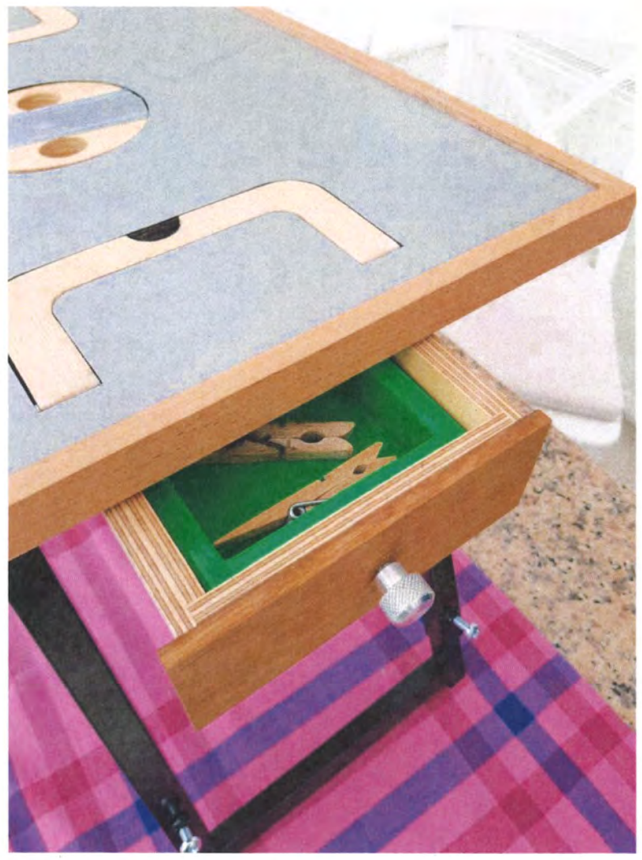
Garden Stool

Francesca Bartlett - 9005
Botham School - 48349



Contents

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Identification and investigation of a design possibility

Client/End User:
Betty Ariel (my grandmother) is 82 years old and lives in a bungalow with her husband Kenneth. They both moved to York, from Stourbridge in the Midlands, in 2016 in order to be closer to their family She loves gardening, playing bridge, reading and spending time with her family.

2. **Design Context:**
Needs of the Elderly

Contact AgeUK <ContactAgeUK@ageuk.org.uk> 19 Jan

to me

Dear Frankie Bartlett,
Thank you for your interest in AgeUK
Unfortunately, as a charity we do not have the resources to help you directly with your project. However you may wish to visit our website for professionals where there may be some resources useful for your project. http://www.ageuk.org.uk/professional-resources-home/

There is also lots of general information available publically on our national website https://www.ageuk.org.uk/information-advice/

I appreciate that this reply may be disappointing to you but wish you luck with your project.

Yours sincerely,
Josh Letten

-----Original Message-----
From: Age UK [mailto:email@transaction.ageuk.org.uk]
Sent: 19 January 2018 10:57
To: Contact AgeUK <ContactAgeUK@ageuk.org.uk>
Subject: Contact Age UK Form

** Contact us **

This enquiry was submitted through the Age UK website. A copy of the message is below:

Firstname: Frankie
Lastname: Bartlett
Enquiry type: Miscellaneous enquiry
Message: Hello, I am a student currently doing A-Levels at college. I am doing a coursework project which is aimed at the needs of elderly people in the UK. I am thinking of doing my project on helping elderly people keep stable/balanced when out and about doing their everyday things. I was wondering if there was any information you could give me which would help with this project, possibly products which are already in the world or things that elderly people commonly find difficult with keeping balanced. Many thanks.

3. **Interviews, emails, Q+A:**
INTERVIEW

Me : What do you find difficult during your every day routine?
Betty : I like doing my gardening but I find it difficult to bend down for long periods of time due to my hip replacement. I also find opening jars very difficult now that I am older since I can't seem to grip things properly any more. Every morning I like to walk to the shop and get the daily newspaper but I get tired quite easily and sometimes I lose my balance - which is quite worrying, for both me and Kenneth. Also, our recycling bins have to be outside because of how big they are and it also gets annoying having to go out every time there is a bit of plastic that needs to be recycled!
Me : So you said that you get tired and occasionally lose balance while walking, would you like a solution that was a walking aid which also doubled up as a seat?
Betty : Yes, that would be a great idea!
Me : With the gardening problem, would it be a good idea if there was some sort of seating that also had the gardening tools with it?
Betty : Yes, that sounds good because then I wouldn't have to keep getting up.
Me : So, to help with opening jars, would some kind of grip that could be placed around the lid help?
Betty : Yes, I know there are already solutions out there but with the ones I have seen, I know would still find it difficult to grip them as you would still have to place your hand around the whole lid.
Me : Okay, I know what you mean. Finally, would you like the recycling bins to be smaller so that you could have them in the house or would you prefer something which you could place the recycling into which could then be transferred over to the larger ones?
Betty : Yes, a smaller one which could be in the house and then I could transfer the recycled materials into the larger boxes when it gets full.

EMAILS/EVIDENCE

I sent emails to Age UK and another company called Essential Aids. Age UK replied but didn't have anything that would help with walking aids other than the ones already in society. I also sent the same email to Essential Aids but sadly I didn't get a reply to my email but did have some interesting things on their website.

- Falls Prevention (1.) - stay active, take care of your eyes, check for hearing problems.

The right shoes:
- Make sure your shoes fit well and don't have a tendency to slip off.
- Well-cushioned shoes offer comfort and support.
- Avoid sandals with little support and shoes with high heels.
- Wear slippers that have a good grip and that fasten and stay on properly.
- Always wear shoes or slippers, and never walk indoors in bare feet, socks or tights.

- Falls facts

Falls and fractures in people aged 65 and over account for over 4 million hospital bed days each year in England alone.
• The healthcare cost associated with fragility fractures is estimated at £2 billion a year
• Injurious falls, including 70,000 hip fractures annually, are the leading cause of accident-related mortality in older people.
• After a fall, an older person has a 50 per cent probability of having their mobility seriously impaired and a 10 per cent probability of dying within a year.
• Falls destroy confidence, increase isolation and reduce independence, with around 1 in 10 older people who fall becoming afraid to leave their homes in case they fall again.
• A tailored exercise programme can reduce falls by as much as 54 per cent

Assistive devices help with dealing with the pain of arthritis. "If your hands are stiff or painful, or if you have trouble holding, gripping and turning, assistive devices can make tasks easier on joints and more efficient for you. These products, which range from simple to elaborate, help keep joints in the best position for functioning, provide leverage when needed and extend your range of motion. Simple arthritis self-help devices, such as jar openers, reachers and easy-grip utensils, can be purchased at many hardware or medical supply stores." (3.)

User Needs:

Garden - Betty said she would like a device which would allow her to kneel comfortably while gardening without any aches in her hip. Also, she said she would like the tools to be within the device to they were to hand which would eliminate the need to keep getting up and down.

Recycling - The recycling bins my grandmother has are very big and so, have to be kept outdoors which isn't good since she has to keep going outside every time there is a bit of recycling.

By having some smaller bins inside, this would eliminate the need to keep going outside, when the weather isn't very nice. This would also mean that the kitchen or wherever the recycled product is, could be neatly tidied away into the smaller bins, getting rid of waste that can't be placed into the outdoor bins due to bad weather. The City of York Council recycling bins are 600mm by 400mm, making them quite difficult to have in the house, especially when there are 3 of them.

Kitchen - Betty would like a jar opener that had a long handle so that it would require less energy to be put into opening the jar, giving it mechanical advantage, thus making it easier to open.

Help with balancing - Betty said that she would like a walking air that could also double up as a seat for long distance or short distance walks. This means it should be able to be used in all weathers, especially ice when it is even more dangerous

Kenneth and Golfing - Betty had another problem, but this one was not for her. It was about Ken and getting his electric golf trolley in the boot of the car, which is difficult for him since it is very heavy. So Betty said that Ken would benefit from having some sort of device that would make it easier for him to lift the golf trolley into the boot or something that would mean he didn't have to lift it at all.

Specific need I am going to focus on: I am going to focus on coming up with a solution to the gardening problem. Difficulty with gardening after having a hip replacement is common for many gardeners in this situation. The Emersons Green Treatment Centre (2.) says to :"Avoid spending hours stooping over flowerbeds to weed and plant. Don't be in one position for long time as it puts a strain on your whole body. It is good to keep changing your position or do other work, which involves change of position.". This is due to the pressure on the joint which needs to be relieved otherwise it could damage the fake hip. There are already solutions out there, however I have not seen any that also include space for tools.

Francesca Bartlett, 9005, Boonam School, 48349

Design Brief and Task Analysis

I am going to try and solve the problem of having difficulty gardening due to pain before or after an operation such as a hip replacement.
The product could be used by anyone who likes to garden and would eliminate the need to get up to retrieve tools as the product would have a built in storage space for gardening tools and other things.

Things to investigate	What will I try to find out?	Why will I do this?
Anthropometric data	• The size of the average human body for the size of the seat. • The average hand size so that the product can be moved around comfortably by the user • The average leg size so make sure that the product is large enough if someone wants to kneel on it	I will do this because I will need to figure out what size the product should be and the sizes of the features so that it can be inclusive for everyone who wants to use the product.
Ergonomic data	• How the product can be adjusted for the user • What types of grips are most comfortable for the user	So the product can be of maximum comfort for the user.
Mechanism	• The strongest types of mechanisms that will withstand the weight of a human body • The easiest types of mechanism to use	So I can work out which mechanisms can be used for my product and which will work effectively.
Sustainability/ Materials	• What materials are the strongest to withstand body weight • What materials are strong and also sustainable • The life cycle of the materials that I could use for my product • Assess the impacts they may have on the environment during the production of the material	I will do this to try and minimise the impact which the product might have on the environment. I will also make sure I get my materials from sustainable sources and that they can be reused/recycled at the end of its life cycle.
Safety	• How safe the mechanisms will be to use • How safe the materials will be to the environment and also to the user	To make sure that there is no hazard that may harm the user while being used.
Tools	• What tools will be stored within the product • The size of the tools that will be stored • The weight of the stored tools.	So I can work out how big the storage part needs to be and how strong it needs to be

Sources: (1.) https://www.ageuk.org.uk/globalassets/age-uk/documents/reports-and-publications/reports-and-briefings/health--wellbeing/rb_2013_falls_prevention_guide.pdf
(2.) http://www.emersonsgreentreatmentcentre.nhs.uk/news/gardening-after-a-total-hip-or-knee-replacement-professional-advice-from-physiotherapy-0/
(3.) https://www.arthritis.org/about-arthritis/where-it-hurts/wrist-hand-and-finger-pain/wrist-hand-and-finger-care/prevent-hand-wrist-pain.php

