Minimalistic Desk Shelf

Design & Technology NEA

Candidate name: David (Fletchworks)

Personally identifiable information removed for privacy.

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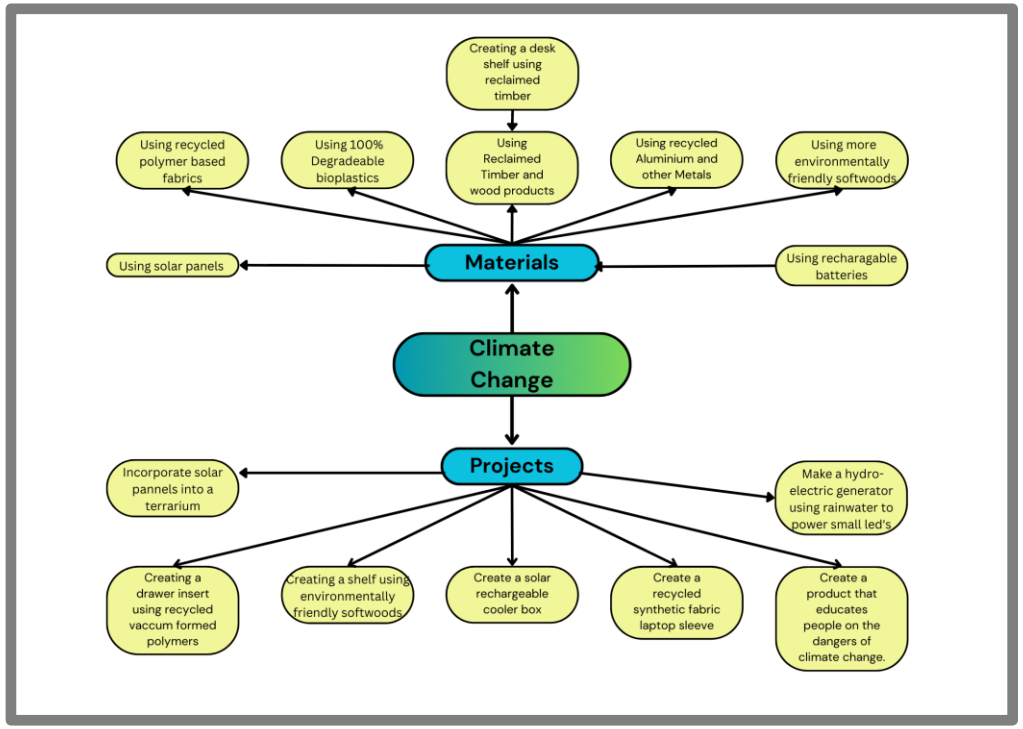
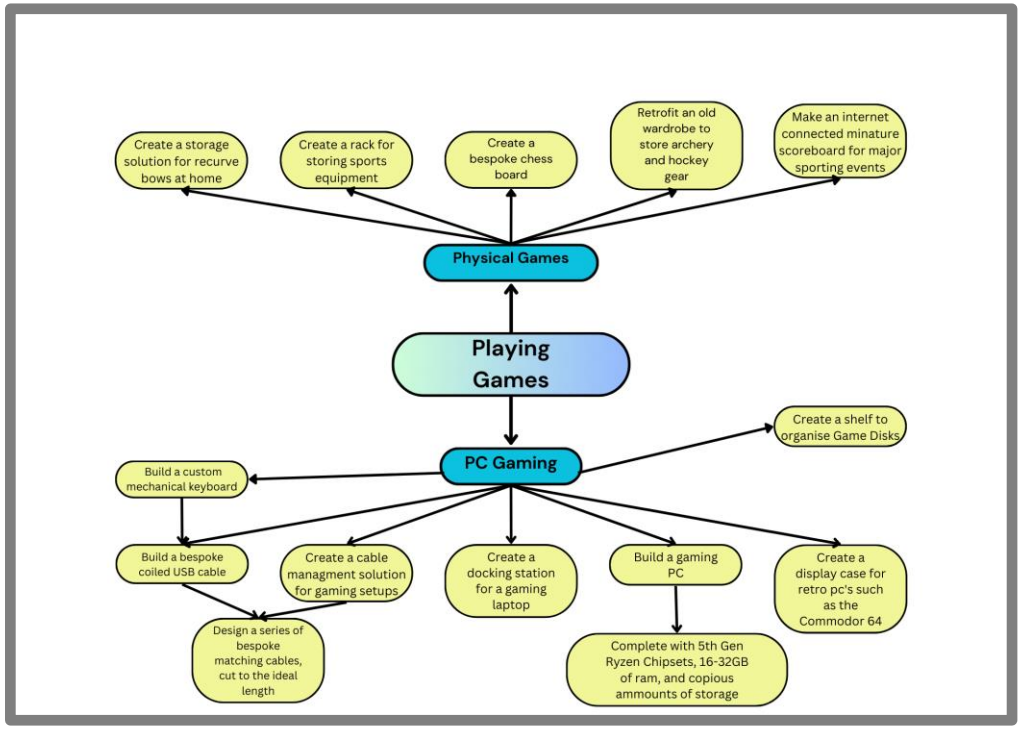
Investigating Design Contexts



Climate Change

An interesting design context in the sense that it creates an opportunity to use unique materials and manufacturing methods. Potential products could utilise reclaimed or recycled materials or educate people on the dangers of climate change.

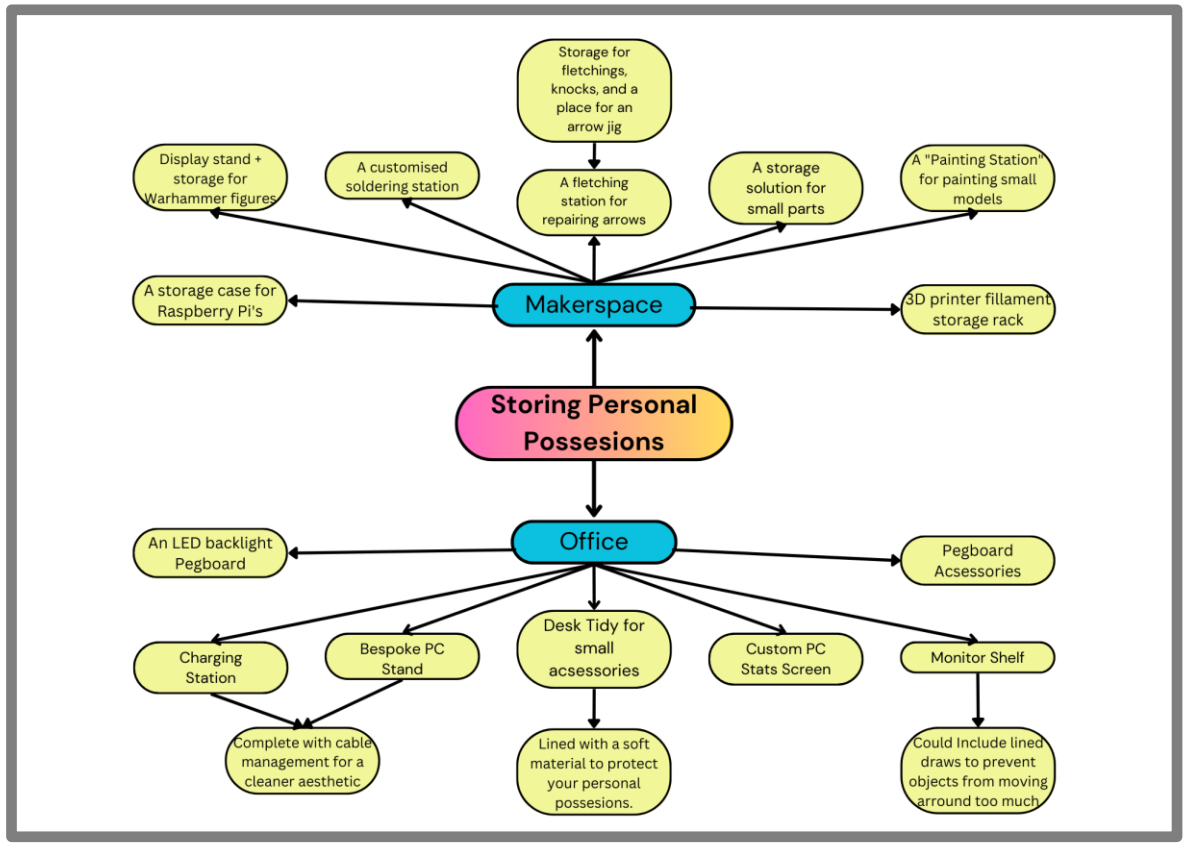


Playing Games

Offering the opportunity to create a product revolving around PC gaming *(such as desk organisers or custom keyboards)*, or sports/activities such as hockey, chess, archery, and more, this context is unique in terms of the relatively large scope, which is open to a variety of interpretations.

Spider diagrams made using Canva – A graphics design tool.

Preferred Design Context



Storing Personal Possessions

Upon creating mind maps for each of the 3 design contexts, it became clear that storing or securing personal possessions would be the idea one.

With such a wide scope of potential projects, it would allow me to design the ideal product for my client, with no caveats or limitations.

Some potential projects could include:

- *A bespoke desk shelf, designed to fit underneath a monitor, that would create space for laptops, and smaller items such as cables or USB sticks.*
- *A charging station, customised to the exact dimensions of the client's devices and designed in line with the client's preferred aesthetic.*
- *A more niche product that caters to my intended client's hobbies. A unique arrow fletching station complete with an arrow jig and small drawers to store supplies and arrow parts.*

Summary:

Storing personal possessions is the ideal NEA context thanks in part to the large scope of potential projects. Potential products include a bespoke desk shelf, a charging station, and a niche fletching station for archers.

Spider diagrams made using Canva – A graphics design tool.

Client Interview

Q1) What equipment/tech do you use daily?

I own and regularly use a customised gaming setup, resulting my desk being filled with everything from gaming monitors to a gaming pc, complete the associated peripherals.

Q2) What issues do you have with this gaming setup?

Personally, I feel that my desk is rather cluttered with cables and small gadgets that I need quick access to, but that I do not use regularly. In addition, I find that I am wasting valuable space underneath my monitor, since it is mounted on a rather bulky stand.

Q3) Do you have any ideas as to how to rectify these issues?

Upon looking online, I found that many people in a similar situation to myself use desk shelfs. They occupy the space underneath your monitor, which is usually unused, while creating storage space for small items, all at an arm's reach.

As such I would like to have a customised desk shelf designed to meet my needs.

Q4) How would you like this product to look like?

To integrate a desk shelf into my setup, it should be made of solid wood, preferably reclaimed to save on costs, MDF where appropriate to further save on costs, and 3D printed parts to help facilitate a unique design. I would also like the shelf to be minimalistic in nature, so that it would blend in seamlessly.

Q5) Are there any features you would specifically like?

I would like to have a drawer built into the design to store and organise some of my tech gadgets and other clutter related to my setup. Some way to charge my devices would also be a useful addition.

Q6) How would you prefer to organise your gadgets, and any associated cables?

It would be great if the drawer could be organised with multiple dividers for my gadgets, padded or felt lined to protect the items inside. As for cables, channels or grooves could be placed onto the rear of the shelf to hide them from view.

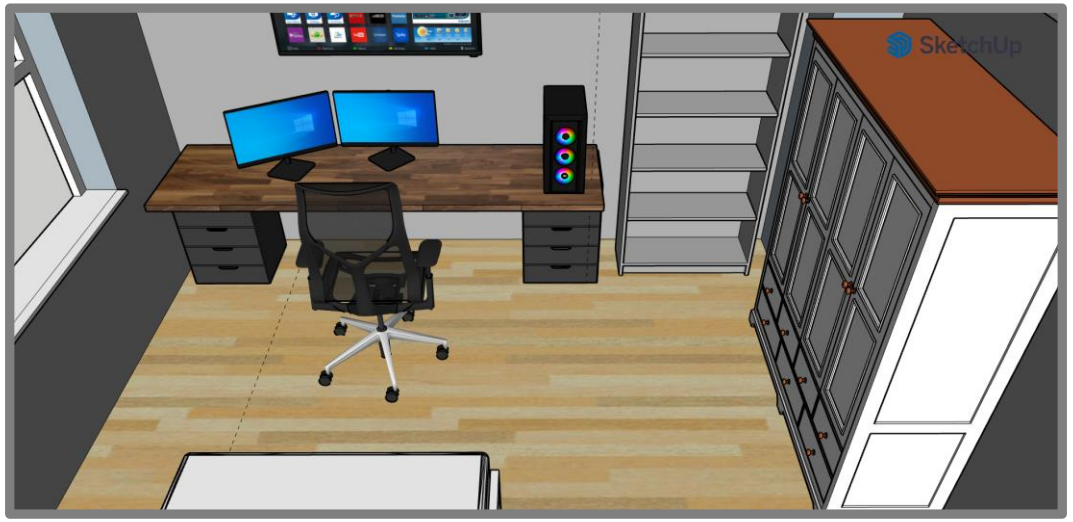
Summary:

To solve the client's issues surrounding desk clutter and a lack of storage, the best solution would be a bespoke desk shelf, fitted with drawers for storage and charging solutions for the client's devices.

