The drawers have been excellent for storing bits and bobs and so far have been great for storing student ID cards since we just had them lying around pretty much.

The content being stored in the drawers

Myself: How do you like the large drawers and the small drawers? Should there be more large ones and less small ones? Or vice versa?

My Client: No, the drawers are absolutely perfect as they are at the moment. I love the diversity of items I can store and how I can sort them by color. They are the perfect size and height for what I want to store, and I love that the large drawers perfectly fit and store the spare chargers!

Myself: I'm so glad you like it. How about the cabinet, how have you liked that?

My Client: It's really great being able to free up space around the office by putting the loaners in here. It can store so many so easily. I think it's actually better that it doesn't have a lock on the door, since the office doors are usually locked so having to use a key to open the cabinet would make it a chore to use.

Myself: Lastly, how do you like the Mondrian art style?

My Client: It's exactly what I wanted. You already know about the 'white furniture policy' we have at the school, but that doesn't apply to student projects! So I love the multicolored design and it's great how one piece of furniture can bring in so much color. On the topic of color though, I think it would be great if the rest of the body could be painted to fit the Mondrian style, like the back and sides, however I still love what you've made here.

Chargers being stored in a large drawer

Product Evaluation of Cabinet by Client	
Marketing Spec.	
Target Market	10
Competition	8
Target Audience	10
User Needs	10
Market Analysis	10
Design Spec.	
Aesthetics	10
Cost	7
Customer	10
Environment	10
Safety	10
Size	10
Function	10
Manufacturing	10
Materials	10
Total (/140)	135

Suggested Improvements Based on Specifications:

<u>In the Marketing Specifications:</u>

- The product should have multiple holes parallel to the wooden divider slabs in between laptops. This would be an extremely simple and cost-efficient method to implement internal charging
- Use an assembly line to mass produce the drawers. That way every drawer will be the same and the storage unit can be fully customizable and the user can determine the placement of specific colors in the Mondrian art style

Apart from these two minor points, every criterion of the market specification was met. Thus there is no need to identify and revise any criteria.

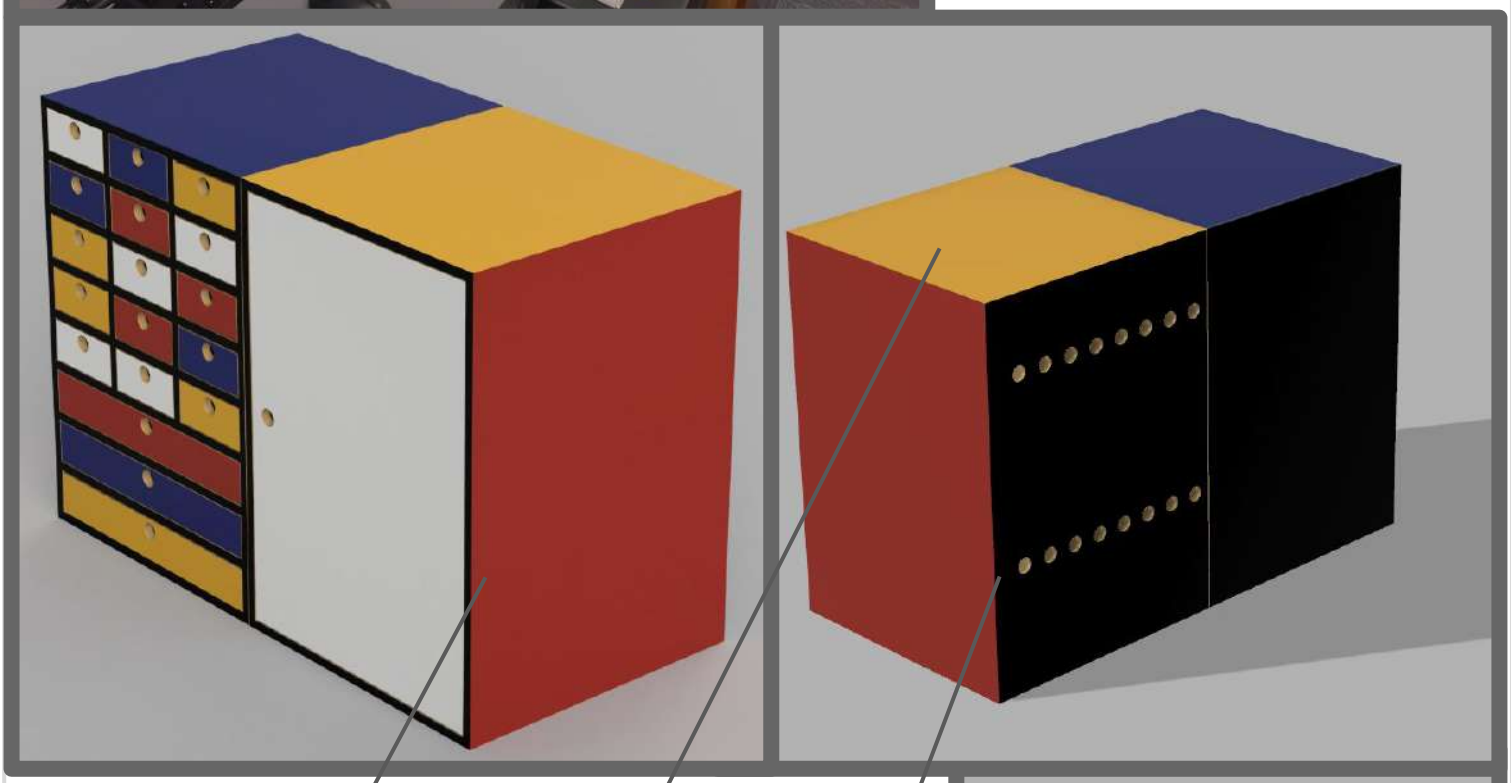
<u>In the Design Specifications:</u>

- No labels are included on the drawers. Even though they are colored which assists with memorability (a very important factor in organization), it would be easy to attach a plastic card holder on the face of each drawer in the space underneath the opening hole. This would make the product more intuitive
- Lacquer was not applied to the cabinet because of time constraints. Given more manufacturing time for a potential upgraded cabinet, this will be very easy to apply at the end
- Because of my client's willingness to pay for the cabinet despite exceeding the preferred price, cost constraints don't need to be improved and this criterion is met as long as other design improvements don't increase the price of the product
- The outer body of the cabinet could be sanded more to reduce the risk of harming the user
- Ventilation was not required since the laptops aren't being charged on the inside. However, if the design is improved upon by including internal laptop charging then this is definitely a weakness to address in the final product. This can be done by simply cutting two rectangular strips around 3mm thick in the back panel parallel to the where the laptops are resting.

Once these improvements are implemented, every criterion of the market specification will be met. Thus there is no need to identify and revise any criteria.