Existing Solutions

- **A**esthetics - The mixture of green, grey, yellow and black makes the product stand out. The use of yellow for the lid clasp makes it easy to see where it is. The different colours also show different aspects of the product and the colours that have been used don't refine it to one group of people (e.g. gardeners) so it could be used for other things other than as a garden storage box.
- **C**ost - £22.99
- **C**ustomer – This product is intended for someone who likes to garden, and someone who wants to have easy access to their stored tools. The tool cart also doubles up as a seat, however it is quite low, especially if someone like my client were to use it. The handles however make it easier for the person to get up and down.
- **E**nvironment – This stool is made fully out of plastic which has an adverse effect on the environment due to the amount of CO2 that is produced in the manufacturing process, and also the chance of oil spills which severely damage the environment and local ecosystems. If this was made out of thermosetting plastic, this will have an even worse impact on the environment due to the inability to recycle it, thus meaning it will most likely end up in landfill. The product looks like it is most likely to be manufactured by rotational moulding, there is very little waste in the process which is better for the environment when compared to other techniques.
- **S**afety – This product looks reasonably safe but it also looks as though there is a risk of finger traps, especially with the lid, and the clasp that keeps it closed. It may be unsafe to use on a slope as there doesn't seem to be any way of keeping the wheels stationary.
- **S**ize – The product looks as though it is medium size, but there are no measurements on the website.
- **F**unction – The function of this product is to store tools and be used as a seat which can be easily transported around the garden, which are aided by the two handles
- **M**aterials – The product looks to be made out of Polyvinyl chloride (PVC) which is a good plastic to use due to the fact it has good chemical resistance, is weather resistant and is also tough and lightweight. The wheels look to be made out of either rubber or PVC as well, rubber would be a suitable polymer to use due to the fact has good strength, is long lasting and is water resistant.
- Manufacture – due to the fact the product is hollow, it would most likely be manufactured using the rotational moulding process. This is due to the fact that the constant rotation of the mould creates centrifugal force which forms even-walled products.

http://www.elmershardware.co.uk/gardening/garden-accessories/draper-gardeners-tool-cart-and-seat-60852.html

- **A**esthetics - the use of both red and green make the product aesthetically pleasing due to the fact that these colours compliment each other. In addition, the colours make the product stand out within the garden and the different parts of the stool are coloured differently to distinguish each part from another, for example, the red are the bits that are useful for the user (seat and storage tray).
- **C**ost – £30.99
- **C**ustomer – This product is for someone who may have difficulty standing for long periods of time, and also for elderly people who find it difficult to bend over when tending to their garden. It is also for someone who doesn't want to keep getting up and down to retrieve their tools, as there is a tray underneath the seat.
- **E**nvironment – The steel tubing, if made from mild steel, can be recycled at the end of its life cycle. In addition, with the seat and the storage box being made from a thermosetting plastic, it can also be recycled, but could cause environmental problems in the manufacturing process.
- **S**afety – This product is very safe as there are no adjusting mechanisms so there are no risks of finger traps.
- **F**unction – To allow a person to easily move around the garden while sitting comfortably. The product has large wheels for easy transport and these will also help to prevent the stool from sinking into any soft surfaces due to its large surface area. The seat is raised to a good height so that the user isn't low to the floor which may cause pain for them. In addition, it allows them to sit upright, as they would on a normal seat. The triangular shape of the steel frames make the garden stool very strong as this type of structure can withstand heavy weight loads.
- **M**aterials – The main frame of the structure looks to be made out of steel which is tough and has high tensile strength so will be able to withstand the weight of a human body. The wheels and the red body of the stool could be made out of either Polyvinylchloride (PVC) or polypropylene (PP) which are both lightweight, something which would benefit the user when it comes to transporting the stool. However, PVC is weather resistant and tough when compared to PP which would make it more likely to be used for the stool since it would be used outside often.
- Manufacture – The plastic could be formed into the shape of the seat and storage tray using injection or rotational moulding due to the fact these both form thin walled, large, hollow parts. Injection moulding is more expensive than rotational moulding which would explain the high price of the product.
- Design flaws – The product doesn't seem to have a braking mechanism so the stool could move around while the user is sat on it which could be dangerous if it is on a gradient.

https://www.essentialaids.com/garden-stool-on-wheels.html

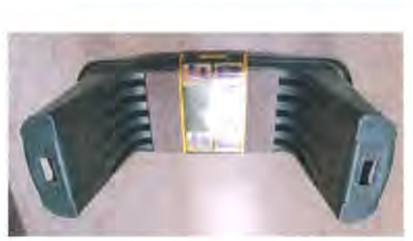
- **A**esthetics – The product looks slightly boring due to the single use of colour. In addition, it could blend into the garden but, different shades of green have been used alongside white for the pouch which adds a bit of variety to the product.
- **C**ost – approx. £17.00
- **C**ustomer – This product is for anyone who likes to garden, and the stool has handles which allows the user to easily get up and down from the stool. It can be used by anyone, and it may be good for someone like my client as there is aid and also somewhere to store tools
- **E**nvironment - The steel tube (if it is mild steel) can be recycled at the end of its life cycle so it reduces the amount of damage made to the environment. EVA is a plastic so could cause environmental problems when it is being manufactured, such as the drilling for crude oil and release of toxic gases which contributes to climate change.
- **S**afety - The stool looks like it has no working components so it looks to be reasonably safe as there is no risk of trapping a finger, and everything is rounded so there is no chance of the user scratching themselves on the product.
- **S**ize – The size of the product can be seen in the bottom photo
- **F**unction/Features – The stool works as a sitting, and also a kneeling aid, that the user can use comfortably and easily as there are no working parts. The cushion takes pressure and fatigue off the knees and lower back of the user. The side rails make it easy to get up and down from the product. The seat is adjustable by a spring mechanism so can be used to sit on or to kneel on. The pouch has lots of slots that can be used for different things e.g. tools and storing water bottles. In addition, the handles on the side of the product have a slight indent for hand grips so it is easy to adjust and fold away.
- **M**aterials – the bench is made from steel tubing so it is strong and can be recycled at the end of its life cycle. The cushion is made from EVA foam which is weather and chemical resistant so is very suitable for outdoor usage. The pouch is most likely to be made out of acrylic or polyester. Polyester is durable, strong and retains its shape which makes it good for outdoor usage. Acrylic fibre would also be a good fabric to use as this is chemical resistant, quick drying and resistant to sunlight degradation which makes it suitable for this product.
- Manufacture – the steel tubing is most likely to be made using the hot rolling process which produces seamless tubes.
- Design flaws - the product doesn't look to be very sturdy when sat on due to the thin, tall legs and the fact the website doesn't say whether the mechanism locks in place or not. If it doesn't lock in place, one of the legs could collapse if the user moved slightly to one side, which could lead to an injury.

https://www.amazon.com/dp/B06XRBT9KG/ref=sspa_dk_detail_0?psc=1

Product I looked at in person

- **A**esthetics – I liked the shape of the product when I saw it in person as it had a streamlined effect going the whole way around the product, instead of being angular. In addition, I liked the fact only one colour was used for the whole kneeler, apart from the foam cushion on the reverse side, which makes the product attractive to all. In addition, it blends into the garden due to the fact it is green which prevents it form being an eyesore.
- **C**ost - £10.49
- **C**ustomer – This product is useful for someone who likes to garden, but someone who doesn't need aid whilst getting up and down from the stool as there are no handles that help like the previous existing product.
- **E**nvironment - The kneeler is made entirely from recycled plastic which makes it more environmentally friendly, despite it being produced from plastic which causes environmental problems in its manufacture
- **S**afety – This kneeler has no working parts so I found that it was pretty safe, however, some of the edges of the product were a bit sharp, meaning someone who was using it could cut themselves on it.
- **S**ize - 66.3cm Length, 25.3cm Width, 34cm Height
- **F**unction/Features – This product is a garden stool which can be used as a seat or as a kneeling platform. The product was very simple to use and it was extremely lightweight, it also has handles on the top side of the product and also within the legs of the kneeler which makes it easy to transport. The kneeler can be reversed and used as a seat. When used as a kneeler, the product has foam to make it more comfortable to use, and I found I could have used it like that for a while when I tested it. I noticed that the base of the legs had holes, which are there to aid drainage of water if it has been left outside and it has rained, which is a very good feature to have. The legs are hollow which allows them to be used as storage for tools, I found that they could also be used, when in the kneeler position, help the user stand up after kneeling as they act as an aid. The product felt very strong and sturdy when I tested it, this is most likely due to the material and also how the product has been shaped in its manufacture. It has reinforced plastic around the edges of the product and also the use of more plastic for the seat, rather than one straight piece of plastic, also reinforces it. This is why the product felt so strong when I sat and knelt on it as it didn't bend at all.
- **M**aterials – The stool/kneeler is made entirely from a very strong plastic. I looked for a plastic symbol, however, all I could find was a triangle with nothing in it so I couldn't identify what plastic was used. However, because it is strong, it is most likely to be made out of PVC or PP. These plastics would both be suitable as they are both lightweight and weather resistant.
- Manufacture – The product was most likely made by rotational moulding as this generates a large, sealed one piece shape. In addition, this method creates tough moulds and they are less likely to split, which would explain why the product felt to strong when I sat on it. This type of manufacture is relatively cheap which would explain why the price of the product is so low.
- Design flaws – The product doesn't compact down in any way which could make it very difficult to store as it would take up a lot of space.

https://www.homebase.co.uk/strata-garden-kneel-easy_p911294



British Standards and European Standards – Chairs

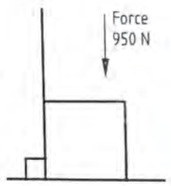
Sadly, all the British Standards I wanted to look at, had to be purchased at a high price, which I was unable to do. However, I managed to find a folder which contained a section on furniture and seating. The section contained performance requirements such as being stable, strong and durable. Each of their requirements come with a set of tests to see if they meet the standards.

Table 1 – Specific applications for furniture in relation to test levels

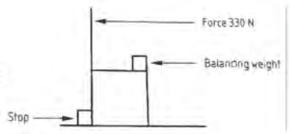
Type of use	Test rating				
	1	2	3	4	5
Folding garden and camping equipment		•	•		
Domestic		•	•	•	
Office			•	•	•
Educational				•	•
Institutional					•
Hotel				•	•

For 'Folding garden and camping equipment', the table above says that the products needs to have been tested at levels 2 and 3. These tests are for 'careful' and 'general domestic' which has 'severe contract'.
Test procedures for seating are addressed in **BS 4875-1** and **BS EN 1728**, which I am unable to get hold of, but it states what the tests endure in the folder.

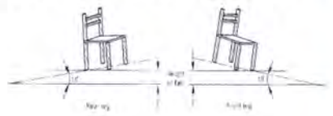
<u>Seat Static Load Test</u>
For the garden equipment, it will have its strength tested by an application of force in this manner: The garden stool should be able to withstand between 1,100 N and 1,300 N, according to the table.