This desk shelf should be constructed with the environment in mind, such as using reclaimed wood, MDF, and 3D printed parts (using environmentally friendly filaments).

It should also be noted that the client would like, to an extent, dividers within the drawer to ensure their gadgets are well organised.

Client Profile

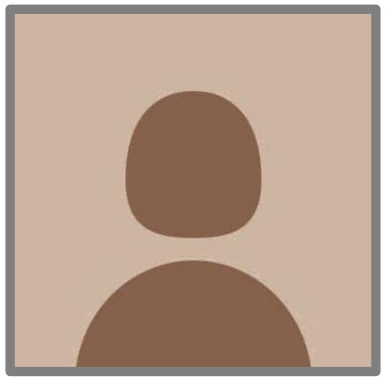


3D render of Client's location post-renovation. Rendered in Sketchup with the use of 3D models sourced from 3D Warehouse.

Client's Location

Using a combination of measurements taken onsite, and 3D models downloaded from the Sketchup 3D Warehouse *(Which Includes the bookshelf, desk, all screens, PC, wardrobe and bed),* I have generated a 1:1 scale replica of the Client's room. In the top left of the bedroom, you can see the client's preferred location for the product, their desk setup. The product should be located underneath the rightmost monitor *(at a measurement of 27" diagonally)*, the one directly facing the client, and not off to an angle. This allows for easy access, as well as a convenient place for the client to store their laptop. The shelf should match the rest of the desk.

My Client – Not A Person



Since the COVID-19 pandemic, my client has been working from home, and so, out of necessity, created a desk setup to meet his basic needs. This desk setup has evolved over time to become more efficient, comfortable, and unique to his needs. As a part of the constant upgrades to this setup, my client would like a way to organise their items in a space efficient manner. As such, a desk shelf would be the perfect choice, creating a space for them to store small items, such as cables and USB sticks, while also creating space for their work equipment, such as their ThinkPad laptop.

My Client is currently in the process of redecorating his room, and so this product will fit into this renovation. The CAD render is a reimagination of the space, and so some things will be subject to change.

Summary:

My Client, Mr Not A Person, would like a desk shelf for his productivity/gaming setup, to enable them to store small items and their laptop. The product should be located underneath the 27" monitor, and span the width of it, slightly extending beyond it if possible. The desk shelf's appearance should match the rest of the setup, so earthy wood tones should be matched with dark grey to be in accordance with this. As this setup acts as a professional desk, as well as gaming, the shelf should have a professional appearance, almost minimalist if possible.

Existing Products

Product	Analysis	Product	Analysis
	Grovemade Desk Shelf System: $190-390 Widely regarded as the premium option amongst Desk Setup enthusiasts, this Grovemade desk shelf features a variety of premium finishes, such as solid plywood, or matte powder coatings. The shelf features an open-air design with lots of storage.		Oakywood Desk Shelf: £150-190 Minimalistic by design, the Oakywood Desk Shelf offers little in the way of features or storage options but makes up for it with a range of finishes and a set of rather unique aluminium legs to support the whole product.
	IKEA SIGFINN Monitor Stand: £25 A simplistic and affordable product, both in terms of materials and design ambition, this IKEA Monitor Stand is a rather functional design. Finished with a bamboo veneer, with the option for a matte white finish, this stand is useful for smaller setups.		Satechi Aluminium Monitor Stand: £40 Known for making USB Hubs, Docking stations, and other accessories, this Satechi unibody Monitor Stand features a unique and somewhat minimalistic design, being constructed exclusively from aluminium.
	IKEA ELLOVEN Monitor Stand: £29 Featuring a two-tone veneered and painted design, this Monitor Stand features a variety of useful features, such as a cable passthrough hole on the back of the stand, and a pull-out drawer for storing small items.		The Range Monitor Stand: £29 Constructed from painted MDF, this Desk Shelf/Monitor stand integrates two useful drawers for storing small items.

Credits: Google Images, Various Sources, images.google.com. Accessed 2023. Various sources downloaded from Google Images, publishers unknown.

Thoughts + Ideas:

Personally, I find that the designs manufactured by Grovemade and Oakywood best represent how I, and most importantly, the client, would like the product to look, with regards to the material choices and minimalistic aesthetics.

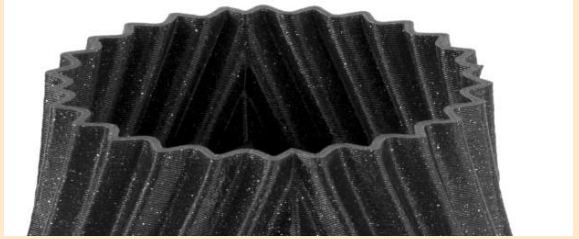
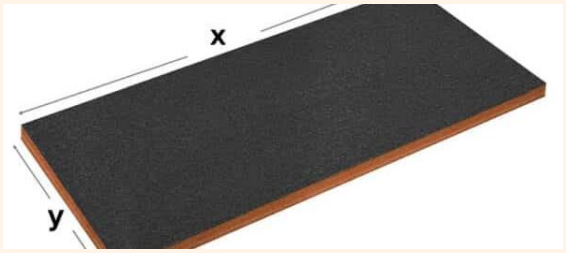
As for function, the Ikea Elloven and The Range Monitor Stand offer the most in terms of storage and practicality.

The Satechi Monitor Stand and Ikea Sigfinn Monitor Stands were interesting in design but were too lacking in functionality.

Summary:

From an overall perspective, the minimalist aesthetics from the Grovemade and Oakywood Desk Shelfs were superior, however the functionality of the more affordable offerings, most notably the Ikea Elloven better fits the client's needs.

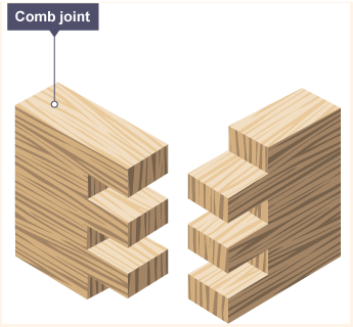
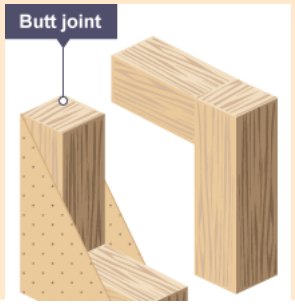
Exploring Materials

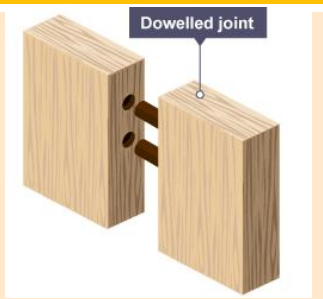
Material	Analysis	Material	Analysis
	Veneered Plywood: Purchasable in large sheets, veneered plywood would offer all the same properties of normal plywood, but with a decorative veneer for improved aesthetics.		3D Printed PLA: Available in a variety of colours, textures, and surface finished, 3D printing can be used to manufacture a variety of parts with complex geometry in a matter of hours. It could be used to make handles or small parts with high accuracy.
	Medium Density Fibreboard (MDF): Purchasable in very large sheets, MDF acts as an affordable manufactured alternative to hardwoods. Aesthetically speaking, MDF is an unattractive material, but if finished appropriately, could be a useful material.		Shadow Foam: Available in a variety of sizes and colours, Shadow Foam is a unique product consisting of layers of heat-bonded foam, that can be used to create custom foam inserts. These could be used to protect smaller items from damage.
	Reclaimed Timber: More affordable than virgin timber, yet more expensive than manufactured boards, when treated correctly, Reclaimed Timber can be a great option. It can offer the best aesthetics, and superior strength.		

Summary:
Upon analysis of various materials, it can be determined that Veneered Plywood strikes a good balance between affordability and premium aesthetics, and so could be useful in the construction of the client's desk shelf. MDF could be used for some internal parts, such as drawers, dividers or backings to save on the costs associated with the use of some other materials. To meet the clients' requirements for the safe storage of personal possessions, using Shadow Foam inserts could reduce the risk of damage to them.

Credits: Google Images, Various Sources, images.google.com. Accessed 2023. Various sources downloaded from Google Images, publishers unknown.

Exploring Joints

Joint	Notes
	Mitre Joint: A mitre joint is a joint consisting of two pieces joined together, cut at 45-degree angles, so they form a right angle when joined. They are known for being aesthetically pleasing
	Finger Joint: Finger Joints, sometimes known as comb joints, are made by manufacturing opposing grooves that interlock when joined together. They are often used when creating a laser cut piece, as they are simple to design and manufacture.
	Butt Joint Butt joints are widely regarded as one of the simplest joints, consisting of two pieces simply put next to each other, and held in place with glues, nails or screws. They are simple but not particularly strong.

Joint	Notes
	Dowel Joint: Dowel joints are often used when accuracy and strength are considered important. In this joint, wooden dowels are glued into sockets present on both pieces. They are complex and can be difficult to manufacture but may be worth it depending on the project.

Summary:

As a sizeable portion of the desk shelf will be made from veneered plywood, laser-cut MDF, and perhaps even reclaimed solid timber, attention must be paid to the types of joints used to make the desk shelf, both to support the weight of the items on it, and to ensure a clean and minimal aesthetic.

As such, using a combination of Mitre joins and Finger joints would be ideal. For the main body of the shelf, using Mitre joins for their arguably superior aesthetics and strength. As for any potential drawers or dividers, using comb joints would be best since they are easy to manufacture, by simply inputting the required pattern into a laser cutter.

Credits: *Wood Joints*, BBC, https://www.bbc.co.uk/bitesize/guides/zdj8jty/revision/9. Accessed Nov. 2023.
A variety of images depicting various wood joints

Exploring Wood Finishes

Finish	Analysis	Finish	Analysis
	Lacquer Finish: Usually made from natural resin, lacquer acts as a clear and often glossy coating that hardens when dried. It is often used in woodworking to protect a surface from damage.		Wood stains: Made using pigments and dyes dissolved in a solvent, stains can be used as an effective tool to enhance or alter the colour of a piece. They are available in a range of colours, from walnut to vibrant hues of blue or red.
	Varnished Finish: Varnish acts as a protective woodworking finish, available in a variety of colours and textures, such as glossy or satin, clear or with pigment.		Paints: Available in an expansive range of hues, tones, and finishes, painting wooden projects can often be aesthetically pleasing. Often, paints can be made using acrylic, water, or oil bases.
	Wax Finishes: Waxes, often beeswax, are often effective in achieving smooth and resilient finishes on wooden pieces, specifically furniture. It is often naturally occurring, non-toxic, and doesn't alter the colour of a piece.	Summary: As made clear by the above options, there are a variety of options regarding surface finishes for the client's project. For the veneered plywood exterior, choosing a relativity dark stain, to emulate the client's existing furniture is of the essence. As for a protective finish, upon further discussion with the client, choosing a smooth, but not glossy finish is important, so Beeswax should be used. As for any MDF used, it should be painted used a matte grey tone, to intergrade with the existing furniture.	

Credits: Google Images, Various Sources, images.google.com. Accessed 2023. Various sources downloaded from Google Images, publishers unknown.