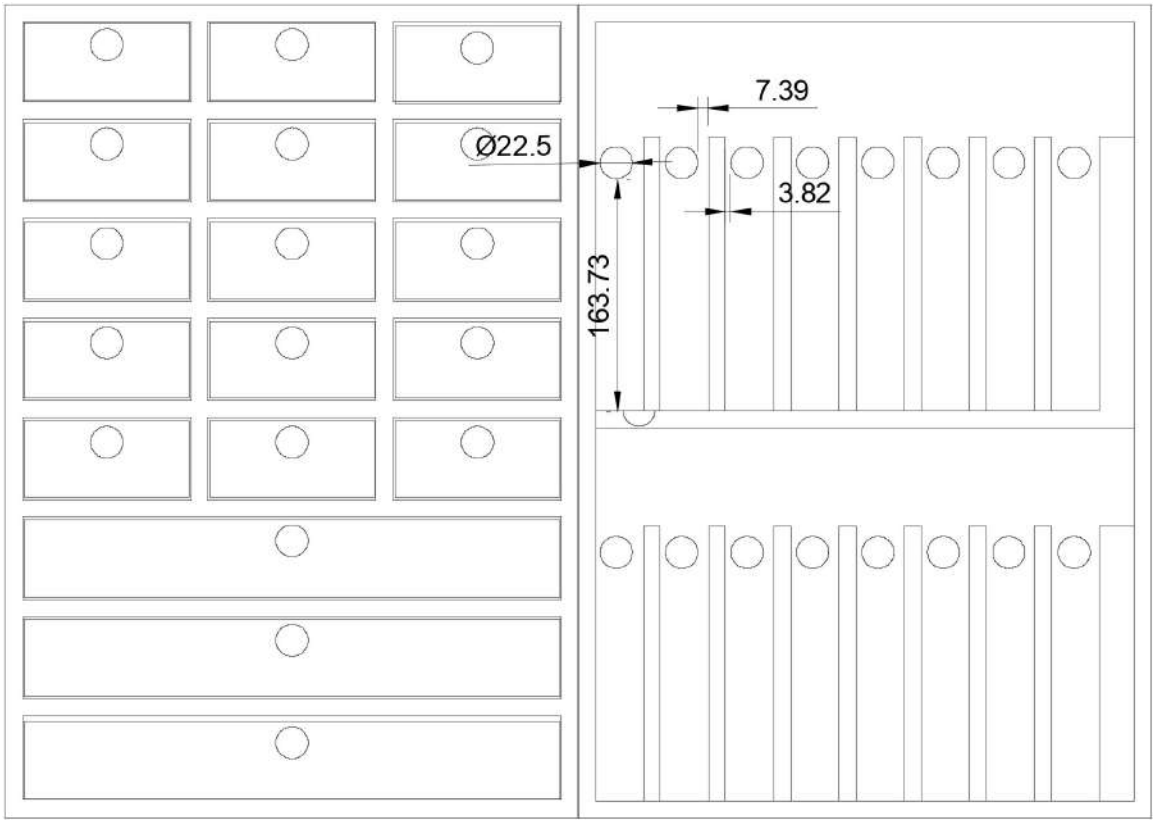
Alterations to Aspects of the Design:

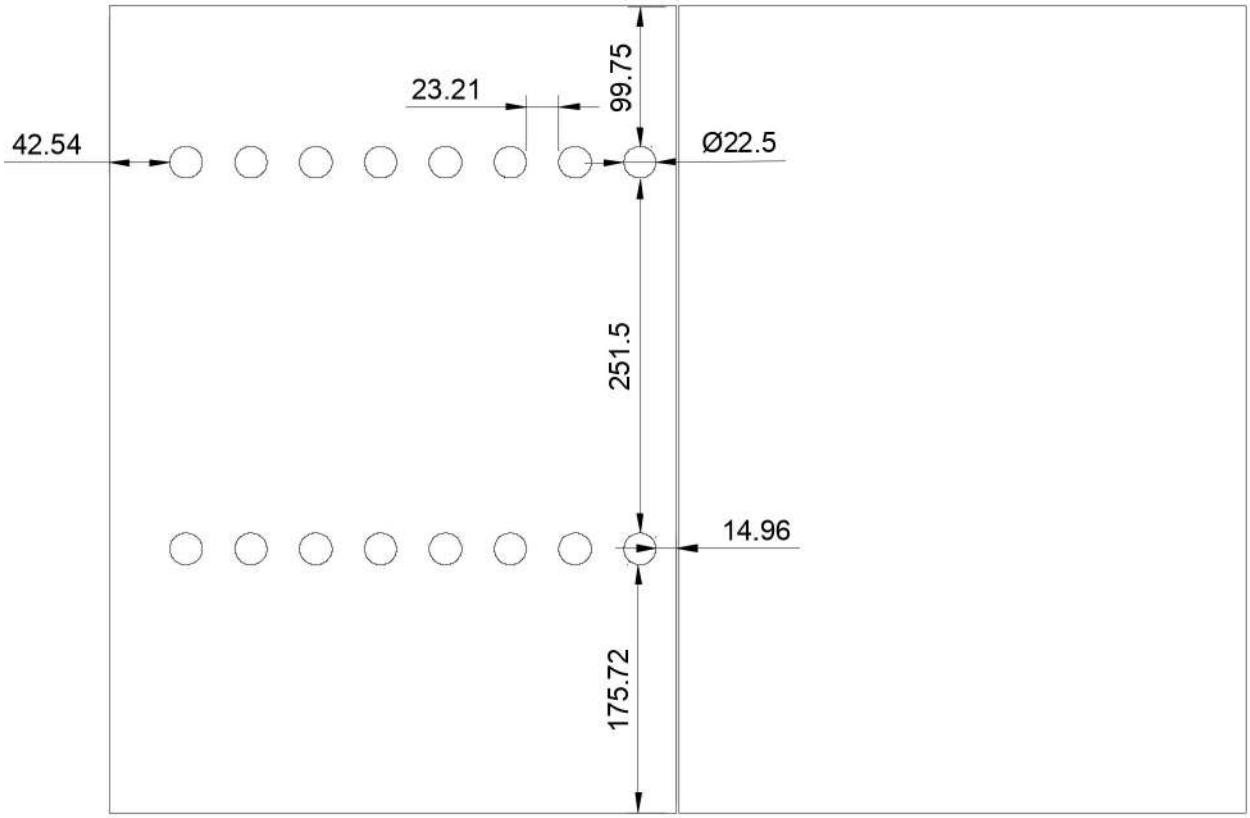
When the cabinet is placed in the office, it can clearly be seen that there is lots of open space for chargers (plugged into the plethora of outlets under the desk) to access the inside of the cabinet. The chargers could discretely reach the interior of the cabinet from behind if holes were added for their accessibility. Thus the feedback from my client can easily be implemented. Below I edited my previous Fusion 360 drawing to incorporate the changes (listed previously) that my client requested I make for future developments. Subsequently there is an orthographic listing the exact measurements for the new aspects of the design to assist in the manufacturing process.