<u>Back Static Load Test</u>
This test is to see how much weight the back and the joint between the seat can withstand when being used. The table that goes along with the test states that the Garden Equipment should be able to withstand between 410 N and530 N

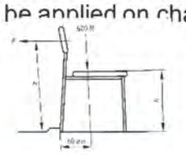


<u>Drop Test</u>
This test is to see whether the legs of the garden stool will be able to withstand a drop from different heights. In the folder it says that the maximum height for "A non stacking chair with legs longer than 200mm" is between 150mm and 200mm.



<u>Rearwards overbalancing</u>
The stability tests are more detailed in BS EN 1022, however I could not view these, but there is one test outlined in the folder. This test is to see how much force the stool can withstand at different angles before toppling over, to see how stable it is. There is a certain formula that is used to work out how much force should be applied on chairs with a seat height less than 720 F (in N) = 0.2857 (1 000 - h)

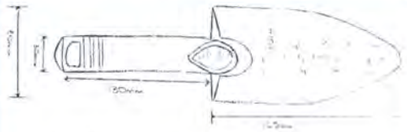
F = horizontal force
H = height at which force is applied
h = height of seat



Further research

Tools to be stored.

Betty would like to store a hand trowel and fork within the product. The average handle size of a trowel is 30mm in diameter however, the head of the tool can vary in sizes. This would mean that the easiest way of storing these tools would be to make holes big enough for the handles so that the tool can be stored upright, however this could be a safety hazard.



The tools could be stored like this, however it would most likely need to be made out of aluminium (however only for this part as it wouldn't be strong enough to withstand body weight) as it is corrosion resistant so would be able to withstand outdoor usage and it is also durable

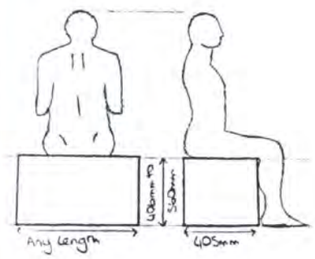
Further Interview

Me: In what ways would you like this garden stool to benefit you?
Betty: for it to be light and easy to carry. Not too low because I have difficulty getting up from low heights. It would be quite nice to have some storage space incorporated, either for small tools (for example a trowel and fork) and possibly a tray-like storage that is shallower so when I'm planting my bulbs in the garden I can easily retrieve them by my side. A removable tray, or a hook that I could hang something off, for example a plastic bag for when I do weeding, would be helpful.
Me: What do you find difficult when gardening?
Betty: my particular problem is, after having my hip replaced, I can't bend over easily or physically kneel down. Due to the reasons just mentioned, therefore I can't easily get up and down to retrieve things I need, such as gardening tools and seeds, bulbs, plants etc.
Me: Would you like this product to blend in with features of the garden?
Betty: To be quite honest, I'm not too worried if it doesn't blend in with the garden. My main need is to be able to use it and for it to be strong enough to withstand my weight.
Me: Are there any particular types of tools that you would like to store within the product?
Betty: The tools I tend to use the most would be a trowel and fork
Me: Would you like the product to be collapsible for easy storage?
Betty: I would quite like it to be collapsible, but only if it was an easy mechanism. If not, it wouldn't matter.

<u>Sustainability</u>
The materials used need to be as locally sourced as possible to reduce the carbon footprint of the end product. If I use wood for the prototype, this should be easy to ensure, however, using a metal may have a larger carbon footprint, as the ores tend to be sourced and extracted overseas. In addition to this, the materials I use need to be sustainably sourced, so if I use wood, I will make sure to use wood sourced by FSC as they help to responsibly manage forests. Although metals cant be fully sustainably sourced, metals like steel balance out the impact as they can be endlessly recycled, without losing quality. Aluminium can also be recycled, using 95% less CO_2 required to create a primary metal. In order to make the prototype as sustainable as possible, at the end of its life cycle, all parts should be recycled, therefore preventing the need to create more CO_2 for another item. In addition to this, the product should be easily repaired to reduce the unnecessary replacement, so standardised parts should be used, and use products that can be bought in any DIY shop, so the user can easily buy and repair any broken parts in the prototype.

Anthropometric Data of Elderly People and Design Considerations
(The Measure of Man and Woman, (Tilley, 2001))

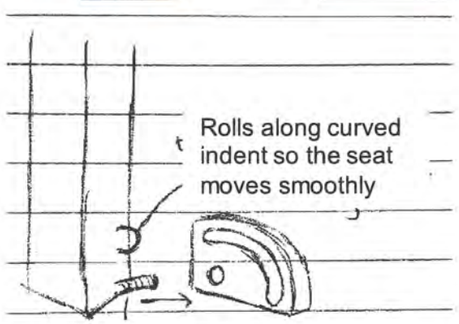
- Avoid front rungs on chairs because their legs move back to assist them in rising. This means that the product would have to be completely clear of anything under the seat
- I'd also have to add some sort of arm support so the person using the product can easily rise from the garden stool
- The height of seats must be adjustable or made to order so that it can be made to the height of the user
- I should also include some form of padding on the base of the seat to make it comfortable when being used for long periods of time. For a dining chair, the padding should be 19mm of thick foam. For a working chair, the padding should be 51mm of medium foam. I should find a thickness between these two measurements.
- For a dining chair, the seat depth should not exceed 405mm and the width should not be less than 405mm. For a universal work chair, from front to back, the seat should not be more or less than 406mm. The width should be between 406mm - 560mm. I will need to find a width between these two seating requirements so that the user has enough space to sit on the stool and be comfortable.
- The average palm size/hand width of a man is 84mm, with the average for a woman at 74mm.
- The average weight of men in the UK is 83.6kg, and the average weight of a woman in the UK is 70.2kg.

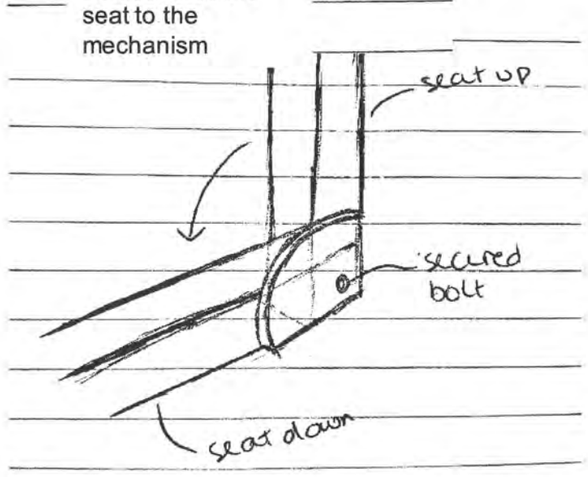


Different types of mechanisms

Mechanisms that could be used to fold down the seat

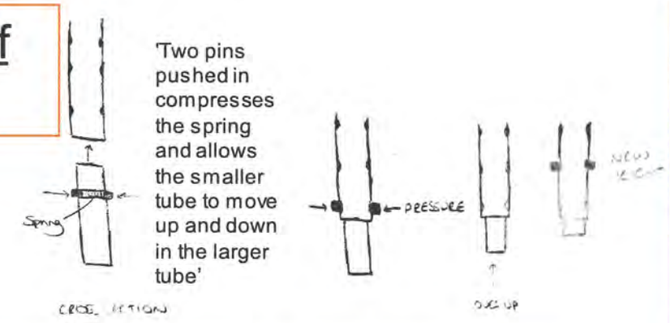
I could use two different types of folding mechanism, one that is commonly used for folding camp chairs, and another which is commonly used for folding down tables. For the latter, I would have to make sure that there was a lock so that the product wouldn't collapse when it is sat on. However, this might not be strong enough to withstand bodyweight so the other mechanism might be the more suitable method.





These seats have the same style of mechanism that is used in cinemas, so the seat of the chair folds up when it's not being sat on. The seat is fixed into the frame by a nut and then there is a peg which is fitted into a curved inset in the metal. Whenever the seat is sat on, or moved, the peg moves smoothly around the curve. It would seem there was some kind of spring which allows the seat to automatically flip up when it isn't being used.

This would be a good type of mechanism to use, however it could be difficult to do due to the fact the frame would have to be sturdy and possibly heavy to withstand the weight being put on it which could make the product quite bulky instead of being easy to store and light, as the client specified. Despite this, it would be very easy for the user to fold the seat.



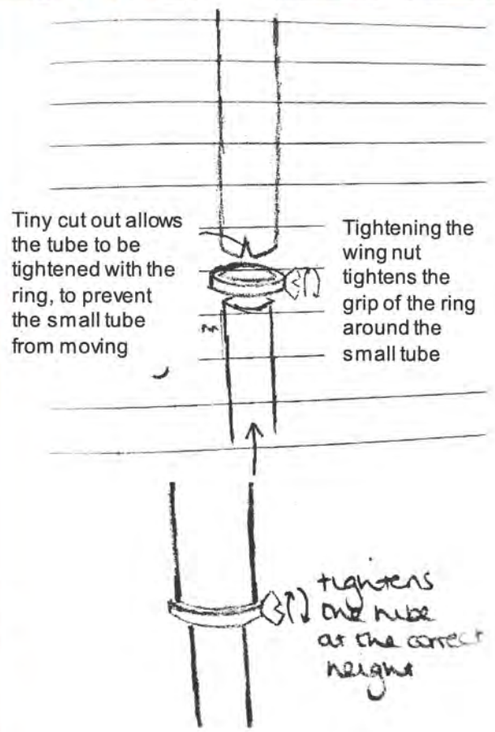
These mechanisms were found on photography equipment to adjust the heights of tripods and studio lighting.

On the tripod (first three pictures) the lock mechanism comprises a lever connecting a pair of lock assemblies associated with each adjacent leg for movement between an unlocked position wherein the legs may be telescopingly adjusted and a locked position wherein the lock assembly exerts a clamping force on its respective leg for locking the leg in a desired position (https://patents.google.com/patent/US5503357) This type of mechanism was very easy to use and it made the legs very easy and quick to adjust. However, the tripod is normally used to withstanding light weights, such as cameras, so I don't know if this type of mechanism would be strong enough to withstand the weight of a human

On the studio lighting (last five pictures), the mechanism features a sliding pole, within another pole, which can be locked into place with a screw-type lock. This lock can be easily undone and the pole can be easily extended or shortened with minimal effort, and then locked back into place again. The outer pole had a hole in it, in which the screw goes so it can be tightened up to the inner pole to prevent it from moving. When tested, it showed it was an effective mechanism to adjust the height of the legs and looked as though it could withstand more weight than the tripod mechanism.

Mechanisms that could be used to adjust height

For the product, I could adopt the same mechanism that is used to adjust the height of crutches. This would be done by using a detent button that is inside of two pipes which both have holes drilled into the sides. The larger diameter of the two pipes would be able to move whilst the other smaller one has the detent button secured onto the inside of the pipe. This would be a reliable method to use due to the fact it can withstand the weight of a human body, as shown by crutches, and it would be extremely easy to use.