Specification + Design Brief

Area of Interest	Specifications and Constraints
Dimensions + Ergonomics	- From an ergonomic perspective, the desk shelf should **not be too tall**, as to not place the monitor at an uncomfortable position, no taller than ~20cm. - The shelf should **ideally be 1m wide** as to be of a good proportion, relative to the desk.
Materials	- The desk shelf should be built out of **veneered plywood**, with **MDF** used where appropriate to save on costs, such as drawers and other internal parts. - **3D Printing** should be incorporated where possible to ensure that the piece is bespoke to the client, and to reduce costs of machining complex parts.
Additional features.	- If design allows, adding a **cable passthrough hole** could be a useful addition to the product to aid in organising and charging the client's device. This is optional.
Storage	- The desk shelf **must include space to store small items of importance to the client.** - This should ideally take the form of drawers, but shelves could also be a viable option.

Area of Interest	Specifications and Constraints
Aesthetics + Appearance	- As the client's current desk is a rather minimalistic one, the desk shelf should reflect this with **a modern design**. - The design, however, **should not be too simplistic,** as this would detract from the modern and tasteful design of the client's desk setup.
Cost	- The design, if possible, **should cost less (in terms of materials) to produce than competitors.** - An ideal budget for materials would be **£120-130,** as to undercut major competitors, for example, the Grovemade desk shelf. making this piece more viable for clients wishing for a more affordable option.

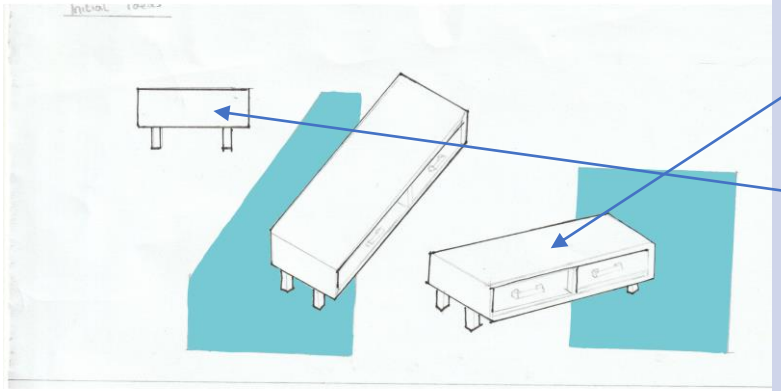
Design Brief:

For my client, I will design a bespoke desk shelf to integrate into their existing desk setup to help organise their belongings and add additional functionality to what can only be described as empty space. It should be ideally 1m wide and made from some form of wood. It is encouraged to use 3D printing where possible to ensure that this piece is bespoke to the client.

A	B	C	D	E	F
	X				

Initial Designs

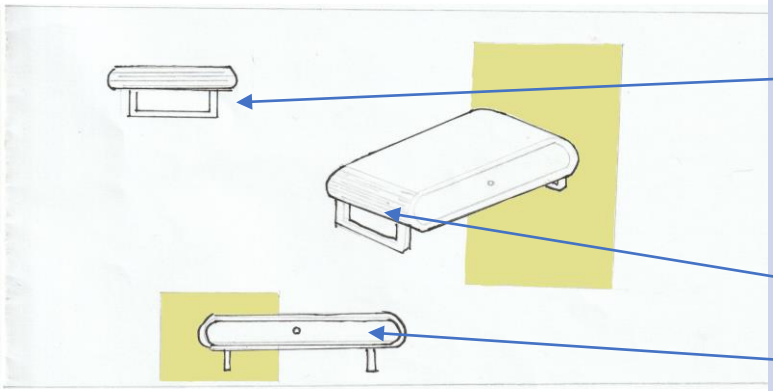
Design 1



Two drawers to store personal possessions

Sleek, minimalistic side profile

Design 2

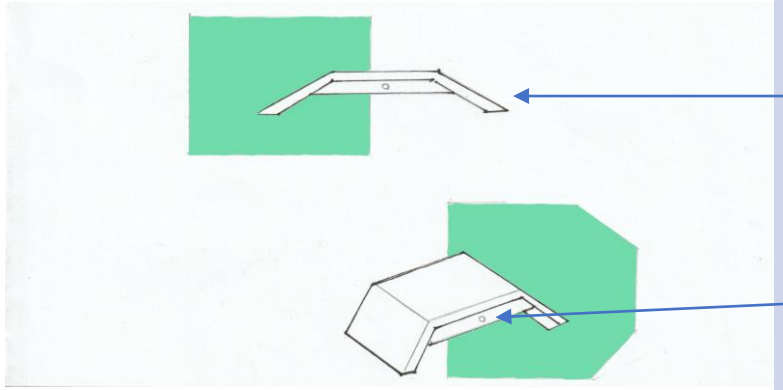


Legs manufactured from Aluminium profiles

Made from kerf-bent MDF, using a laser cutter

A single, functional drawer, for storing small items

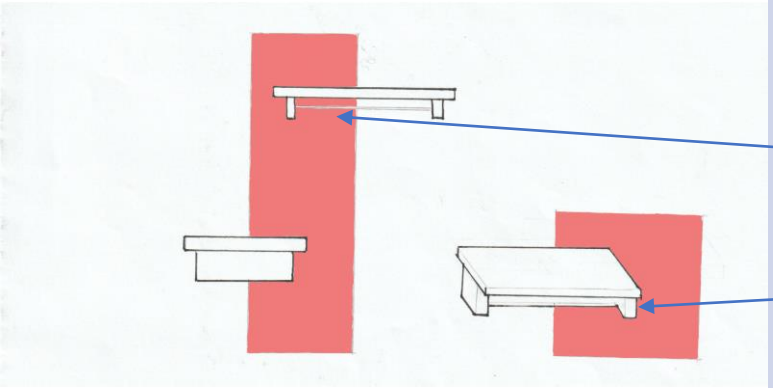
Design 3



Constructed from 3 acrylic panels, joined with 3D printed brackets.

A single drawer, flush with the body, to store items

Design 4



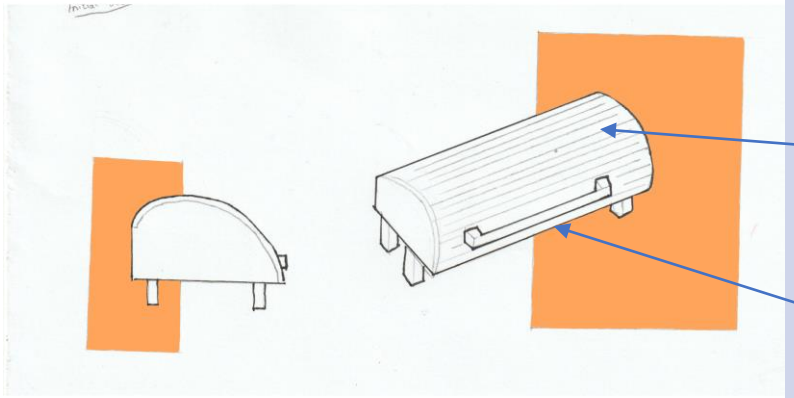
A simple ledge to store, and display, personal possessions.

USB ports integrated into the legs for added functionality

Initial Designs created using hand-drawn sketches, digitally edited to add coloured backgrounds with the aid of Adobe Fresco

Initial Designs

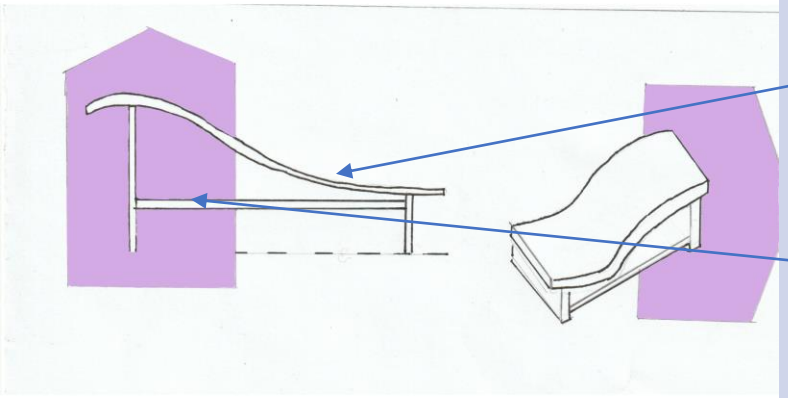
Design 5



A hinged cover, make from kerf-bent MDF, protecting shelfing and organisers underneath

1 large, 3D printed handle to open the top cover.

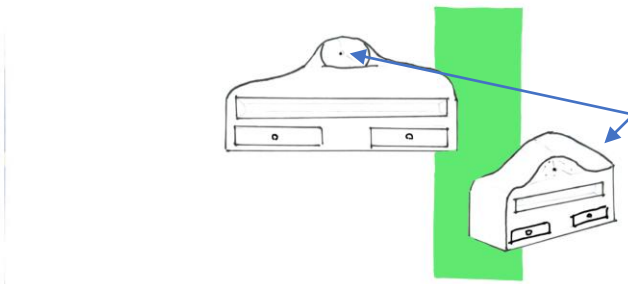
Design 6



Top piece made from formed marine plywood, to create a wavy pattern

A simple ledge to store, and display, personal possessions.

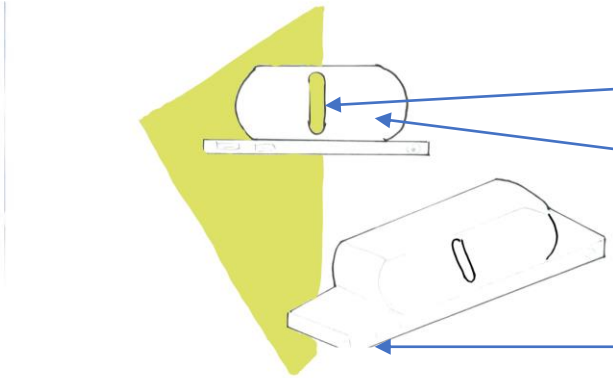
Design 7



Constructed from kerf-bent MDF to reduce manufacturing complexity.

Analogue clock to complete the antique aesthetic.

Design 8



Unique vertical laptop slot for safe keeping

Made from formed marine plywood

USB ports integrated into the solid oak base.

Initial Designs created using hand-drawn sketches, digitally edited to add coloured backgrounds with the aid of Adobe Fresco