- ❏ The left and right sides are colored red to add more color and better balance the colors on the drawers
- ❏ The top faces of the modules are now colored yellow and blue to match the Mondrian style with primary colors
- ❏ Holes to allow charging wires to easily plug into laptops

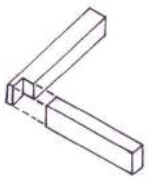
Orthographic Drawing of New Improvements to the Design:

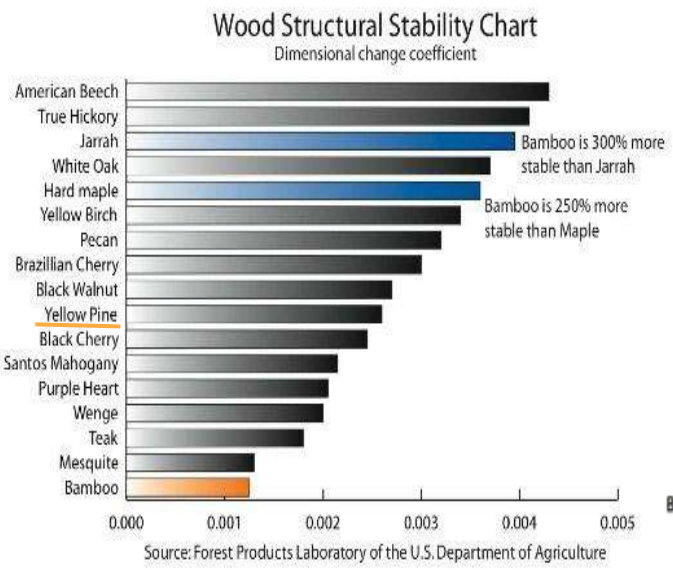


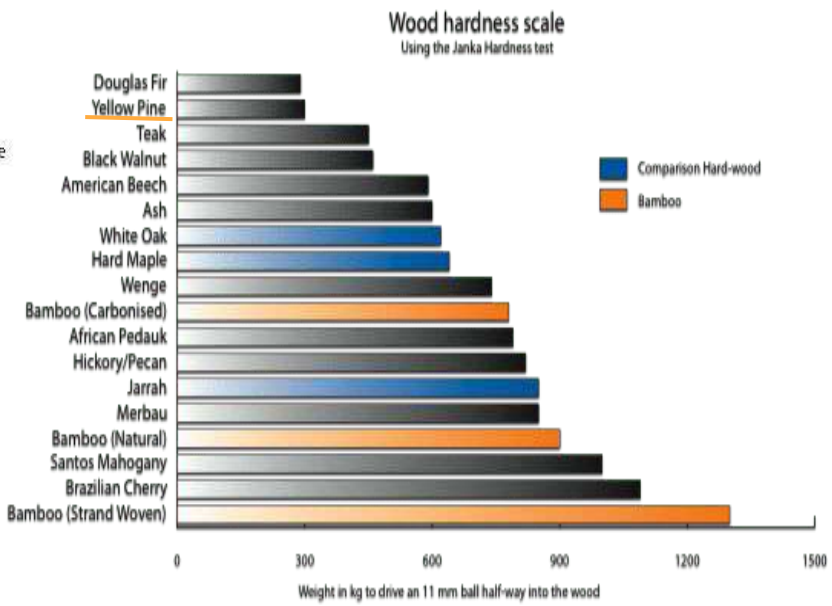


Drilling 22.5mm holes into the back of the cabinet is the best way to allow the charging cables to reach the laptops inside the cabinet. 22.5mm holes were chosen because they provide more than enough room for the 10mm charging cables for Apple Macbook Pros. Every hole in the design is already 22.5mm in diameter, so it would take little to no extra cost to use the same drill for more holes. Thus the orthographic displays the best and most cost-efficient solution. If the cost were to be increased to include an elaborate cable management system, then the product may end up out of the target price range.

Criterion E: Commercial Production

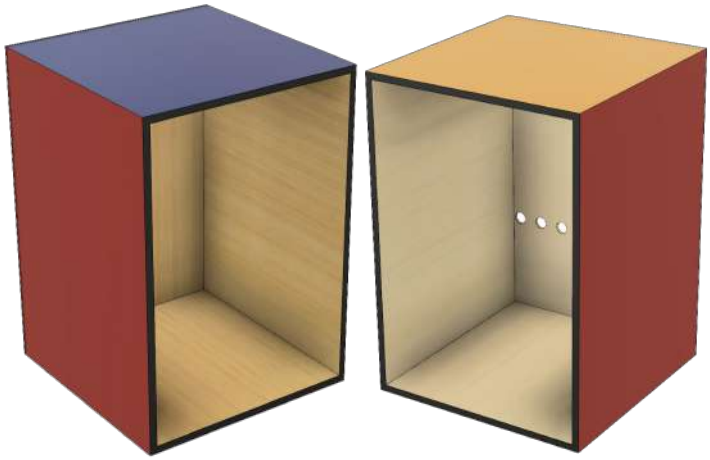
Explanation of Design Modification for Commercial Production		
Original	New	Justification
Using pine wood and acrylic  	Using Bamboo Plywood 	Bamboo offers a sleeker appearance, renewability and one of the highest strength-to-weight ratios of any timber. Bamboo is also one of the most renewable types of timber and its use is how environmental specifications were met. Bamboo is also cheaper to buy than pine, making it an ideal material to construct small furniture pieces out of. Pine wood was originally planned to make up the exterior of the product, and acrylic the laptop divider slabs. In order to keep manufacturing costs low, benefit the most from economies of scale, and to make my product as sustainable as possible, I decided to make the entire product be bamboo. It is important my product is stable and hard in order to guarantee the electronics stored inside will not be damaged if the cabinet fell off of an office desk.
Using wood glue and a nail gun for joints 	Using wood glue on rebate joints 	A rebate joint is relatively easy to construct on top of the extra strength it provides. It is also much more appealing to not see the nails in the wood. This was a problem with my prototype because I wanted to have the wood grain show through the paint in my prototype. If a rebate joint were used with wood glue, then extra support from nails wouldn't be necessary because of the product's small size. I was unable to implement rebate joints into my prototype given my limited skill, however, when manufacturing for commercial production the use of a CNC joinery machine can effortlessly implement flawless rebate joints.