Levels of production

Batch production would probably be the most suitable method of production if the prototype were to go into manufacture since all of the existing solutions are batch produced as they are to be sold to gardening shops and large companies. I would definitely use batch production for the stool as parts can be easily changed and adapted after the first batch go out, if there are parts consumers dislike, which could be discovered in focus groups and reviews. This would be beneficial as it would prevent the wastage of manufactured stools, which would occur in mass production as they are less flexible to market trends. Batch production is also more environmentally friendly, due to the reduced waste and also because it is a smaller form of production meaning less electricity is needed, and therefore less CO_2 is emitted in comparison to mass production. One off production would be too slow if this were to go into manufacture, and it would also be more expensive as it wouldn't be beneficial to buy materials in bulk, like it would be in batch production.

Refined final design brief - based on research.

My final product needs to solve the problem of being unable to garden after a hip operation, or an operation of any kind and it needs to eliminate the need to get up and down, so it makes it easier for the client. As a result, I need to make a product that incorporates tool storage, is easy to get up and down from and is also easy to transport, possibly with the use of wheels or handles. In addition, I need to make sure that it has height adjustment to make sure it is suitable for every kind of user, alongside it being collapsible so it can be easily stored. Every moving component of the product needs to be easy and simple to do, and self explanatory. In addition to this, the product needs to be as sustainable as it can possibly be, with sustainably sourced/locally sourced materials, with easy repairing, and the ability for its components to be recycled or repurposed at the end of its life cycle. The product needs to withstand BS EN 1728 to ensure it is as safe as possible. Based on the further interview, it must be able to store a trowel & fork for my client, to meet her needs.

* I also need to make sure that the moving components don't pose a risk to the user in terms of safety so finger traps & other risks need to be eliminated.

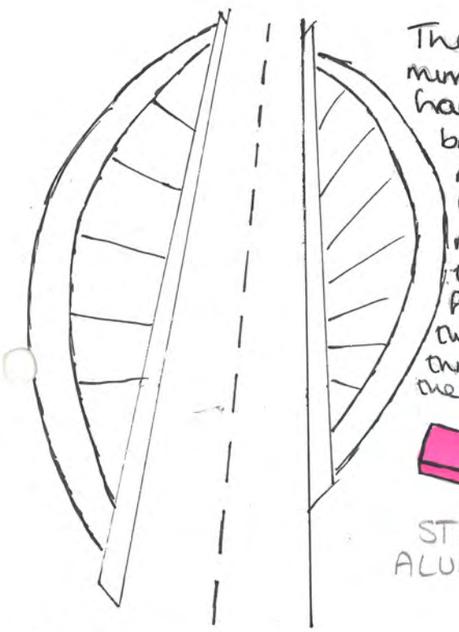
Specification

	Specification	Justification
Scale of production and cost	The prototype, if being sold, would have to be priced between £20 - £30	This is due to the fact, from my research, I found products that have a similar purpose, are in this price range. It may have to be slightly more expensive due to the extra features like the tool storage and the collapsible feature.
	If the prototype were to be batch produced and sold, it would have to be made using jigs in the process	Jigs and fixtures help to make the manufacturing process quicker and more efficient, so more products are produced in a short amount of time which increases productivity. In addition, they provide constant accuracy and uniform quality which helps to make sure that every product produced is the same as the last. Jigs and fixtures also help to reduce cost due to the reduction of waste and the reduction of labour needed.
User Requirements / Size Requirements	The height of the product should be a minimum of 406mm and maximum of 560mm	This is because, if the product goes on sale, it would mean anyone can use it. The average knee height (50th percentile) is between 545mm for men, and 500mm for women. In addition, the ability to adjust the height will enable the user to adjust the height to their desire.
	The seat must be 405mm wide, and wider if necessary	This is so it can be used by anyone and wont be too small for people if it goes into batch production. This will also mean it is comfortable for everyone who uses it.
	It must have tools storage with holes at least 50mm wide	This is so that the product can store a variety of tools as the handles of the equipment that want to be stored by my client, have a diameter smaller or larger than 30mm. The tools will be stored upright, they can be prevented from sliding through by the size of the tool head, so if the holes are too big, it won't be much of a problem. For tools that will be stored, see Further Research Page 1
	The stool must be lightweight, with a maximum weight of 5kg, and easy to transport	My client requested this so she could move it easily and wouldn't have to strain very much when moving it. Therefore, the product should be made out of a lightweight material but one that can withstand the outdoor elements, so probably a metal, such as aluminium. Also, 5kg is a reasonable amount of weight for the stool to not get blown over, but also not too heavy that the user wont be able to lift or transport the product
	The handle size must be between 70mm and 90mm	This way, the handles can suit every user, and it also accommodates for the 5th and 95th quartile.
	The stool must have a maximum footprint of 500mm	This is so it doesn't take up too much space when it is being stored, so it can be easily stored, and also allows the user to be able to put their feet underneath with other gardening things, such as wellies or a bucket.
Sustainability	The product must be easily disassembled.	This is so that, at the end of it's life cycle, parts of the product can be recycled and reused to minimise the impact it has on the environment
	The product must be able to be repaired, and maintained to extend its life.	This is so that the user can keep the product for as long as possible, and maintain it so it works as well as it can for its time as a stool. Also, it should be easily repaired so standardized parts must be used so, if something does break, the user can easily buy parts to replace them, from anywhere.
	The finish of the product, should be done with the minimal amount of VOC.	This will mean that less harmful particles are entered to the environment which will mean that the manufacturing process of the prototype doesn't impact the environment too much. However, a spray finish will have to be used as it will contain metal, so the spray must contain either no VOC's or the minimal amount.
	The material used should be used effectively, with little waste created.	With whatever material is left over, I should try and incorporate it else where in my project to minimise waste so that it is used effectively. If I don't do this, the waste could impact the environment if it were to go to landfill.
	The product must be made with sustainably sourced materials.	This includes FSC woods which make sure that all woods are sourced responsibly through the management of forests, by setting standards on forest products, along with labelling and certifying them as eco-friendly. This means that the wood used in my product should have as minimal impact on the environment as possible and that the user can confidently know this as well.
	The materials must be locally sourced.	This reduces the carbon footprint of the product, and therefore the environmental impact that it has.
Safety	The must be able to withstand the tests stated in BS EN 1728.	This will make sure that the product is safe to use and will be able to withstand forces of the human body. In addition, it will also make sure that if it was batch produced and sold to customers, that it conforms to BSI standards and proves that it is safe to use.
	The mechanisms must be able to be adjusted with ease and safely.	This will mean the user needs to exert minimal energy to adjust the height of the product. When collapsing, the mechanisms won't cause a hazard to the user, such as finger traps which can be dangerous and painful.
	The product must be stable when it is in use.	This will make sure that the user feels stable and safe while using it, so I need to make sure that the weight of the user is equally dispersed around the project so there is a stable centre of gravity, at all heights.
	The product should be quality controlled through out the manufacturing process	This will ensure that throughout the process, the product meets the specification standards
	The product must not sink into the ground while it is being used	This is is so it doesn't become unstable if there is more pressure/weight on one leg of the stool, which will cause it to become slanted and maybe unsafe for the user. As a result, the feet must have a large surface area to spread out the mass on the grass/ground.
	The stool must be able to withstand at least 85kg.	This is so it caters for the average male weight, and over the average, along with the average weight of a woman, without the stool breaking when it is being used.
Form and Function	The prototype must be an effective garden stool which carries out its function well.	Overall, the stool should work well and all the mechanisms should work, however if some parts don't, it will allow me to see what can be adapted and done differently if it were to go into batch production.
	The product must be able to withstand the tests and body weight so a suitable material must be used.	The product will most likely have to be made out of a metal such as aluminium or stainless steel. The material must be able to withstand outdoor weather as well, so these two metals would be a suitable material. However, although aluminuim is lighter and less expensive, stainless steel is stronger and easy to weld.
	The product must have an adjustable leg height	The client requested this and this also would mean that it would appeal to most people since it is not set at one height. This will allow it to be used for tending to raised planters and to ground ones too.
	The product must be collapsible	This will allow for easy storage outdoors and indoors. This will also mean that the product can take up little space when it is not being used.

DESIGN IDEAS

= justification

This bridge in Lesbury inspired this style of garden stool



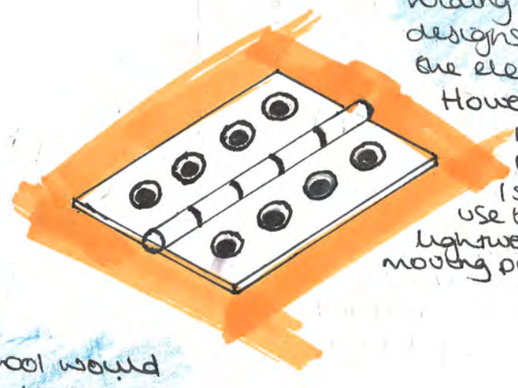
The frame of the seat mimics the steel frame of the bridge. The road running through made me think that the frame could fold in half, like the road going straight through the middle

STEEL OR ALUMINIUM?

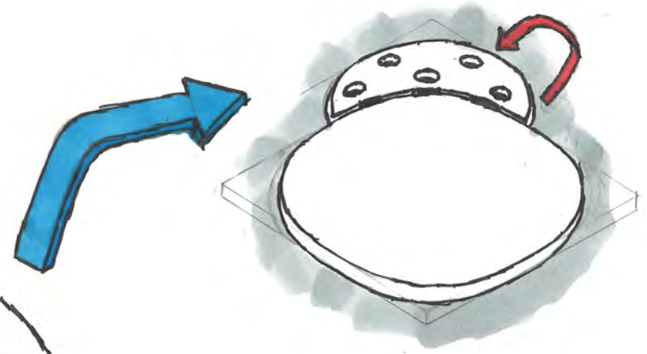
There would be two hinges in the seat frame, allowing it to fold in half when the legs are pushed together.

This garden stool would need to be made of mild steel as it is a strong material which can withstand weight. However, this may prevent the stool from being lightweight. Steel is a sustainable material because it can be endlessly recycled & therefore releases less CO_2 than making steel from scratch.

A hinge would be the mechanism used for the folding elements of the designs drawn & it allows the element to fully fold. However, these hinges may not be able to withstand lots of weight so I should only use these for lightweight moving parts.



The rose petals could be reused to create a tray (drawn below) which folds in when the stool isn't being used.