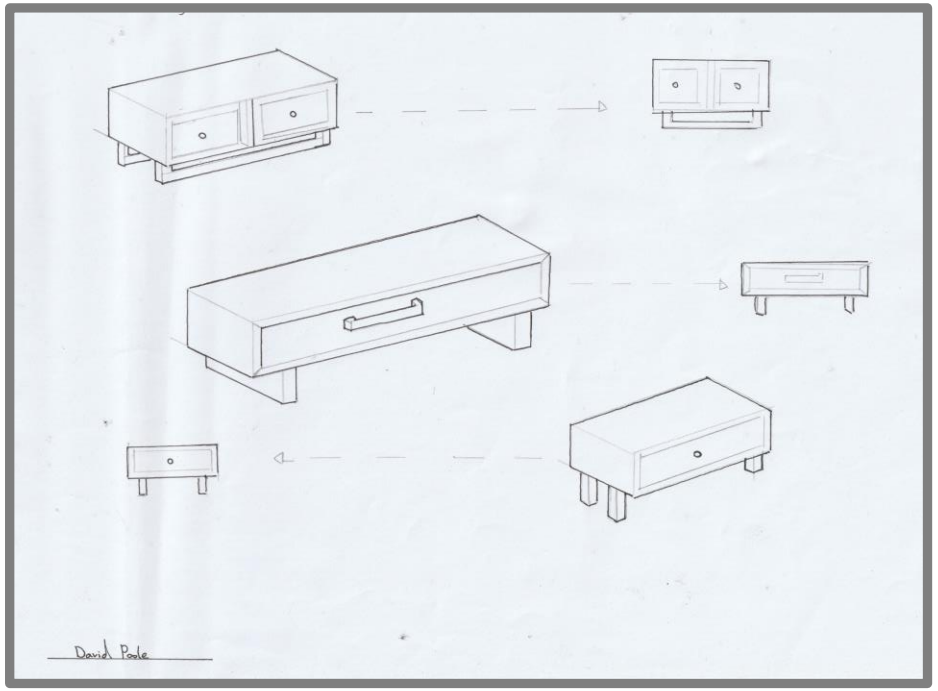
Feedback of Initial Designs

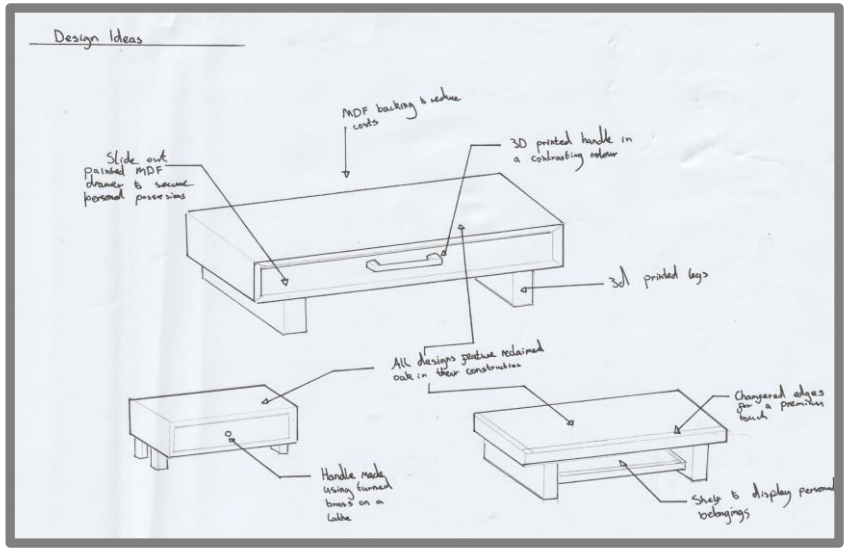
Design	Client Comments	Evaluation
1	*" I love the practicality of having two drawers to separate and sort my items, it looks great aesthetically too, albeit a touch bulky "*	Design 1 features two slide out drawers, made from a laser-cut MDF, housed within a mitre-jointed enclosure, using a birch-veneered plywood. A simple set of 4 legs suspend this desk shelf off the desk. To satisfy the client, the design could be reduced in height to reduce the apparent 'bulkiness'.
2	*" The curved sides of this design look nice, but I'm worried that the complexity of the design might make it too expensive to build "*	Design 2 builds upon the foundations of design 1, trading a mitre-jointed plywood exterior for a MDF construction, kerf-bended and veneered to create a curved appearance. A curved drawer slides out, revealing the contents within. Unfortunately, the clients' worries are justified, the additional complexity makes it expensive and complex.
3	*" This design looks a little tacky, and is too small to store all my items "*	Design 3 is far smaller than the other designs. It consists of 3 pieces of timber, jointed in a way that creates a sloping design. It contains a small drawer for storing personal possessions. Unfortunately, this design strays too far from the client's requirements in terms of size, and so can't be pursued further.
4	*" This design is too barebones. For me, it doesn't offer enough features. That being said, I do like the minimalistic aesthetics "*	Design 4 emulates many designs found currently on the market, and so shares many of their drawbacks, such as a lack of secure, safe storage for items. The client finds the lack of features to be too unacceptable to develop the concept further, but draws attention to the minimalism, which can be implemented into other designs going forwards.

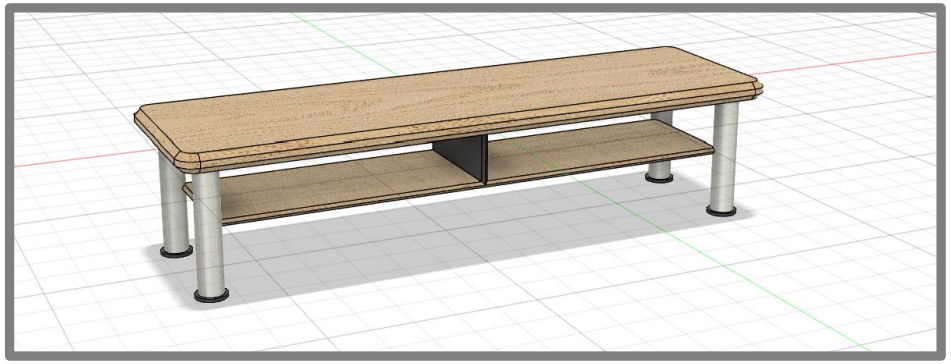
Feedback of Initial Designs

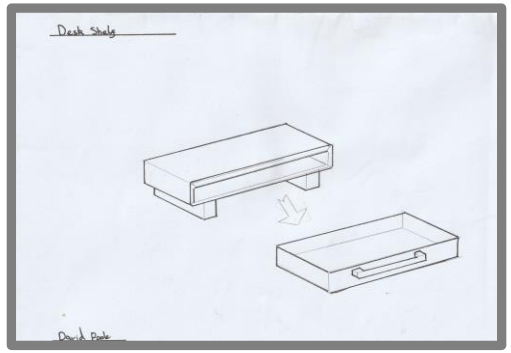
Design	Client Comments	Evaluation
5	*" Design 5 looks too much like a breadbin, as much as I like the concept, I don't believe it would fit well "*	Design 5 was always considered to be outlandish by comparison with the other designs produced. The client makes an unfortunate connection to a breadbin, and so it would be silly to pursue this design further.
6	*" I like the curved top of design 6, but it suffers from the same flaws of design 4 "*	Design 6 strikes a nice balance between the curves of design 2, and the minimalism of design 4. Unfortunately, it shares the same downfalls in practicality as design 4. Perhaps curves could be implemented in some way in future designs.
7	*"The almost antique design is interesting, but far from minimalistic."*	Design 7 takes inspiration from antique clocks, with a wavy top, and sturdy, rectangular base. There is a slot for a laptop, in addition to drawers to store personal possessions. However, given the requirement for a minimalistic design, design 7 is not suitable.
8	*"The vertical laptop holder is very unique, but the product seems bulky"*	Design 8 features a secure location in which to house a laptop in an upright position, it would be made from formed marine ply, and mounted on a reclaimed oak base, with plenty of USB ports. Though, given it is rather bulky look, may not be a design to explore futher.

Further Development





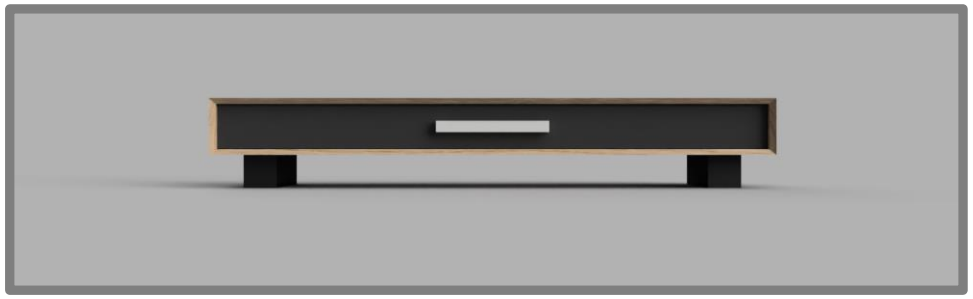




Note:

Drafted using a combination of Fusion 360 and hand-drawn illustrations.

Developed Design No.1



With a cabinet constructed from veneered plywood, mitre-jointed and finished simply with beeswax, this desk shelf is intended to compete in the premium segment of the market, but at a reduced price, all while offering more functionality.

A singular drawer, spanning the width of the desk, made from laser cut MDF, is placed into the centre of the product.

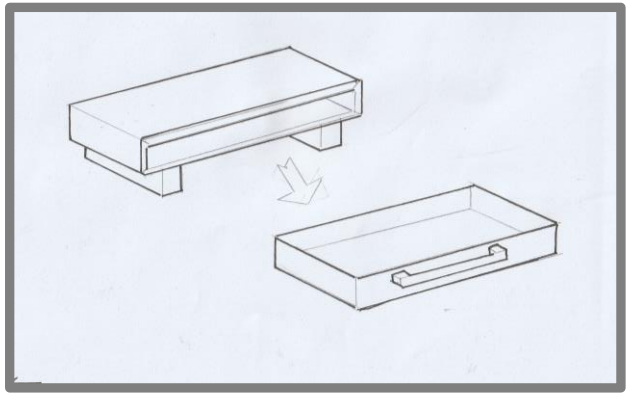
A set of 4, colour-matched 3D printed legs support this structure. Two contrasting handles, printed in white PLA are fixed upon the drawers.

This design suffers from some flaws, most notably the scale. It would be impossible to manufacture the drawers given the abundance of 600x400mm MDF sheets, lack of other sizes in stock, and the fact that the Boxford CO2 lasers have a max cutting area of 600x400mm.

Additionally, the widespread use of mitre joints could present a challenge during construction as measurements must be precise to the millimetre for the outer shell to join.

Summary: This design features a single, rather wide drawer, enclosed within a plywood shell fixed upon 3D printed feet. Competing in the premium segment of the desk shelf market, this desk shelf aims to be minimalistic in nature, while cutting down on price relative to the competition.

Not free from flaws, the highly skilled nature required in the joinery of the outer shell and issues with laser cutting such a large piece could create hard to rectify issues during construction.



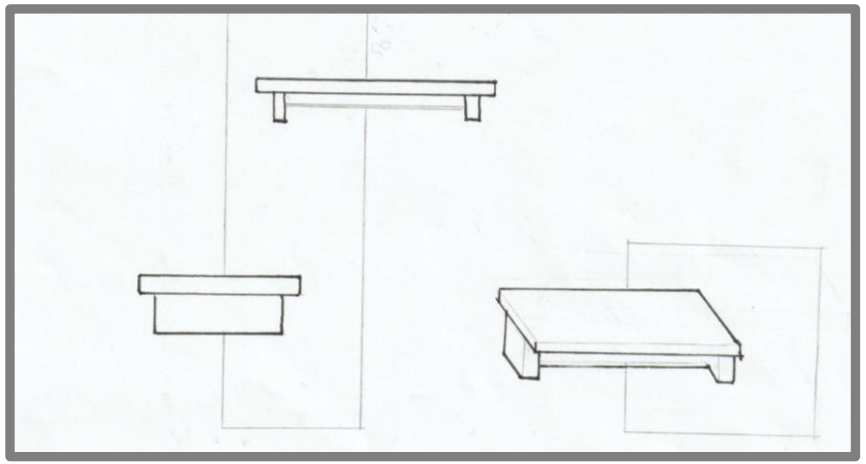
Developed Design No.2

This concept of a desk shelf is simple, with clean and minimalist aesthetics that mirror that of the client's desk. Reclaimed oak is used for the two tiers of the shelf, held up by matte, dark grey, 3D printed legs, complete with Integrated USB ports for charging.

All the wooden surfaces are chamfered to reduce the presence of harsh edges, helping the product to feel more premium

This concept is not without flaws, however. The lack of drawers means small items have the potential to be lost.

In addition, the size of the legs would make it impossible to print on domestic 3D printers, requiring the renting of larger equipment, or having files sent off to be printed by 3rd parties, driving costs up significantly.



Summary: Using a variety of sustainable construction practices, such as additive manufacturing, and the use of reclaimed timber, this desk shelf is simple in nature, yet uses high-quality materials

This concept's simplicity, however, is also its greatest flaw, and is perhaps a little too simplistic for the Client and their setup.

Developed Design No.3

Summary: This design is arguably more interesting from a visual perspective but may not be suitable due to the design straying away from the client's specifications for a minimalistic product.

The addition of a drawer is a welcome feature, and so is the cable pass-through hole towards the rear of the desk shelf

This 3rd Design aligns closer to No.1 than 2, also containing a single drawer, spanning the width of the product. The Increased use of wood throughout the piece creates a rustic appearance with more details than other designs. The seamless top and back piece could be created with the use of a mitre joint, though creating the two supporting legs could prove to be more of a challenge. A hole located in the rear of the shelf supports cables to be passed through, reducing desk clutter for an overall tidier looking desk.

The main disadvantages to this design stem from the fact that it features a rustic aesthetic, which may stray from the Client's request for a minimalistic aesthetic.

Regardless, the design proves the need for a drawer, or another form of secure storage for the client's possessions.