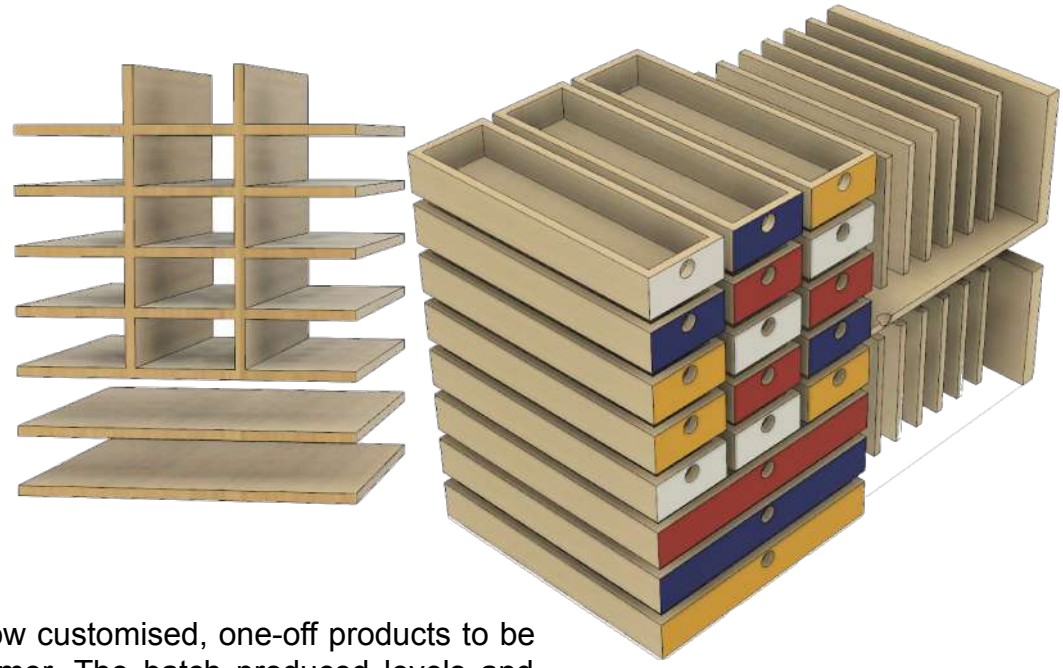
Scale of Production:

I kept commercial production in mind when designing and building my prototype which makes the transition to commercial production very easy. I divided my product into 2 modules (storage drawers and laptop storage cabinet). While differing in use, the modules can be viewed as part of a product family because they have the exact same size and outer body. This allows me to produce my product using all 3 main production methods:



Mass Production

The outer 'shells' of the modules are exactly the same. Thus they are a standardized product and be autonomously produced via an assembly line in large quantities. This will save time since no specialized work is required and allows more to be made. The paint job and whether or not it has holes will be determined by what batch it is used for.



Batch Production

The drawers, levels and dividers can all be batch produced to create the different modules out of the 'shells.' With batch production, one production line can be used to produce both modules of the product which saves time and money, thus allowing more products to be manufactured.

One-Off Production

One-off production will allow customised, one-off products to be made for a specific customer. The batch produced levels and dividers can be used to make customised interiors while still using the same 'shell.' This gives customers exactly what they want while using little to no extra resources. However, the extent of customizability will be limited. For example, the product would still consist of either one or both of the modules and the customer could specify what interior layout of a shell they need to best suit their office space. Whether it's the drawer module consisting of all large drawers (pictured right), or the cabinet module having multiple levels to store iPads (which are shorter than macbooks and therefore more can be stored in the same shell), the customer's specific need would be met and brand loyalty will be developed. The product would sell extremely well if a major IT company like Microsoft or Apple were to develop brand loyalty. The ability to customize large orders would be unique to my product because of its module system, which gives it the potential to become a dominant design.

Justification of Materials Used for Commercial Production		
Material	Component It's Used for	Justification
Bamboo Plywood 	Entire product	The bamboo plant is excellent for plywood production because it grows rapidly, ensuring constant availability of raw materials to keep up with mass producing my product. Bamboo plywood is very cheap, costing around $700 HKD for 2.88 m^2. Bamboo plywood has high moisture resistance which can help protect electronic devices stored in its interior from water damage. Bamboo plywood is also very light. This only comes as a disadvantage when using it for beams or boards, none of which are related to the product. Asia is one of the largest manufacturers of bamboo in the world, so if my factory were to be locally rented in Hong Kong, the shipping cost of purchasing bamboo plywood would be minimal.
Gorilla Glue 	Every joint	PVA glue is preferable for use on woods since it water-based and is absorbed by the pores of the wood. Gorilla Glue in specific is chosen because the product is described as “incredibly water resistant,” and to “dry a natural color.” Being water resistant ensures that water-based paint will not affect the joints, and being a natural color ensures that my manufactured product will not have to sacrifice aesthetic appeal to be extremely durable.