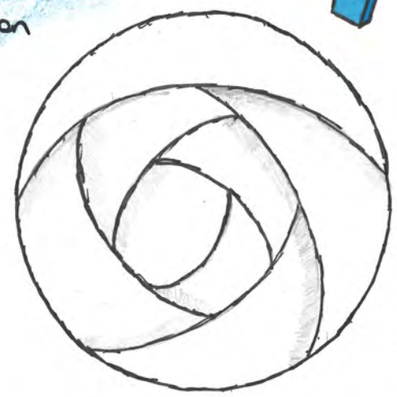
When I was drawing the design idea, I became confused as to how the seat would fold in half when the legs were pushed together. So, I made this model to allow me to see how the mechanism would work.

This stool would need to be between 410mm & 580mm so I will need to figure out which form of height adjustment would work best with this design

I constructed this quick model using match sticks, thread, a hair bobble & some double sided tape.

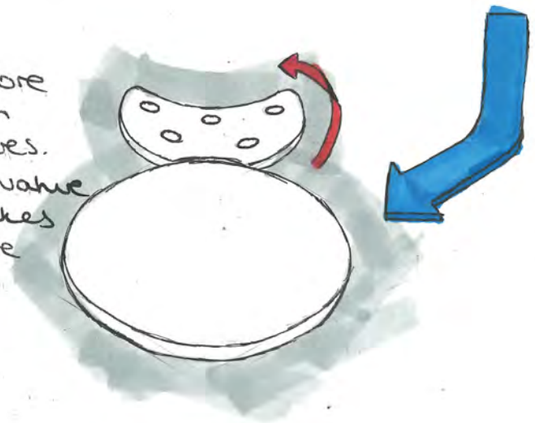
I would also have to figure out a way to make sure that the seat doesn't fold up when it is sat on, since the seat would fold inwards

However, I realised that when the seat folds in half, there may be a risk of a finger trap so I will have to figure out a way to prevent this.



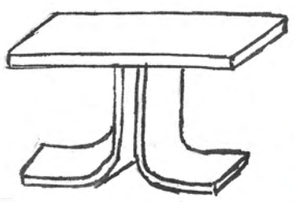
The Charles Rennie Mackintosh rose from the Art Nouveau design era was an inspiration & made me start thinking about the way component my client asked for.

This design looks more like the rose which features lots of curves. In addition, the curvature of the storage pot makes the product look more interesting & it will probably be more functional than the initial design

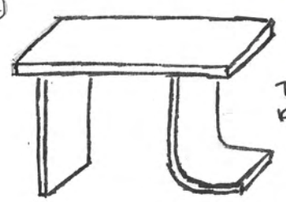


DESIGN IDEAS 2

I started off with the letter J & duplicated it':

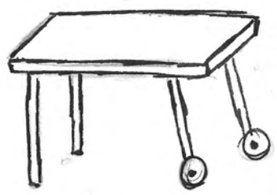
① 

I then realised this probably wouldn't work so I made one of the legs straight - TT sign

② 

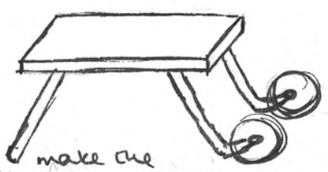
This leg would probably be unstable.

I began thinking about the requirements in my specification & how the product needs to be transported so:

③ 

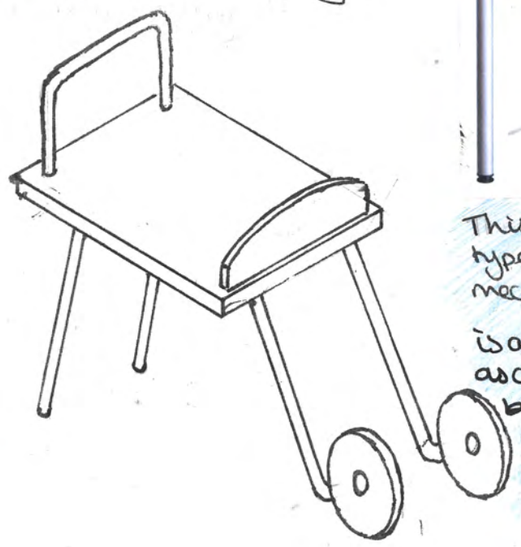
this type of leg would use less material so would also be lighter

I then realised that it wouldn't be stable like this so I adjusted the leg angles.

④ 

make the stool more stable

The legs could be made adjustable so that the product could turn into a wheel barrow-type object with a handle & a lip on the end to prevent tools from falling off.

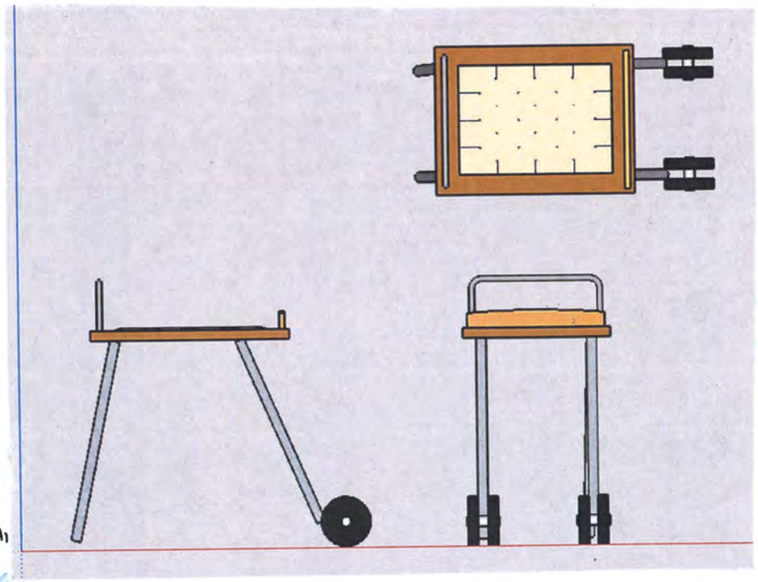
⑤ 

I could also make the legs collapse in so that it can be easily stored.

I took inspiration from a folding table, where the legs go from a vertical 90° angle & fold up to a 90° horizontal angle so it disappears under the seat

This would be the type of folding leg mechanism I would use as this is a strong mechanism, as can be seen by it being used for tables & it's also reliable as it clicks into the correct position

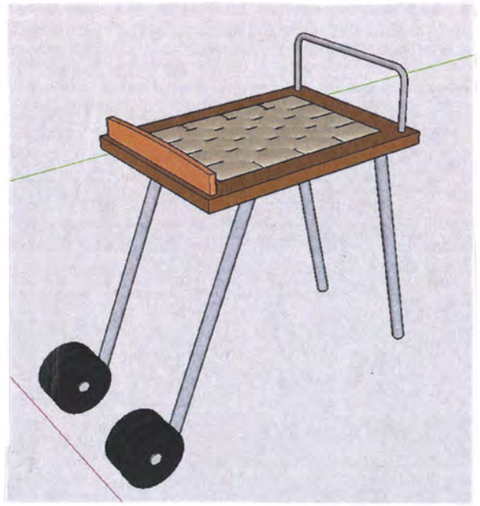
These models allowed me to see how the product would stand. I realised this product may be slightly unstable due to the legs being close together so it could topple sideways when in use.



I would use wheels similar to those used on a wheel barrow due to the fact these are made for heavy duty purposes & can withstand heavy loads making it suitable for this stool.

The wheels would need to be on an axis

While making these models I began thinking about how the product would be secured together. I would probably use nuts & bolts since this would mean strong joints & mean the stool could be easily disassembled at the end of its life.



Making the physical model made me realise how unstable it would be when I added pressure to it. I will need to find a way to space out the legs, possibly at an outwards angle to give the stool a better centre of gravity.

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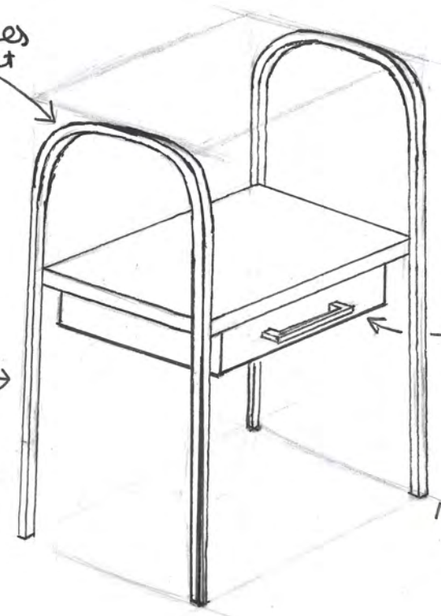
DESIGN IDEAS 3

I would use steel or aluminium for the frame. Steel is a strong, durable & sustainable material, but heavy unlike aluminium. Aluminium would help keep the stool lightweight but the thin frame may collapse under the pressure of a person so steel would be the material I use.

Raised handles help the user get up & down with ease



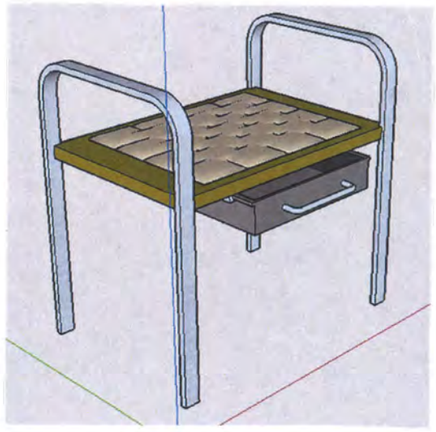
Thin frame makes the product lightweight & uses less material than a solid frame

Storage space for tools & other things (gardening gloves)

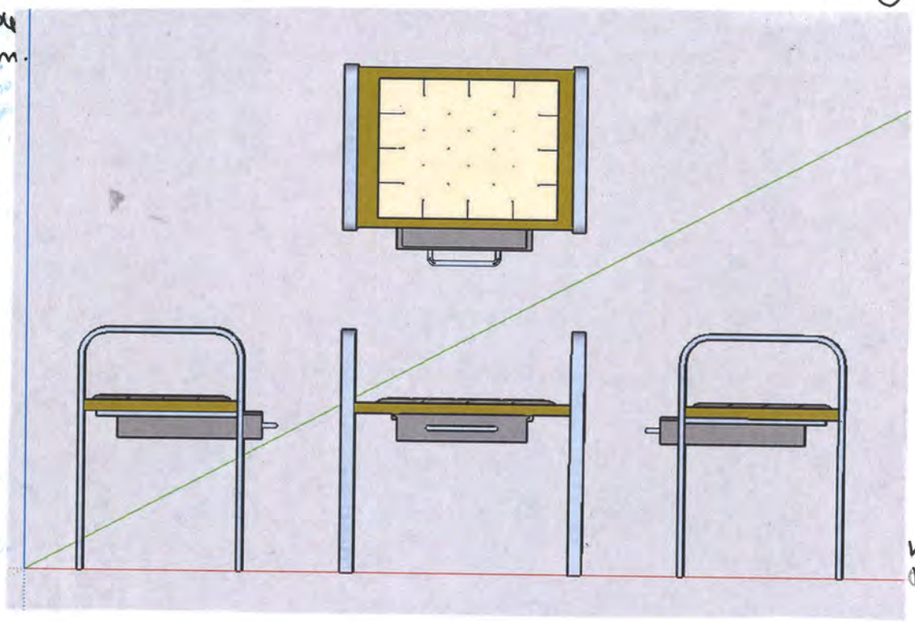
I would use polypropylene for the seat & drawers to keep the stool lightweight & it can also withstand bodyweight as seen in my existing solutions.