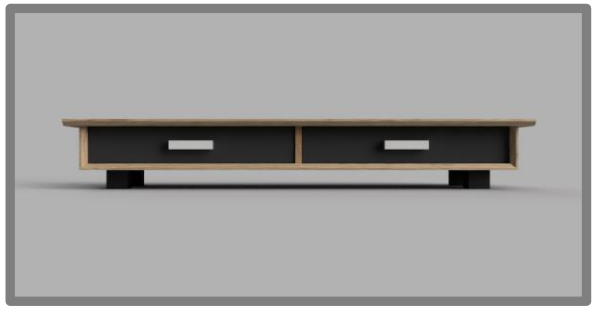
Final Design

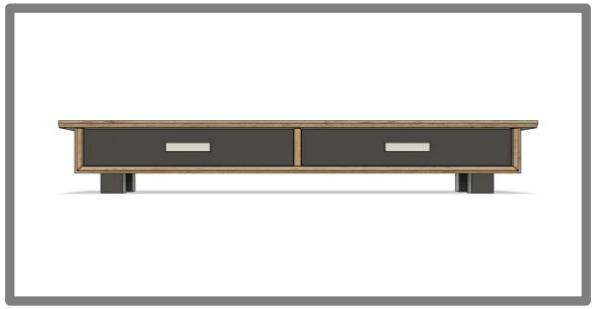
The final design produced for the client features a blend of features from prior iterations, incorporating many of the lessons learned.

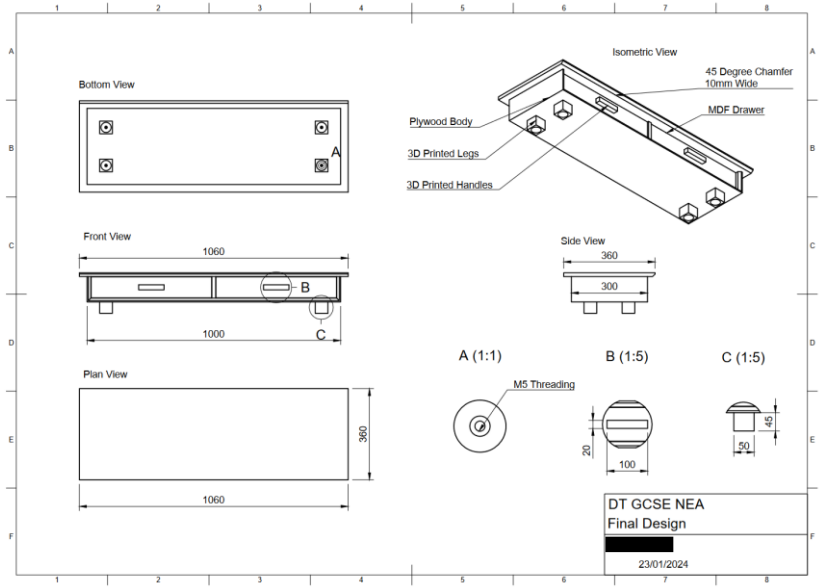
Taking heavy inspiration from the 1st developed design, itself built upon knowledge gained upon the initial designs drafted up for the client, the final design incorporates the following:

- Veneered-plywood exterior, finished with a silky-smooth texture, made possible using natural beeswax, and jointed using a combination of mitre joints and butt joints for a sleek, minimalistic aesthetic.
- Bespoke, 3D Printed Handles and Legs, both fastened with M5 bolts for ease of construction.
- Painted, laser-cut MDF drawers, built using finger joints for their simplicity and to reduce cost for the client.
- Internal MDF dividers and backings to save on costs for the client.

Summary: Made with lessons learned with other designs, and heavy inspiration from the 1st developed design, this final design incorporates a variety of thoughtful features presented in a tasteful and minimalistic package. This design has been sent to the client and approved, meaning

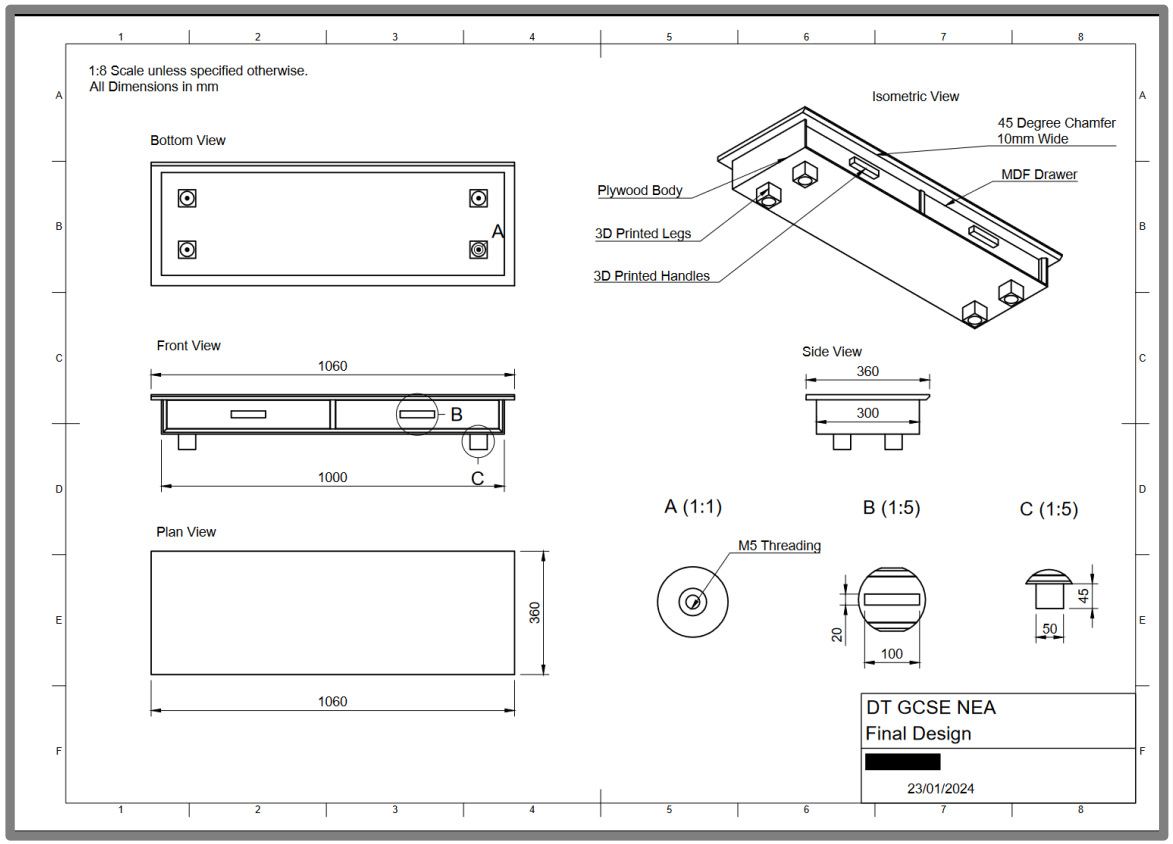


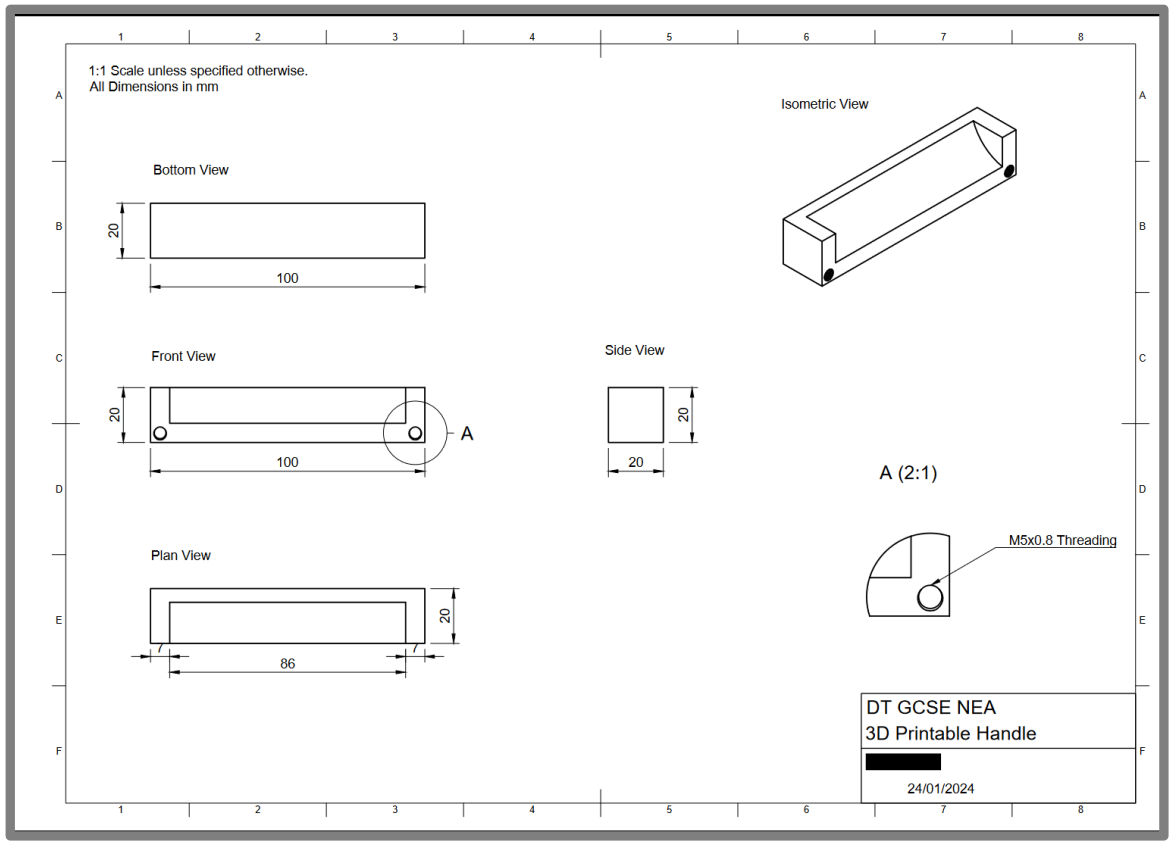




Final Designs have been created using Fusion 360 CAD software, using extra features such as Rendering and Technical Drawing