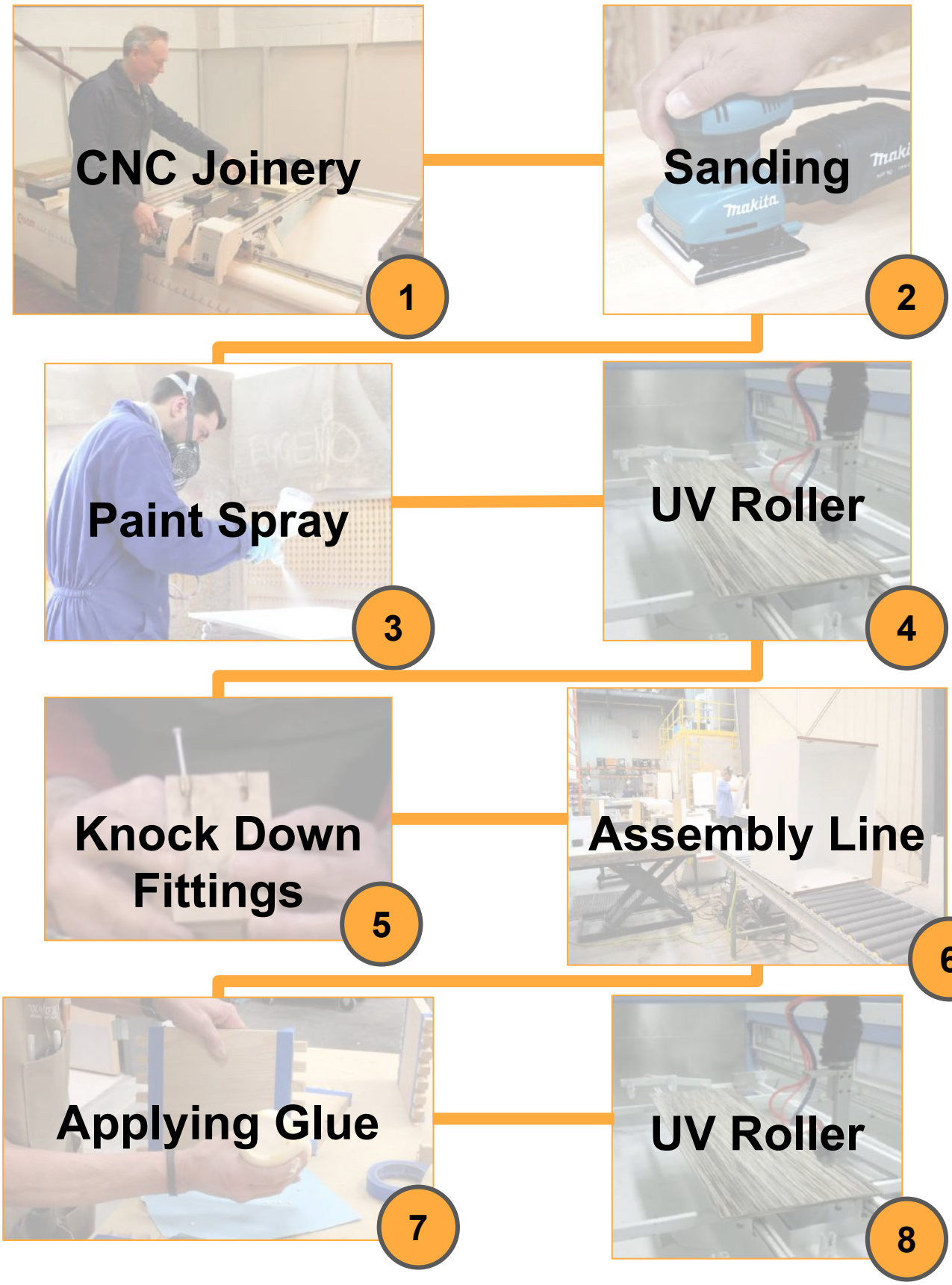
Justification of Manufacturing Processes for Commercial Production		
Manufacturing Process	Justification	Cost
CNC Joinery Machine 	The CNC joinery machine will be used to implement rebate joints into the components so they can easily fit and stay together when moving down the assembly line. It will rid the need for skilled workers to make perfect rebate joints constantly.	Although the setup and energy consumption cost for the machine is very high, the automation of implementing rebate joints saves a large amount of time than if they were done by hand. Thus the process is sped up and more products can be produced.
Finishing Sander 	This process will be done to smoothen the edges and faces of the product after the rebate joints have been made.This part of the production line will be done by hand on the production line by workers. The sanding needs to be done before the wood is painted in order to guarantee a clean coat of paint is applied.	Several units of this tool can be distributed to the workers since the cost of the finishing Sander is relatively cheap compared to the other machinery.
Paint Room 	This room will be where every sanded piece of wood goes through to get painted before being lacquered. Spray guns will apply the water-based paint on a large scale.	Although the setup cost is quite high, the cost will be made up for as time is saved and more products are produced.
UV Roller Lacquering 	Lacquer will be applied to the product with an automated UV rolling coating machine. The movement of the nozzle can be programmed to follow the shape of the completed cabinet since the machine uses an automated spray. To ensure that even the inside of the cabinet gets efficiently lacquered, the UV roller coating machine will be used once after the paint room and a second lacquer time after the glue is applied at the end of the manufacturing process.	It will be very expensive to implement the machine, however, it can be seen as an investment since the process will maximise the efficiency of lacquer application and prevent wastage of lacquer.
Knock Down Fittings 	Knock down fittings will be implemented to keep the rebate joints together and prep the product to be assembled. These fittings can be put together easily and are 1 out of 3 methods of joinery used for the cabinet.	Knock down fittings only use a screwdriver, a drill, a mallet/hammer and other basic and inexpensive tools.

Justification of Manufacturing Processes for Commercial Production		
Manufacturing Process	Justification	Cost
Assembly Line 	An assembly line following a conveyor belt will be mostly run by workers who will have help from machines. This is a process in which individual parts of a larger product are put together in a specific order. All movement of material is simplified, with no cross flow, backtracking, or repetitious procedure. Work assignments, numbers of machines and production rates are programmed so that all operations along the line are compatible. This is the process in which the product is simply put together.	While having a very costly setup, there is no other way the product can be mass produced without an assembly line. An entirely automated workforce isn't required since little to no craftsmanship is required in operating the assembly line, thus workers can be used with consistently good results.
Glue Station 	This process will be done on top of the rebate joints and the knock down fittings in order to easily ensure the product's joints are reliable. This will be done by hand after the product is assembled. It is important the joints are secure because the user needs to feel confident in the product's ability to securely store expensive electronic devices without falling apart. Glue bottles are used to precisely insert the glue into the already connected joints.	Since this is done by hand, it will be very inexpensive to purchase the large amount of glue bottles that will be needed.

The processes of manufacturing listed above are all incorporated to promote lean production. Machines being used for repetitive, high skilled tasks will provide high **quality assurance** on top of high productivity. Both of these are important to lean production because they reduce the chance of a faulty product or wasted manufacturing materials. The 'product family' nature of my product promotes the reuse of materials throughout the manufacturing process. This is done so in order to eliminate as much waste in the manufacturing process as possible, since lean production is usually profitable if implemented early. **The manufacturing processes above also incorporate all components of the design, therefore no special processes are required for different components. This, on top of a lean production, guarantee that my product is commercially viable.**

Assembly Line Diagram:

This diagram will show that the manufacture of the product can be summarized into 8 main steps. Each step is necessary in the production of both modules and the processes have been selected to maximise efficiency and quality whilst minimizing material usage and long term costs. The photos below provide a visual representation of the production line, which conforms to a **Just-in-Case production** method.



Criterion F: Marketing Strategies

Market-Based Pricing:

The market need for my product will determine the sales pricing for my product. Although my product is imitative of others on the market, it combines various features that are not seen together in any existing products. This means I can use a **market penetration pricing strategy** which encourages more people to buy my product and increases the size of the target market. Ensuring my product has a wider range and appeal of features while managing to undercut competitor prices will make my product more aesthetically and financially appealing. Therefore my cabinet will be priced at $3,000 HKD because that is significantly lower than the prices of existing products which will attract prospective customers by offering more for less. However, this price isn't too low in order to maintain an image of high quality.