Legs would be adjustable so the seat can suit the user. This is also how the product would be 'collapsible' but it might be difficult to make it hold up.

The inspiration for this design was from swimming pool steps due to the fact the curvature of the tubing assists people getting up & it. I felt like this may help/benefit people like my client as they can use their upper body strength to push themselves off the seat, rather than using their legs alone since after hip surgery, this may be difficult



After drawing out this CAD model, I realised that the frame would probably need to be a lot thicker to withstand the weight of a person. It may also need disks on the base of the legs to spread out the weight so that the stool doesn't sink into the ground.



I could make this modular by adding attachments the user could choose. Hooks to hang off bags for weeds, grips would slip around the handles (silicone) to make it easier for the user to carry.

hook onto handles

there would be a slit down the middle of the finger grip so it can slip around the handle.

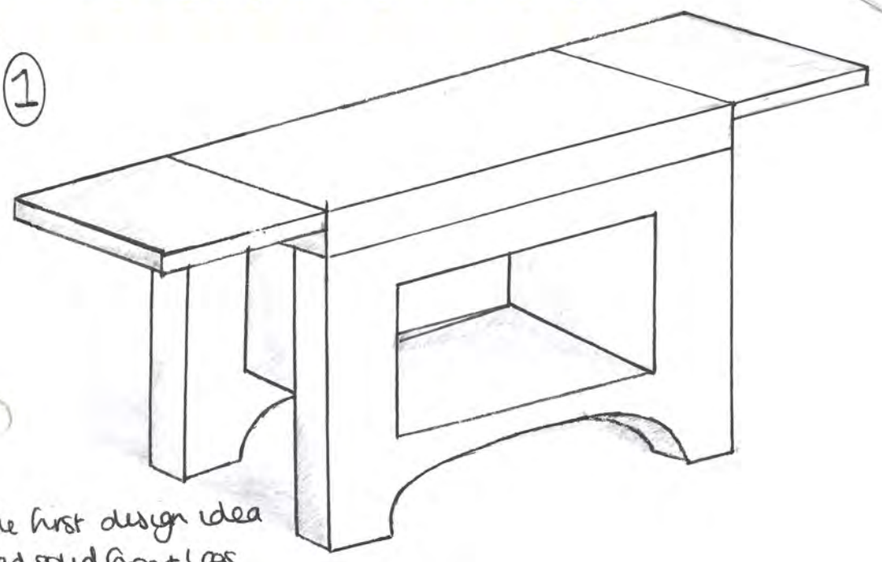
The drawer would hang down off the seat using runners meaning that the drawer wouldn't need to be housed in a box (like a drawer in a wardrobe) so it can hang freely & be pulled out easily. This would also mean less material is used.

Making this model allowed me to see the problem of securing the seat to the legs. The frame won't be cylindrical so I began thinking that I could drill through the frame, into the seat & use either a screw or a pop rivet to secure it.

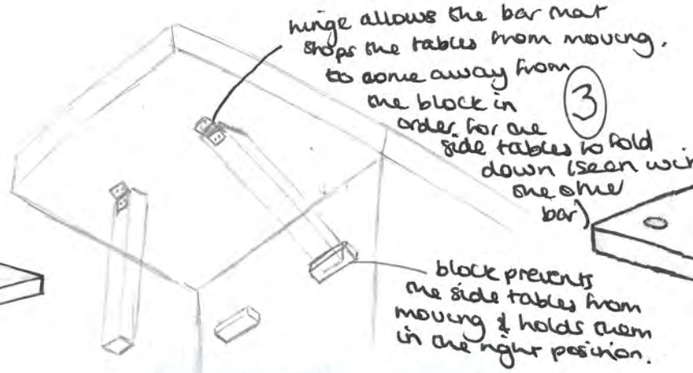
This physical model looks out of proportion when compared with my drawing & CAD model since the legs are too short & handles too long.

DESIGN IDEAS 4

(1)

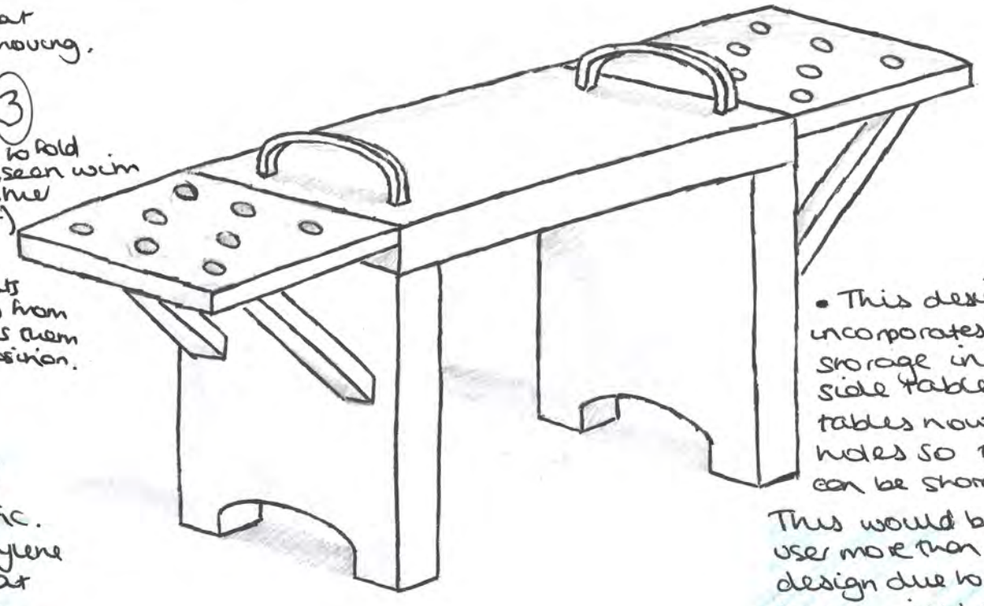


The first design idea had solid front legs with a cut out box in the middle where tools could be stored by the user. However, I realised this was an unnecessary use of material. So in the next two developments I took this into consideration by altering the legs.



(3)

This stool will be made out of a plastic, most likely polypropylene due to the fact it is a strong, durable plastic. In addition to this, polypropylene can be recycled meaning that the end of this products life cycle, it can be made into something new, while releasing less CO_2 into the atmosphere than it does when it is first manufactured from crude oil.

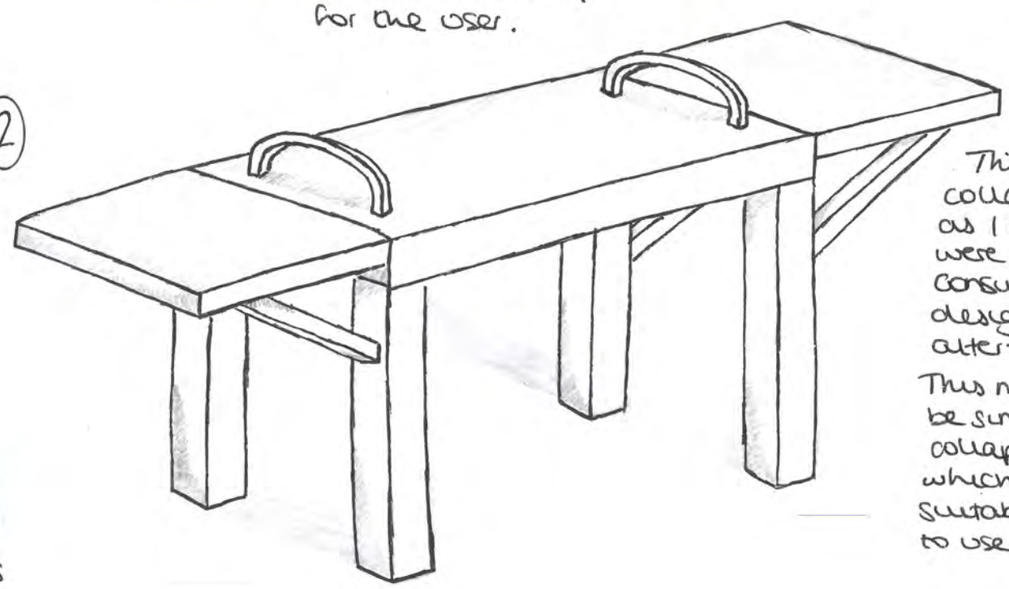


• This design incorporates tool storage into the side tables. The tables now have holes so the tools can be stored upright. This would benefit the user more than the first design due to the fact the user will be able to see what they are picking up & will therefore, also be less dangerous.

I added handles to the design so that it is easier to transport for the user.

I decided that the second style of leg may not be as stable as the first style, so I took the concept of the first & changed which legs would be solid.

(2)

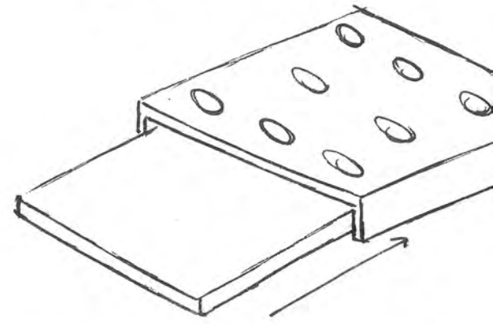


The garden stool will be flat pack so it will be easy to dismantle if needed & will also be easy to transport. This will make the manufacturing process cheaper since I won't need to put aside extra time to assemble it, making it quicker to manufacture than my other designs

This design features collapsible side tables as I realised the arms were quite space consuming in the first design, so I decided to alter it.

This mechanism would be similar to that of a collapsible/fold out table which would be suitable as it is easy to use & durable.