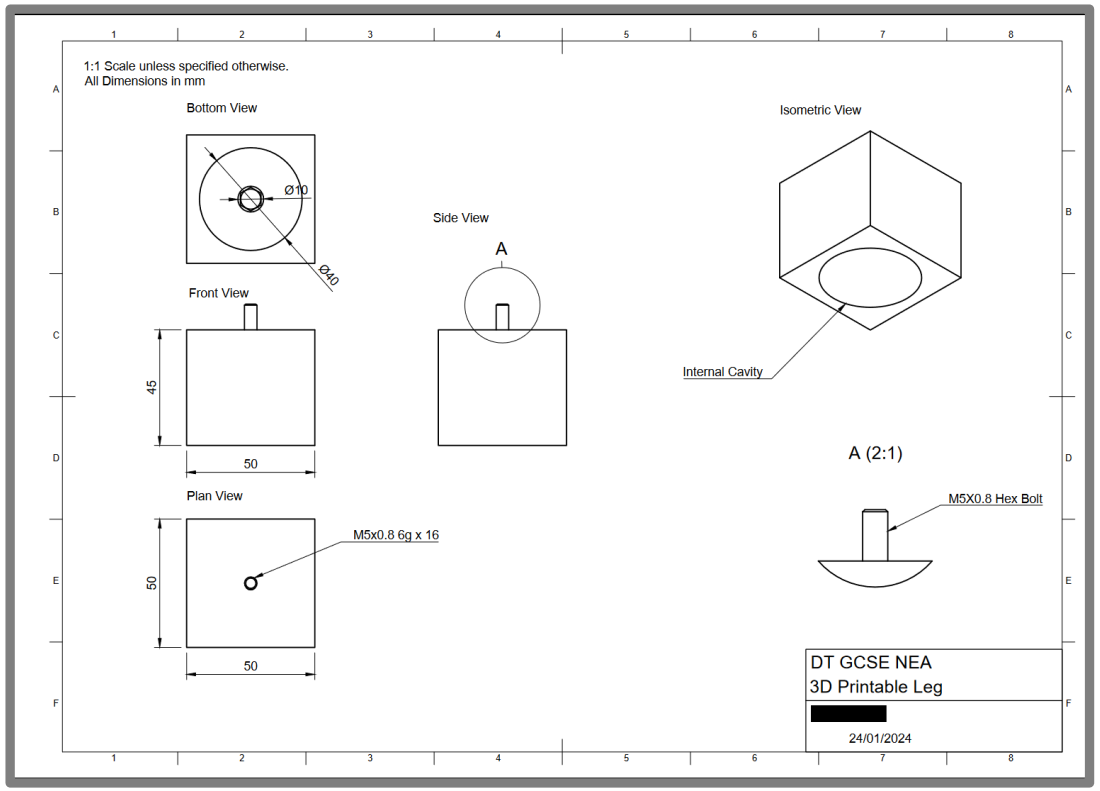
Schematics

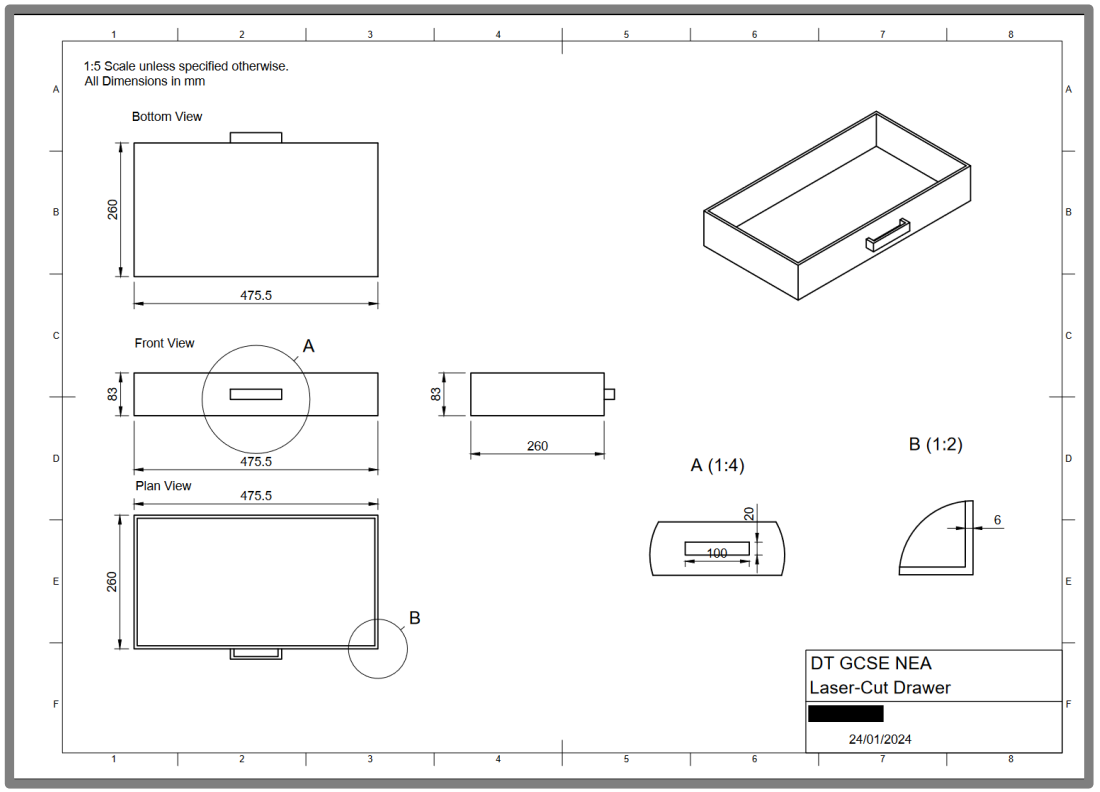




A	B	C	D	E	F
			X		

Schematics





These schematics represent both the design, and each of the component parts that need to be manufactured separately. Displayed above are the 3D printable components, Laser-Cut drawers, and the assembled product, detailing how these parts, in addition to others, will come together.

Isometric and Plan views were generated using Fusion 360 from existing CAD models, and dimensioning and threading notes were added for ease of manufacture. When printed in A3, the provided ratios are correct, with the ratios stated for each design sheet. All fittings consist of M5 bolts, of varying lengths, thanks to their abundance and reliability.

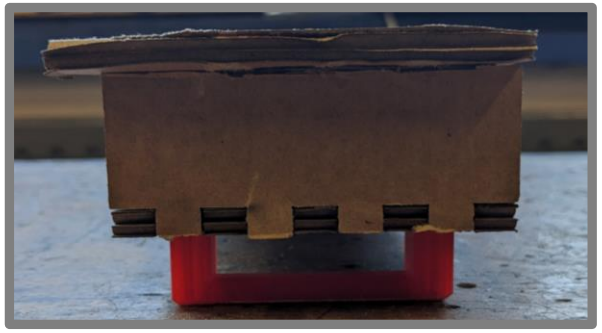
Summary: To summarise, all relevant schematics are available on this page. Schematics were generated with the aid of Fusion 360. All fittings and measurements are listed on the schematics in addition to other notes and annotations.

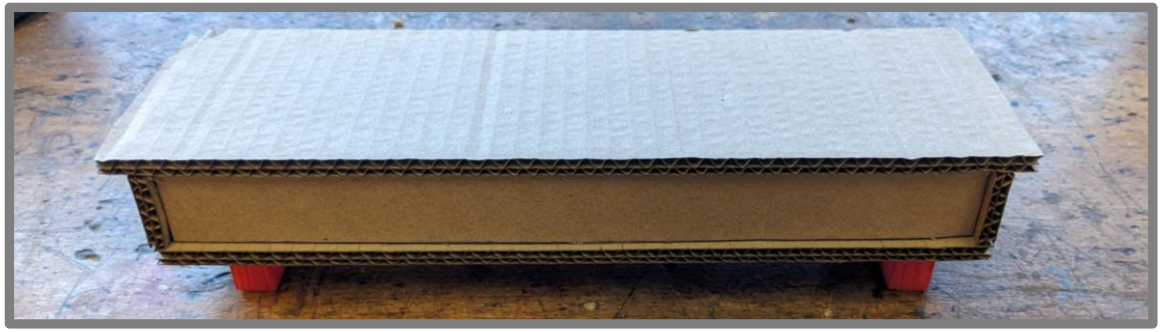
Design Development

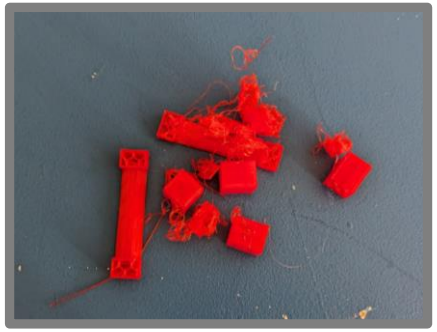
Prior to manufacturing, several cardboard mock-ups were constructed to gain a better sense of the final design's proportions, using a 1/3 scale. This scale was chosen due to the limitations of available equipment, notably the maximum cutting area of 600x400mm, a limitation that influenced the final design of the product.

Creating mock-ups of the final design came with several advantages, especially:

- The ability to gain a better understanding of proportion
- Gaining a scale model that can be presented to the client prior to manufacturing, ensuring that their vision is fully realised.
- The ability to test and refine certain processes prior to manufacturing, such as tuning settings for 3D printing, or improving confidence and efficiency in using Laser Cutters.







To-Scale cardboard mock-ups were designed and built using Techsoft Design V3, a 2D CAD design tool, with reference to Fusion 360 schematics and design files. All Images featured from this point onwards have been captured using a Google Pixel 6A.

Note: During the production of scaled-down 3D printed components, issues were identified with the slicing software. This software is used to take 3D models and convert them into simple steps that a machine can understand, known as GCODE. The previously used slicer, Ultimaker Cura, although listed as compatible with the printer, produced sub-par quality parts. This issue was rectified upon switching to Flashprint, a slicer designed by Flashforge from the ground up for their printers.

Summary: During Design Validation, scaled-down prototypes and mock-ups were created to give a better sense of scale, and to refine manufacturing techniques, such as issues found during the operation of the 3D printer, which was rectified, preventing future issues later in the manufacturing pipeline.

Cutting List

Parts List										
Part	Dimension	Material	Quantity	Cost/Part	Cost/Total	Material Available?	Print Time/Part	Print Time/Total	Filament Used/Part	Filament Used/Total
Top Panel	15x1060x360mm	Birch Plywood	1	~£45	~£45	Yes	N/A	N/A	N/A	N/A
Side Panel	12x100x300mm	Birch Plywood	2	~£10	~£20	Yes	N/A	N/A	N/A	N/A
Bottom Panel	12x1000x300mm	Birch Plywood	1	~£35	~£35	Yes	N/A	N/A	N/A	N/A
Divider	12x270x85	MDF	1	~4	~4	Yes	N/A	N/A	N/A	N/A
Backing	9x97x85mm	MDF	1	TBD	TBD	Yes	N/A	N/A	N/A	N/A
Drawer Bottom	TBD	MDF	2	TBD	TBD	Yes	N/A	N/A	N/A	N/A
Drawer Side (Long)	TBD	MDF	2	TBD	TBD	Yes	N/A	N/A	N/A	N/A
Drawer Side (Short)	TBD	MDF	2	TBD	TBD	Yes	N/A	N/A	N/A	N/A
Handle	100x20x20mm	PLA	2	~£0.52	~£1.04	Yes	1hr 24min	2hr 48min	19.25g	38.5g
Leg	50x50x45mm	PLA	4	~£0.98	~£3.92	Yes	2hr 18min	9hr 20min	36.36g	145.44g
Total:					**£108.96**					