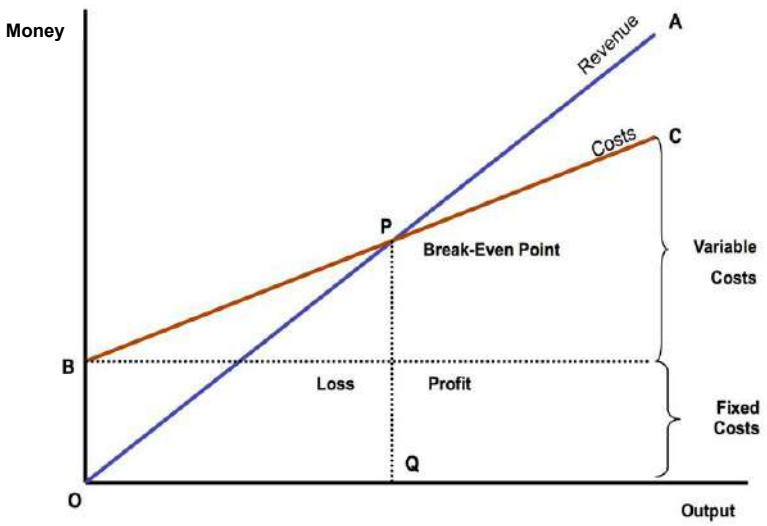
Costs of Commercial Production:

Fixed Costs	Estimated Price for 10,000 Square ft. Factory (HKD)
Machinery setup	$1000/hr for 2 hrs a day = $2000 x 24 working days = 48,000/mth
Factory rent (including utilities)	$100,000/mth
Labour cost	$100,000/mth
Tools	$10,000/mth
Electricity bill	$80,000/mth
TOTAL:	**$338,000/mth**

I chose to open up my own factory based on the potential profit for my product. This way the entire product would be manufactured in one place which raises **quality assurance** significantly. If multiple production plants were used to manufacture the product and a malfunction occurred in one of the plants that resulted in faulty products, it would take an extensive amount of time for the problem to be pinpointed, and every factory would have to halt production until the problem in the manufacturing process is detected. Having a singular production plant that covers the whole manufacturing process makes the company more self-reliant, which could save hundreds of thousands of dollars in crisis management and wasted materials.

Variable Costs	Estimated Price (HKD)
Bamboo	2.88m^2 of bamboo = $700 Sum of component surface areas = 6.9m^2 6.9 ÷ 2.88 = 2.4 2.4 x $700 = $1,677 per unit
Wood glue	$20 per unit
Right-angled hinges	$15 x 6 = $90 per unit
Paint	$40 per unit
Over-coating	$50 per unit
Cost to manufacture	$200 per unit
TOTAL:	**$2,077 per unit**

Break-Even Point:

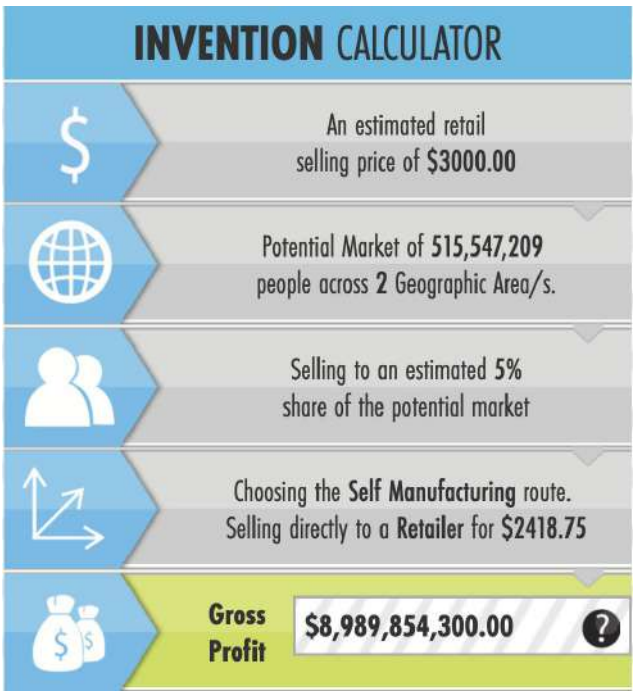


Total fixed and variable costs will be compared with sales revenue to determine the number of units sold at which neither a profit or a loss is made. This is called the break-even point, and is represented on the chart by the intersection of the two lines. I need to know the number of units I need to sell in order to break-even and begin making a profit. This will help me adjust the pricing on my product and potentially re-evaluate the fixed and variable costs in order to suit my scale of manufacture.

Break-even level of output = fixed costs / (price per unit - variable costs)
= 338,000 / (3,000 - 2,077)
= 367 units

It's certain that more than 367 units will be manufactured if the production plan and manufacturing scales are followed. However, whether or not 367 units can be sold is still unknown.

Estimated Profit:



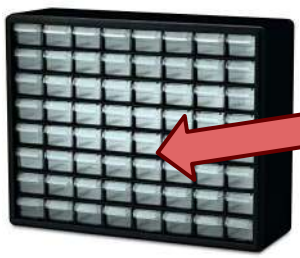
The Invention Calculator predicted my product to generate a gross profit of almost $9 billion HKD when sold at a unit price of $3,000 HKD. However, the Invention Calculator isn't entirely accurate and shouldn't be the sole predictor of success. One of the only options for market size was geographic location, for which I chose South East Asia and **China to stay realistic and save on overseas transport costs, but fortunately as seen on page 6 these locations are two of the biggest in the world for my product.** The other was the number of products bought per household and it is an unrealistic assumption to say that every household in these geographic locations will have my product since not many people would have enough laptops to make proper use of the cabinet. I also input my market share as 5% since the product would be the sole product a brand new company, yet is still unique and innovative to take a higher percentage than 1%.

Statistical Estimation of Profits and Market Size:

Retail Price Per Unit	Estimated Number of IT Offices in China	Market Share (20%)	Number of Products Per Office	Revenue	Total Cost of Manufacturing	Gross Profit
$3,000	~60,000	12,000	1	12,000 x 3,000 = 36,000,000	12,000 x 2,077 = 24,924	36,000,000 - 24,924,000 = $11,076,000

The more realistic calculations above were done by hand in response to the vague prediction given by the Invention Calculator. Assuming my unique product can sell to 20% of the market, a profit of $11 million HKD will be made. Since the break-even point is at 367 units, and 367 x 3,000 = $1,101,000, my product will pass the break-even point by a large amount. Whether or not the numbers in the Invention Calculator and statistical estimation are entirely accurate, the large amount the product will pass the break-even point by provides a viable start to the business.