Jig for tool storage holes



If the product were to go into batch production, a jig would be needed to make sure that all the tool holes are identical

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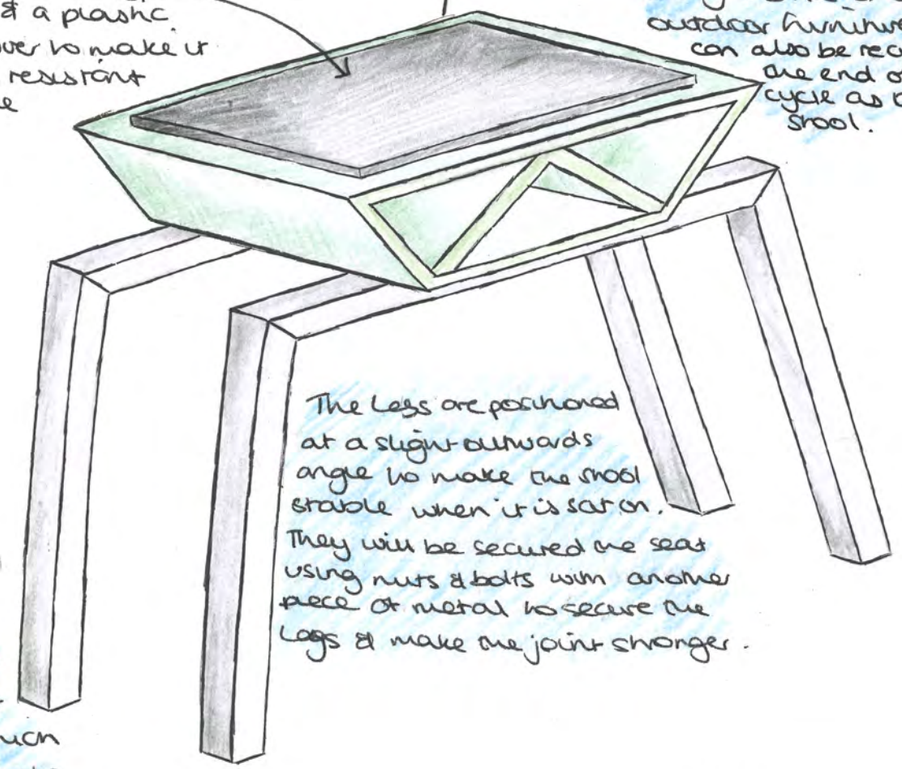
DESIGN IDEAS 5

The structure inside the seat adds strength but can also double up as storage space as it would be easy to retrieve tools

The seat will be made using polypropylene since it is a strong material that can withstand body weight since it is used for outdoor furniture/seating & can also be recycled at the end of its cycle as the stool.

The cushion will be made using foam & a plastic vinyl cover to make it weather resistant & durable



The legs are positioned at a slight outwards angle to make the stool stable when it is sat on. They will be secured the seat using nuts & bolts with another piece of metal to secure the legs & make the joint stronger.

The legs would be made out of steel tubing which would help to make the stool as lightweight as possible as they are hollow. This also makes the stool more sustainable as steel can be recycled

The legs would most likely be made out of steel as this is a strong material.
To get the leg angle I want. I will have to cut & braze the metal together, I would braze it rather than weld it because brazing requires a lower constant temperature & so is less dangerous & easier than welding.

This design is more contemporary than my other designs. I got my inspiration for the trapezoid prism shape from electricity pylons & decided to incorporate angles wherever I could to make the design more interesting than some of my other ones.

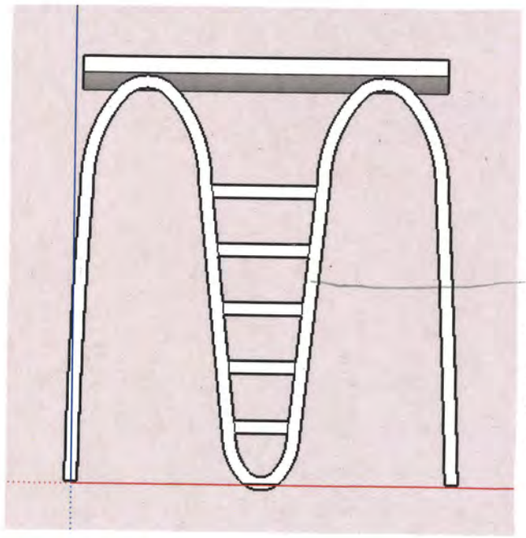
The curved seat should make the stool more comfortable for the user to sit on.

This design incorporates shelves for easy tool placement & retrieval

Since it will be made entirely from wood, this should reduce the chance of people finding the colours of the stool offensive.

The legs will be shaped using wood & laminated as this is a strong material however this would have to be done with water resistant glue to prevent the pieces of laminate coming apart if the stool gets wet.

The seat would have to be made out of wood that has been curved as this would be difficult to do with plastic or metal. This may add some weight to the product but it means that it is more sustainable than metal & plastic as wood biodegrades & at the end of its life as a stool, it could be repurposed.

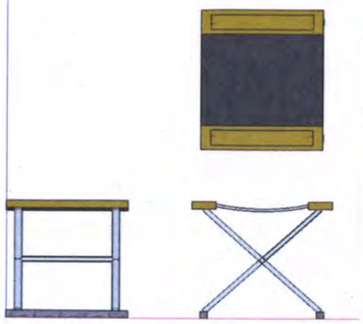


There are lots of shelves which means there is a lot of space for tool storage but only while being used by the user.

The 'M' inspired design means that there may be more strength in the seat as there are 6 points touching the ground instead of 4 which means there will be less stress on each leg & more weight distribution

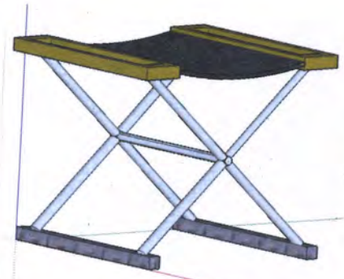
To lower manufacturing costs the product would be flat pack so there would be no extra joining costs which would be beneficial in batch production as it means less time is lost so there would be more productivity.

DESIGN IDEAS 6



Drawing this model made me see that I would need a rod to hold the two legs together as they would be incredibly unstable, & would possibly break without something holding them together.

The seat will be made from a durable plastic mesh (polyester) since this is a strong, lightweight material that is mildew resistant & quick drying.



This seat will fold upwards when the legs are pushed together. Easy because of the mesh middle.

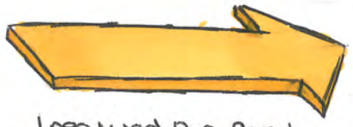
Solid but is hollow so that tools can be stored sideways - easily for user to pick up one tool they want (acts like a tray)

The product will hold up like a camp chair to make it easy for the user

I colour green is important to the Islamic religion because it was Muhammad's favourite colour & also that he wore a green cloak & turban

Legs made out of steel tubing that incorporates the clarken-pop height adjuster.

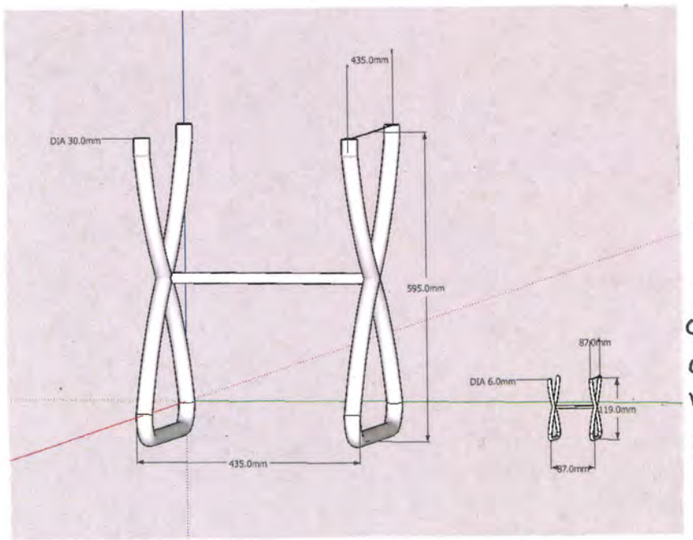
I thought I could add a separate storage space for tools as I found it difficult to incorporate storage space into the actual stool. It would be made out of wood to make the product more sustainable. The wood would need to have a finish added to make it weather resistant



I realised the stool was too similar to my very first design so I decided to adapt it into something slightly different

The colour black in Christianity can represent sin & death so may not be a good colour to use as it may exclude this religion.

Legheight can be easily adjusted

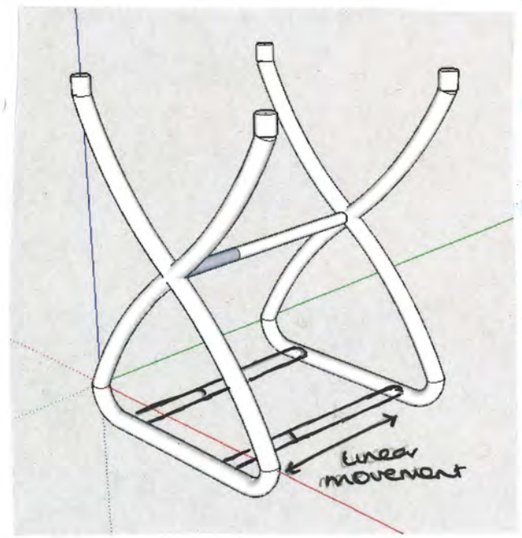


Here is the scaled down version that will help me produce my physical model. (scaled down by 1/5)

The legs on this design would be pushed together in a linear motion, instead of a rotary motion.

I will need to make a model to figure out how I will bend & join the legs to each other.

I will also need to test the model to see how much weight it can handle in proportion to its weight so I can see how strong it is.



This change in leg design was inspired by the languid lines used in a lot of Art Nouveau design. These legs could be bent through the heating & bending of metal or I could create the curves through laminating wood which would mean the stool was strong yet also flexible.

Design 7 Model

For Design Idea 7, I needed to make a model so I could figure out how I would shape the legs of the stool & also how I would join the pieces of metal together. The model was scaled down by 1/4 of the CAD model.

I began testing the stool by adding 8kg of weight to see how strong it was but I realised this wasn't much use to me as the stool didn't move at all so I decided to test it a different way.

I tested the strength of the model by putting weight on it until it broke.

The model weighed 0.092kg & I applied my full body weight on the stool along with a heavy book

The stool withstood 72.134kg before it began to bend at the top, but it did not fully break meaning it could probably withstand more weight

I decided to braze the legs together as this would probably be the method to use if the stool was to go into batch production

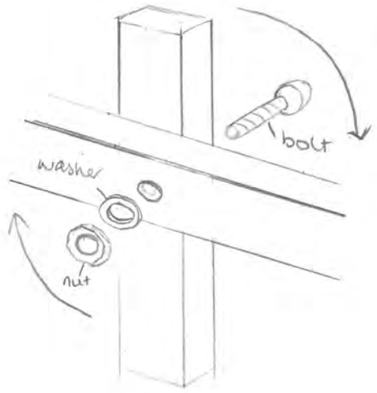
I also used the brazing method because I felt this would be the strongest joining method for steel

Overall, the stool withstood approximately 75.4 times its own weight before it became deformed.

If I were to make this into a full size prototype it would easily withstand the weight of a human but I would have to consider adding something to the top half of the structure to make it stronger.