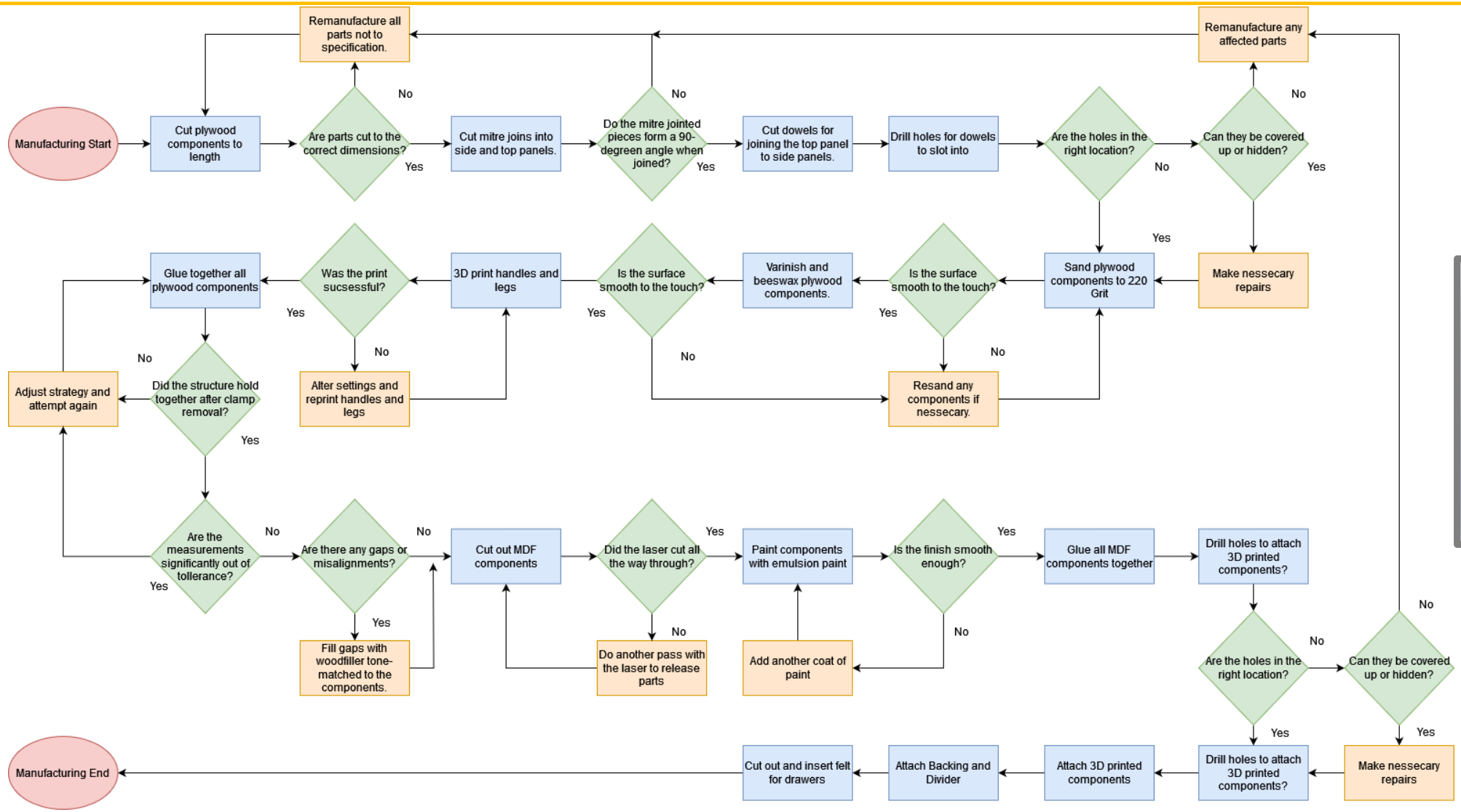
Tooling and Parts

Process	Image	Description
3D Printing		3D Printing, as detailed within the Schematics, will be used in the manufacture of the legs and for the Handles. The work will be completed using a Flashforge Adventurer 3 machine. With an ample build volume of 15x15x15 cm, objects can be nestled together, and batch printed, reducing the manufacturing time required.
Laser Cutting		Laser Cutting will be used in the manufacture of the drawers *(shown in schematics)*, and the dividers and backing *(not shown in schematics)*. To accomplish this, an 80W Boxford C02 will be used. An inbuilt Ruida controller, with the accompanying RDWorks software will allow for the uploading of DXF files to the machine.
Woodworking		In addition to computerised manufacturing, known as CAD, some more tools are required for assembly. The outer plywood shell will be manufactured with the use of a bandsaw, with the blade tilted at both 90- and 45-degree angles. Black and Decker mouse orbital sanders will also be used, in addition to vertical drills and other small power-tools.

Part	Dimension	Material
Top Panel	15x1060x360mm	Birch Plywood
Side Panel	12x100x300mm	Birch Plywood
Bottom Panel	12x1000x300mm	Birch Plywood
Divider	12x270x85	MDF
Backing	9x97x85mm	MDF
Drawer Bottom	TBD	MDF
Drawer Side (Long)	TBD	MDF
Drawer Side (Short)	TBD	MDF
Handle	100x20x20mm	PLA
Leg	50x50x45mm	PLA

Summary: Here, the various tools used for manufacturing, in addition to the parts to be manufactured, are set out. In addition, more detail is provided as to the tools used, for example, specifications of the 3D printer, Laser Cutter, and clarifications as to the types of tools used during woodworking.

Manufacturing Timeline



Summary: Here you can find a full manufacturing timeline, in the form of a flow diagram, which details all the steps necessary to manufacture the desk shelf.

Manufacturing steps are coloured in blue, quality control steps in green, and remedial steps in the event of breaching quality control in yellow.

Flow diagram created with the use of draw.io, a diagramming and flowchart tool

Manufacturing Log: #1

To begin manufacturing, the component parts for the outer shell need to be cut to the appropriate dimensions from larger sheets of plywood. For a project of this scale, finding sheets large enough was a somewhat difficult task. In the end, two large sheets of plywood, in the thicknesses of 15 and 12mm were procured.

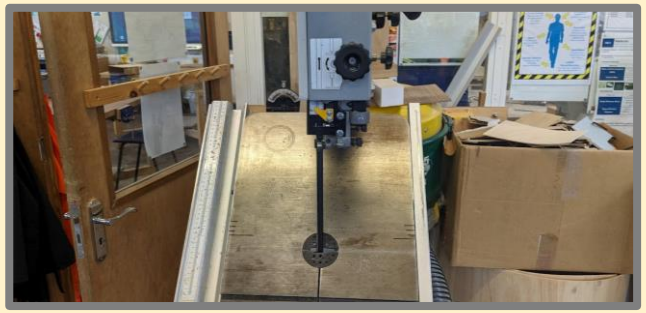
After these materials had been collected, they needed to be cut to their final lengths. This was done with the use of a bandsaw, a large reciprocating blade that sliced through the plywood with ease. As per risk assessments, a teacher aided with the use of this machine for safety purposes.

For quality control, measurements were taken after cutting to ensure a precise fit of all component parts, and the adage of measure twice, cut once, was adhered to strictly. In addition, an excess piece of plywood was trimmed to an appropriate slide in preparation for testing the next step.

Summary: Here in step 1, appropriate pieces of plywood were trimmed to their final dimensions, as detailed in both the cutting list, and the Fusion 360 schematics. This was done using a bandsaw. In addition, an extra piece of plywood was cut in preparation for the next step. Quality control was managed through measuring components after cutting.

Manufacturing Log: #2

To make the mitre joints, the bandsaw can be used, but must be tilted at a 45-degree angle. As the blade cannot be tilted, instead, the bed must be tilted so that the piece can slide through the saw at an angle to the blade



After the saw was set to the correct angle, the top and side pieces were mitred appropriately. In this instance, a guide was attached close to the blade, so that the cuts would be even and precise.

Prior to this, the excess piece, trimmed off in step 1, was mitred. Afterwards, they were glued together and checked with an engineer's square to ensure that they form a perfect 90-degree angle. This is a necessary step to validate that the bandsaw was setup correctly.

Summary: In step 2, the bandsaw table was tilted to a 45-degree angle to accommodate cutting mitre joints. After the table was adjusted, an excess piece was cut and tested to ensure a good fit and that the bandsaw had been adjusted correctly. Following this, all the relevant pieces were mitred and put to one side for the next step.

Manufacturing Log: #3

To seamlessly join the side pieces to the top pieces, 6mm dowels, chosen for their abundance and ideal diameter, were measured in 40mm increments, and cut to length using a small bandsaw.

After this, holes were drilled into both the side and top pieces of plywood, and dowels were then glued into place on the side pieces.

Note: Unfortunately, due to a mistake when creating drilling templates, a hole on the top piece was drilled in the wrong location, and so another hole had to be drilled close by to fix the issue. As this will be covered up by the side piece, there was no cause for concern.,

Given that all the necessary parts to assemble the outer shell had been cut to length, mitred and drilled, they were all test fit together. This was done prior to applying finishes to the pieces, as they may otherwise be scratched, stained, or damaged in the event more cutting or drilling needed to occur.

Summary: Step 3 details the creation of some dowel joints, used to join the top piece with the side pieces in a secure and seamless fashion. After the joints were created, they were tested alongside the mitred joins in a full test fit of the outer shell, prior to applying surface finishes.

Note: The image of the small bandsaws in the top right has been altered to remove the licence plates of the cars in the background for privacy reasons.

Manufacturing Log: #4

To finish the plywood components, it was decided that varnish and beeswax should be used to guarantee a smooth, satin finish. Before applying products, the plywood was first sanded, with the aid of an orbital sander, with 120 Grit, then 240 Grid discs, achieving a smooth finish. A paper towel and brush were used to remove sawdust to ensure a smooth finish

After this, 2-3 coats of varnish was applied to the surfaces, with light sanding using 240 grit pads in between coats. Brown paper was used to protect the underside of the table, from which the painted surface could have marked the surface.

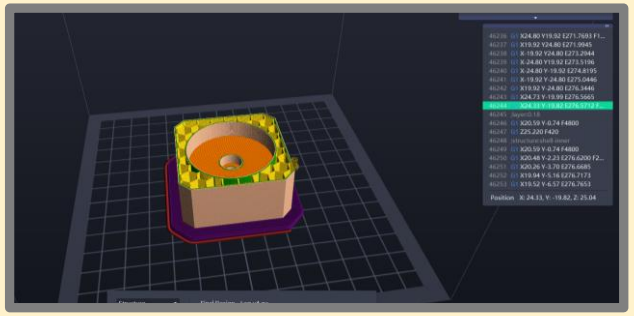
Note: Due to the work being left unattended, later, a grey mark was later discovered on the surface of the top piece. Nail polish remover, consisting mostly of acetone, removed the mark, but also stripped away the finish, so the finish needed to be re applied.

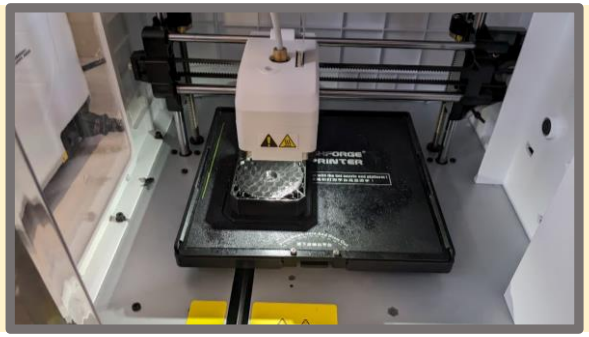
Then, a coat of BRIWAX was applied to all the plywood surfaces. BRIWAX, a blend of beeswax and carnauba wax, created a smooth and satin finish, while also introducing a warmth to the piece thanks to the tint of the wax.

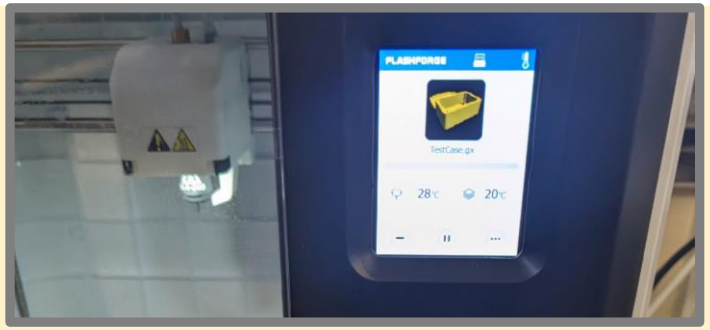
Summary: In Step 4, all plywood pieces were sanded, varnished, the finished using BRIWAX, a blend of beeswax and carnauba wax, creating a smooth, satin finish.

Manufacturing Log: #5

3D printing was used throughout the project to create bespoke plastic parts at an extremely low volume, with unique shapes and finishes. To start, digital files from Fusion 360 had to be imported into slicing software and converted into GCODE instruction files, so that they can be used with the printer. Slicing also enabled the changing of parameters, such as layer height, which impacts surface smoothness, or rafts, which 'tac down' the print to the build plate.

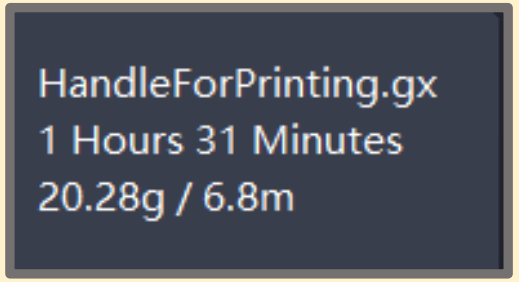






After the files had been sliced, they were then loaded onto a USB stick, and transferred to the Flashforge Adventurer 3, the 3D printer used for this project. After transferring, files can be started from the machine using the onboard touchscreen

In total, each leg took 2h 40m, and 1h 31m for each handle. That equates to approximately 7h and 40m total printing time. In addition, 201.56 grams of filament was used to produce these parts



Summary: In step 5, the various bespoke 3D printed components were manufactured as per the CAD files exported from Fusion 360

A	B	C	D	E	F
				X	

Manufacturing Log: #6

All pieces relating to the outer cabinet, including all plywood components, and 3D printed legs, were gathered, and were test fitted one final time.

Then, the plywood pieces were glued together using wood glue. Plenty of clamps were used to hold everything together while the glue dried.

Wooden blocks were clamped to the corners of the piece as a means of quality control, ensuring that angles remain at 90-degrees

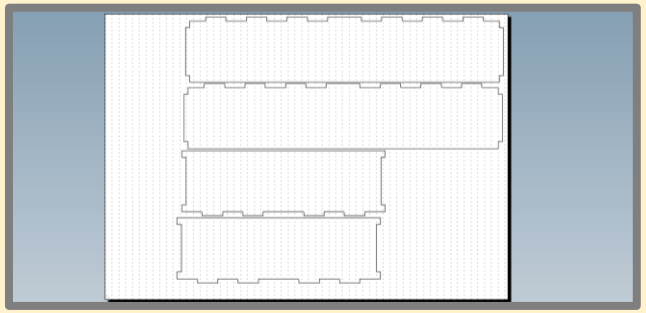
Note: Unfortunately, due to issues with the mitred surfaces, there were gaps along the bottom edges of the piece. These were rectified with the use of a wood filler that matched the tone of the finished plywood.