Comparison to Competitors' Prices to Justify Market Share:



The Akro-Mils 64 Drawer is priced cheaper but only has one basic function and only one drawer size
Priced: $370 HKD

The product is priced reasonably and combines the best features of both products and expands upon them
Priced: $3,000 HKD

The Learniture Laptop Storage Cart is more expensive but only has one basic function and stores less laptops (12). This is because it's made of metal
Priced: $5,000 HKD

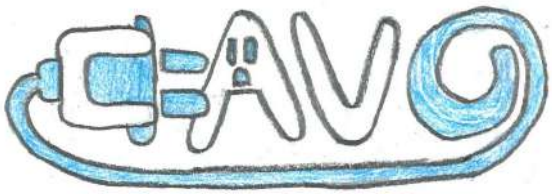
Advertising/Sales Promotion:

Brand Identity

A logo is one of the most important branding methods a business can adopt. A logo can be described as the face of a company/product, and is typically the first thing a customer notices about a company/product. A logo needs to represent the nature of a business so potential customers who have never heard of the business before can get an immediate idea of what it's about. Symbols are a succinct and efficient way of doing this. A good logo should be distinctive enough to be easily recognised and simple enough to be effective at any size, whether it's on a business card or a billboard. I came up with 2 different names for my company and 2 logos for each:

The first, CAVO, means 'cable' in Italian. I chose this word because it is very simplistic and easy to remember. It also represents the nature of my company's product.

The aim of this logo was to appear modern and clean to suit the nature of my cabinet. I achieved this by focussing on symmetry and simplicity.



The aim of this logo was to communicate the electronic and creative nature of my cabinet. I did this by using discrete and widely known symbols to show a plug (forming the letter 'O') plugging in to and outlet in the letter 'A,' along with a curvy, bright-colored underline to highlight the creative nature. I made this in contrast to the first logo above to see which representation best depicted my product.

The inspiration for logo 2

The second, Twenty 77, is in reference to the year 2077. I chose this name because it also is simplistic and easy to remember. It represents the futuristic nature of technology which gives potential customers the impression that my company's product is part of that future.

The aim of this logo was to appear unique while remaining simple to capitalize on the futuristic title. The logo achieved this by combining the number 77 into the last two letters, 'T' and 'Y,' in twenty. This is emphasized with sleek, contrasting colors.

This logo, similar to the above, combines the numbers 20 and 77 to appear unique while remaining simple. The number 77 replaces the hole in the number 0. This is emphasized again by sleek, contrasting colors.

Chosen Name and Logo*

Cavo in the Cambridge Italian-English Dictionary

cavo
adjective

hollow [adjective] having an empty space in it

cavo
noun

cable [noun] (a set of) wires for carrying electric current or signals

I chose the name CAVO (stylized to add emphasis to the small word) over Twenty 77 because I felt it better fit my cabinet. My product isn't as 'futuristic' as the name Twenty 77 would imply to potential customers, an example being the visible wood grain through the paint which is done to give a homely feeling. CAVO is also a more unique, simplistic and easier to remember name. Also, both definitions of cavo suit my product perfectly (hollow referring to the cabinet interior) I chose logo 2 for CAVO because I felt it is more unique than logo 1, and again better fits my cabinet. The simplicity of logo 1 made the nature of the company very vague, as in that logo could be used for any other type of business/service. I scanned, traced and then edited logo 2 in CorelDRAW to make it more tidy and with better colors.

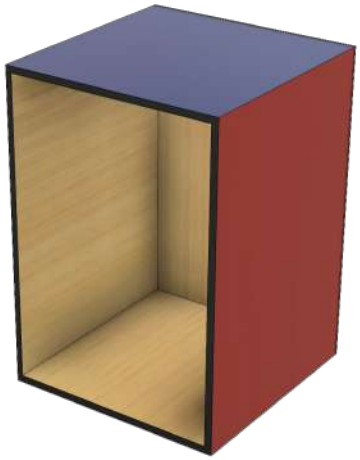
Promotional Strategies

IT office workers such as my client are generally very business oriented people, and as such I developed business cards as a method of personal selling. Since my product offers customization based on client requests, a business card is a great way to spread the name and contact information of my business for potential clients to get in touch. There are no downsides to having a business card. They are an inexpensive etiquette that demonstrates professionalism and are easy to carry and distribute. I could even include one in every unit that I sell, so clients that purchase my product from a retailer can know that the option to get in touch and request a custom product is available. The featured slogan uses alliteration and short clauses to stay memorable.

Front

Back

Product Family:



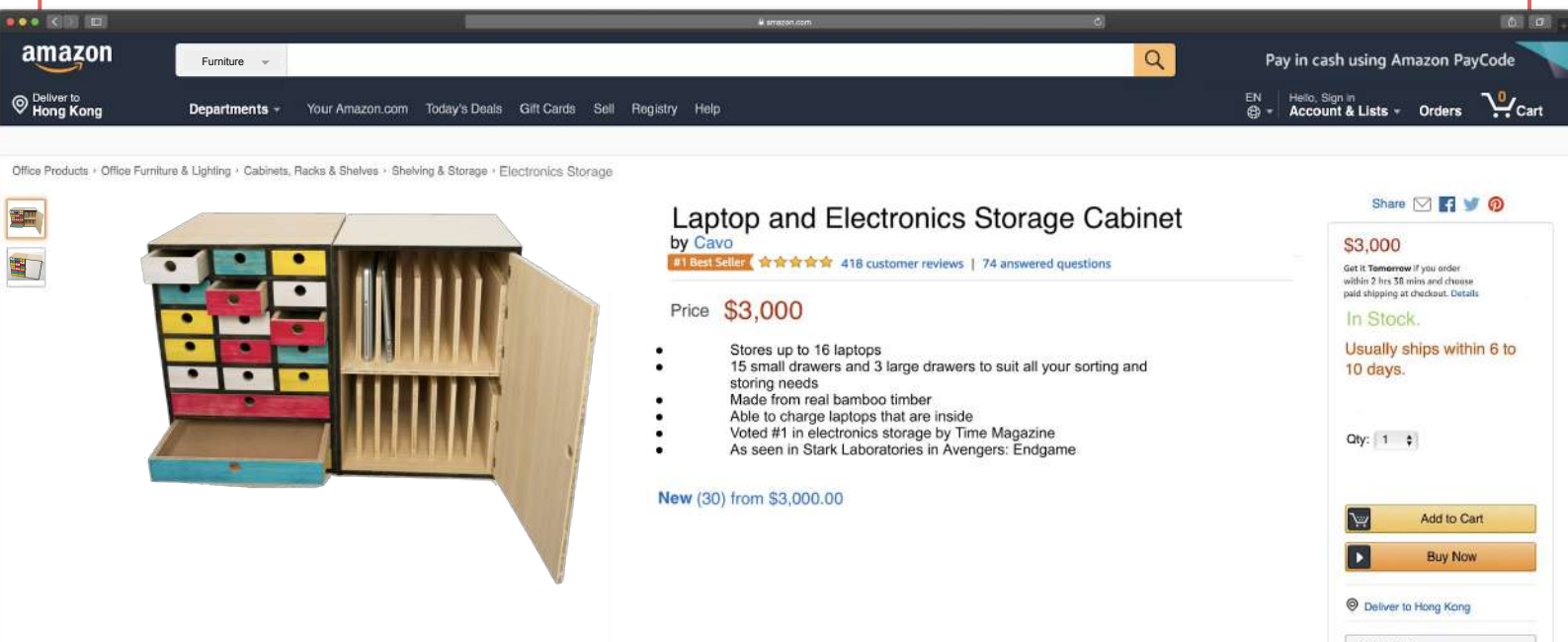
The module system of this product gives it several possibilities for expanding into a product family. As mentioned on page 37, the modules Could be used for more tech-based functions like iPad storage. Another Idea is expanding into the sole furniture market. With no extra redesign and basically no extra cost, the modules could be fitted with different combinations of drawers and be marketed as a bedside table, a file cabinet, etc. While there is more competition for these products, the profits from the laptop and electronics storage cabinet would completely remove the worry of drowning in the extensive competition the furniture market has.

Pricing Strategy:

Cost-Plus Pricing	Competitor-Based Pricing	Penetration-Pricing
A markup of $923 HKD will be added to the manufacturing price ($2,077) per unit. Hence the product is sold at $3,000 and helps guarantee profits for the company	As seen earlier, my product is sold at a much lower price than competitors', but also not too low in order to benefit from cost-plus pricing and to not let the customer mistakenly think a low price means a low quality product.	As mentioned earlier, my product is priced very low in comparison to competitors'. Given the multitude of functions it has over their products, a penetration pricing strategy should guarantee more units are initially sold

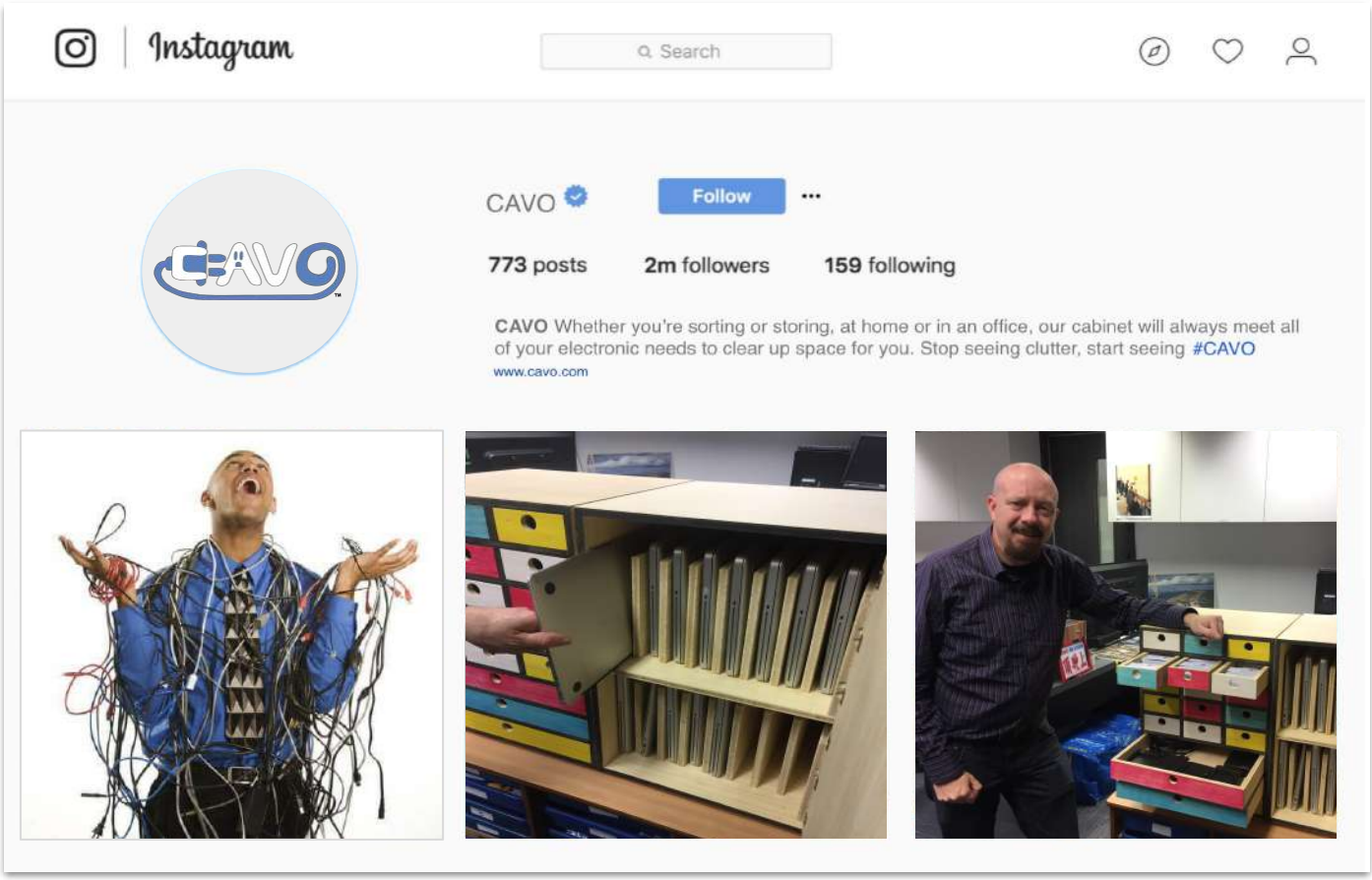
Internet Marketing Strategy:

Online Retailers



Because of my tech-focused audience, the likelihood of a potential customer purchasing my product online is far greater than from a physical retailer. Thus popular websites such as Amazon and eBay will be perfect for reaching my target audience. The user base for these websites is far greater than the user base for my company's website, therefore my product will reach a wider audience and sell more.

Social Media



The screenshot on the previous page shows off CAVO's Instagram page as it would be seen by public social media users. The purpose of using social media is to attract the target market of IT workers and people generally interested in technology and furniture for free. Anyone who views the page is a potential customer. The relative of an IT office worker may see the page and recommend it to them to reduce the fire hazard in their office and promote a healthier working environment. The overarching theme of the content that will be featured on CAVO's Instagram page is centered around promoting the multiple uses and high quality of the product. The sample images above demonstrate the problem CAVO solves, one of the uses for CAVO and customer satisfaction. The 'innovative' theme of the page aims to promote conversation amongst potential consumers to raise the public image of CAVO so potential customers will start becoming real customers.

Packaging

The packaging for the product is a simple cardboard box with the CAVO logo on the side. Since the product will mostly be purchased online, and physical retailers display furniture out of its packaging on store shelves, there is no need for the cabinet to have a design on its package and thus money is saved. It will also be easier to reuse cardboard since no design needs to be printed and instead a CAVO sticker can be placed. When being shipped overseas, the product would come in individual pieces with instructions on how to put it together. This will be very easy for the user to do since knock down fittings hold the product together which means it can be easily put together and taken apart. The product will also be protected by bubble wrap to maintain **quality control**.