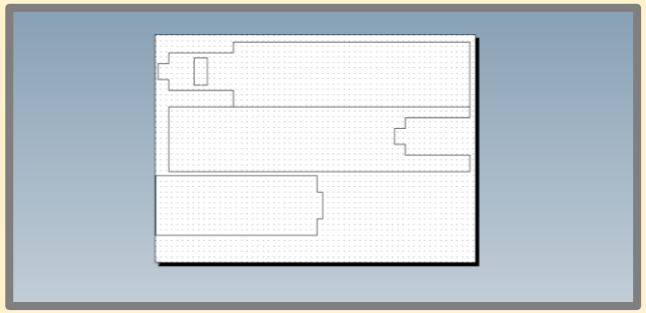
After removing clamps, measurements were taken to check the internal dimensions as part of quality control. This ensured that the drawers would fit properly into the outer cabinet.

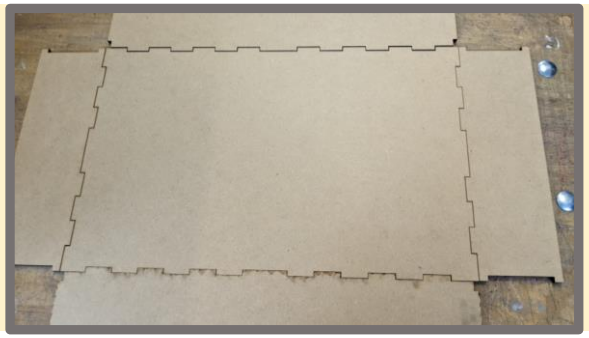
Summary: Step 6 saw the assembly of the plywood components and 3D printed feet. Various techniques were used to correct and/or prevent issues during assembly, such as the use of blocks as support, or wood filler to correct minor gaps. Measurements were then taken to create the drawers to fit inside.

Manufacturing Log: #7

Using the CAD model, and measurements taken of the final outer cabinet, drawers were modelled in Techsoft Design V3, using finger joins for stability. An interlocking divider (made from 3 MDF pieces glued together), and backing (made from two interlocking pieces glued together to work around the laser restrictions of 600x400mm)







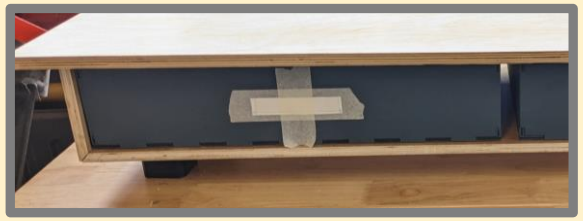
After this, the laser-cut components were cut out using a Boxford C02 laser. This machine using a C02 tube to generate and focus a laser beam to cut material. As 6mm MDF was use, the laser was set to a power range of 90-95%, and a speed of 8.

Then, all MDF components were given 3 coats of paint, using a foam roller for a smoother finish. The specific paint chosen was a Valspar emulsion called 'Cadet Song', which appears as a petrol blue with hints of grey when dried. Any components that needed assembly, such as the drawers or divider, were glued, then clamped to dry.

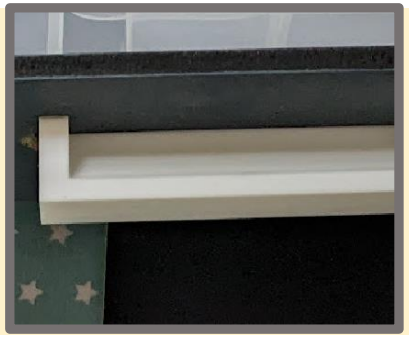
Summary: In step 7, any MDF components, such as the drawer and interlocking divider and backing were cut out, then painted using Valspar Cadet Song. Any components that needed assembly were glued together.

Manufacturing Log: #8

Firstly, as a form of quality control, all components were test fitted prior to final assembly, such as the drawers and the divider.



Then, using drilling templates made simply by drawing the location of holes on a piece of A4 paper, the holes were drilled, and the handles were bolted using M5 bolts to the front of the drawer.

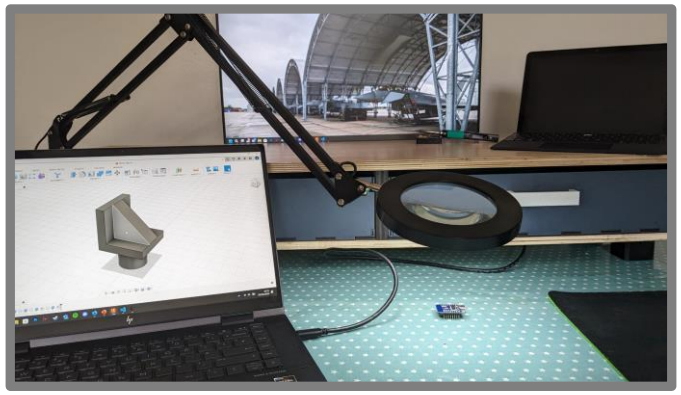


Note: Due in inaccuracies when creating the drilling template, some holes were drilled incorrectly, leading to holes that were partially covered by the handles, but still slightly visible. After further discussion with the client, and due to time constraints, the holes were painted to camouflage them better.

Finally, to finish the desk shelf, the backing was fastened to the back of the piece using screws, then the divider was slotted into place, and fixed into place, using relatively longer screws. In addition, felt lining for the bottom of the drawers was cut out and fixed into place.

Summary: In step 8, the final steps were completed, such as test fitting drawers and other components, fixing handles to the drawers, and screwing the backing and divider to the outer cabinet.

Final Product



Client Evaluation

Positive feedback	Negative feedback
“The minimalistic aesthetic of the product exceeded my expectations. It will blend well into my office space when the renovations are complete”	“ The legs are somewhat slippery, and so I may need to put some non-slip pads underneath them to keep the shelf from moving and scratching my desk.
“The petrol blue / grey paint used on the drawers and back complement the shade of grey used on the drawers in my office space.	“ I worry that the paint may be prone to scuffs and scratches”
“The drawers are large and spacious, giving me plenty of room to put all my possessions that I use daily at an arm's reach”	“ It was noted by the designer that there were some small defects relating to the handles. Upon receiving the desk shelf, there were some small holes partially covered by the handles, in addition to the left handle being misaligned, though this does not bother me too much.

Summary: A few days after taking delivery of the desk shelf, the client provided some valuable feedback for future reference. Some points raised included satisfaction of the overall appearance and how the final product blends seamlessly into their space.

Concerns and issues were raised regarding the durability of the paint, slippery nature of the feet, which though the shelf may be difficult to move due to its weight, may scratch the wooden desk. Issues were further raised regarding the manufacturing defect relating to the holes near the handles, as a result of a poor drilling template.

Commercial Production

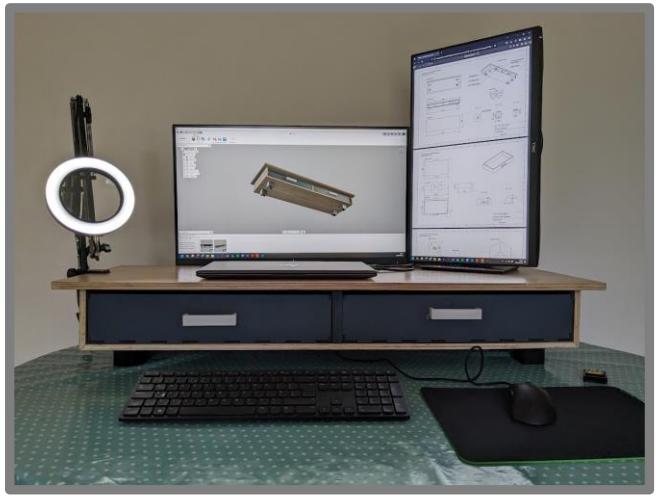
Issue	Resolution
Product would be too bulky to ship to consumers	Introduce knock-down fittings into the design to make it flat-pack and able to be user assembled. This could reduce shipping and manufacturing costs, which the savings from which could be passed onto the consumer or reinvested into the business.
Product would be too heavy to ship to consumers	Replace the 15mm top plywood panel with a 10mm panel, substantially reducing the weight. This would also reduce the material cost, creating additional savings
3D printed components pose a logistical and financial challenge to scale to mass-production.	Given the high labour and tooling costs of using 3D print farms (a means of scaling 3D printing to mass-production), a cheaper alternative could be to switch to injection moulding. Injection moulding machines have a far greater throughput, allowing for faster manufacturing

Issue	Resolution
Holes for dowel joints and various fixtures are inefficient to drill by hand	Automated systems, such as CNC routers and drilling machines, could be used on an assembly line to drill holes precisely. The increased efficiency would reduce costs and reduce defects arising from human error.
Fittings such as screws or knockdown fittings are expensive to purchase	Purchase in larger quantities where possible to save through discounts. Purchasing in larger quantities would also ensure the assembly line will not stop due to shortages, saving on labour costs per unit produced

Summary: Here, a plan is detailed for the mass production of the final desk shelf, through addressing various concerns, such as the expensive nature of shipping heavy, bulky furniture, the cost implications of various additive manufacturing techniques, and the costs of procuring and producing fixtures and fittings.

Evaluation Against Specification

Area of Interest	Notes
Dimensions + Ergonomics	• The dimension constrains were strictly adhered to, with the product having a height below 20cm, as to 'slot underneath the monitor', and the width being 1.06 meters, which is approximately in line with the given width constraint.
Materials	• The outer cabinet of the desk shelf was made from birch-veneered plywood, while the drawers, dividers and backing were made from MDF to save on costs. • 3D printing was used to manufacture the handles and feet
Additional features.	• Unfortunately, the design was unable to accommodate a cable passthrough hole.
Storage	• A set of two larger drawers are used to provide ample space to store personal possessions in a safe and secure manner
Aesthetics + Appearance	• Using mitre and dowel joints to create seamless joints, and the attention paid to creating a smooth finish, a minimalistic, yet not basic design, was achieved
Cost	• The bill of materials came to approximately ~£110, slightly more affordable than the target budget.



Summary: Overall, the design specification was adhered to stringently, though during design and manufacturing, the length was slightly out of specification at 1.06m instead of precisely 1m, and the removal of a cable-passthrough hole.

Self-Evaluation

Self-Evaluation:

Throughout the course of this project, the design and manufacturing of this desk shelf has been heavily influenced by the design specification outlined earlier in the project. Purely evaluating success based on the adherence of this specification, I believe the project can be considered a success. The dimensions were taken strongly into account when designing the project, with the height being under 20cm.

A decision was made during design to exceed the 1m standard by 6cm, to accommodate an overhang around the project, which arguably added character to the design, and made final assembly easier as dowel joints could be used for better alignment. For similar aesthetical reasons, the cable-passthrough hole was omitted, although this was not a stringent requirement.

I personally like the way the surface finishes were executed in the end, from satin smooth plywood, to bold tones of grey for MDF components, giving the desk shelf a unique, minimalistic aesthetic.

Overall, the project delivered on the promises of a minimalistic and functional project, satisfying the design context of' storing or securing personal possessions', with the pair of drawers providing ample, safe, storage space for possessions, notably the client's technology.

What went well?	Even better if?
The quality of the surface finished, including plywood and MDF components	More care paid to the drilling of holes, to prevent misalignment
Quality of the laser-cut components	More time was taken to ensure no gaps are created during mitre joint assembly
The effective use of 3D printing to create bespoke components for the desk shelf.	

Summary: Overall, I found many aspects of the project to be enjoyable, though some challenges were faced, mostly during the final stages of the project. Despite these challenges, I believe I succeeded in creating a minimalistic desk shelf that satisfies the design context. I believe that the use of 3D printing to create customised parts, and the attention paid in creating satin smooth finishes on plywood components helped in achieving this project.