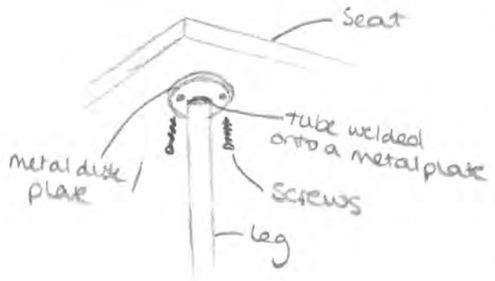
Design 1 & 6 - Construction

Collapsible mechanism



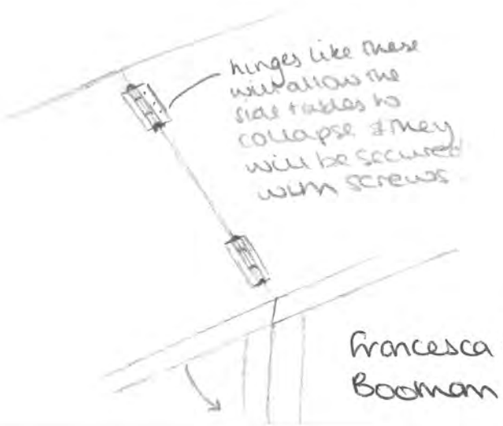
This method of construction would be used because it is strong & it allows easy movement & therefore easy collapsibility for the user.

Design 2 - Construction

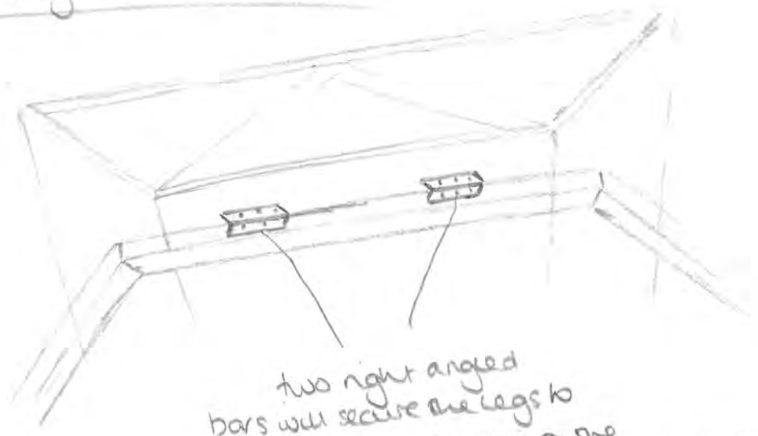


This construction method will create a strong joint, especially with the tube welded to the plate. The screws will prevent anything from becoming loose.

Design 4 - Construction



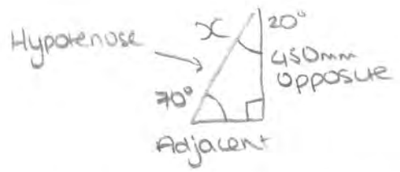
Design 5 - construction



two right angled bars will secure the legs to the seat. Screws will go into the seat as these are strong & work with plastic. The bar will be welded onto the legs as this creates a much stronger joint than pop rivets would

MATHS

Working out length of angled legs



S = O/H C = A/H T = O/A

$\sin 70 = \frac{450}{x}$

$\frac{450}{\sin 70} = x$

$\frac{450}{\sin 70} = 478.8\text{mm}$

$= 480\text{mm}$ (2SF)

Length of leg to keep stool elevated at 450mm

$= 480\text{mm}$

Nesting for batch production

Design 3 - Seat & drawers

Seat size = 405 x 320 x 10

Drawer - base = 320 x 320 x 10

Drawer sides = 320 x 50 x 10 mm (x4)

Polypropylene stock size

1000 x 500 x 10 mm

= £46.54 (excluding VAT)

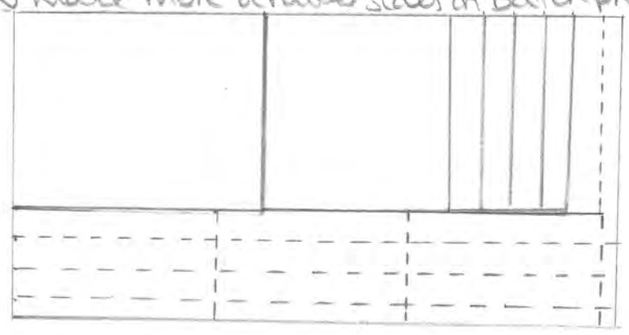
Area of polypropylene sheet = 500000mm^2

Area of sheet required = 296000mm^2

Percentage of sheet used = 59.2%

Cost of material needed = £27.55

I could also adjust the layout so the material is used effectively, by using the leftover material to make more drawer sides in batch production.

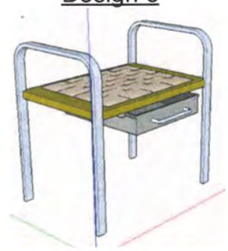
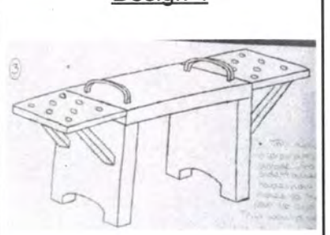


10 extra drawer sides will be cut out.

Percentage of waste material = 8.8%

Francesca Bartlett, 9005, Boorman School, 48349

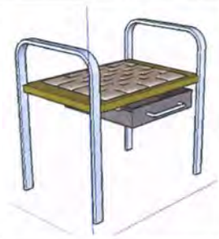
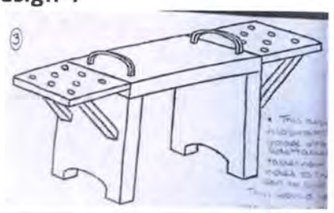
Design Evaluation

DOESN'T MEET SPECIFICATION PARTIALLY MEETS SPECIFICATION FULLY MEETS SPECIFICATION	Design 1 	Design 2 	Design 3 	Design 4 	Design 5 	Design 6 
Product can be easily disassembled	Nuts and bolts would hold the product together - this could be difficult for some users to disassemble. Also, it may not be quick or easy to do - very fiddly	The product would be constructed using nuts and bolts, holding the legs and handle to the seat. The wheel extension would be welded/brazed to the leg.	I am yet to figure out how this product will be assembled - possibly using screws or pop rivets	This product will be a flat pack meaning that it will be easily assembled as it is disassembled.	The product will be flat pack meaning that it can be both easily assembled and disassembled.	The product may be hard to disassemble because it will be brazed together.
Product is lightweight and easy to transport	The lack of solid material (the whole thing is just a frame) would make the product as lightweight as it can be. I need to figure out what type of material I will use for the product as aluminium is lightweight and durable, but is not as strong as steel.	The seat would be made using a plastic, along with steel or aluminium legs which will make the product very light overall	This product should be lightweight because it has a thin frame of steel tubing so this should keep the product light, rather than having a solid structure. The drawer may weigh the product down as it will require quite a bit of material. The seat should keep the product as lightweight as possible due to the fact it will be made from polypropylene, which is a weight saving plastic. Because the plastic is lightweight, this means it should also be easy to transport - despite not having wheels.	The product will be made using polypropylene which is a reasonably lightweight material due to its low density. The handles either side of the seat make the product easily transportable.	It will be made using laminated wood so it should be reasonably lightweight, with the shelves being made out of plywood (instead of solid wood). The stool could be lifted by the curves at the top of the legs, however it could cause strain as they are quite far apart.	It would be made out of steel rods and tubing meaning that it may be heavier than some of the other designs.
Product has tool storage (50mm diameter holes)	There is no storage space for tools so I would need to incorporate this if I develop the design idea.	There is no storage space so I will have to include this in my development	The product has a drawer which will be able to store most of the hand held tools my client wanted to be stored in the end product.	The tables either side of the seat contain holes that tool handles can be placed in. This means that the user can easily see where each tool is however, this could also be slightly unsafe if the user accidentally cut themselves on a sharp tool.	This design doesn't have holes for tool storage but the shelves mean that any tool (or other things) can be easily stored. However, there is a risk of the tools sliding off the shelves so I will need to think of a way to prevent this.	There is currently no tool storage.
The mechanisms can be adjusted with ease	The leg height would be adjusted with ease as it is just like a crutch. Also, the folding seat would be very easy to use	The leg extension can be easily adjusted using the crutch like mechanism	At the moment, there are no mechanisms on this product.	The mechanism to make the side tables collapse would be the same as those used for collapsible party tables due to the fact they can withstand a reasonable amount of weight and are very simple to use.	There are no mechanisms.	There would be a horizontal 'pop' mechanism which would be self explanatory but it could be hard to push together since they are 435mm away from each other.

It carries out the function well	This design would carry out the garden stool function however it would not carry out the storage part so I will need to come up with ways to solve this.	This stool can carry out the stool, and height adjustment functions well. However, there is no collapsible feature yet, nor is there any tool storage. This will have to be added in the development stage.	The product will carry out the function of being a stool and having storage space, however it fails to collapse and extend its height	This garden stool provides the user with a place to sit, store their stools and a way that they can easily transport the stool.	It works as a garden stool that has tool storage but cannot be adjusted.	It works as a garden stool, it has no storage space but can be adjusted.
The leg height is adjustable	There is an adjustable leg height mechanism that would be easy to use	The leg can be made longer or shorter, depending on the user	There is no height adjustment at the moment	There is no way of adjusting the leg height as it is has solid plastic legs	Leg height can't be changed.	The leg height cant be changed.
It has a height between 406mm and 560mm	Yes, because the leg height is adjustable	Yes because the leg height is adjustable	The standing height will be 450mm, but I will need to make the height adjust if I decide to develop this design	The stool will have a height of 450mm, but the user can't change it	It has a fixed height of 480mm.	It's height currently exceeds the limit but it can be scaled down to the right height.
Is it collapsible?	The stool would be collapsible but there may be a problem in the way that it does collapse. It currently collapses inwards, which would be an obvious problem since the stool would collapse when it is sat on by the user. I need to look at other ways of making the stool collapsible.	I will need to come up with an idea as to how this product can be collapsible	The product cannot collapse at the moment	The tables either side are the only form of collapsibility at the moment. I would need to figure out a way to do this in development	The stool isn't collapsible.	It is partially collapsible as it can only be decreased by half, horizontally rather than vertically.
Can jigs be used?	Jigs would need to be used when making the leg mechanism. The holes in the pipe/tube used would need to be the same distance apart so that one side of the stool isn't shorter than the other. In addition, it would make the drilling process a lot quicker than measuring and marking out the holes every time. I may also have to use a jig for the circular seat part of the stool, as it would be difficult to bend by eye. This would also make the building process a lot quicker	Again, jigs would be used to drill holes in the legs for the height adjustment. Jigs could also be used when bending the handle that allows the user to push the stool.	Jigs could be used to bend the frames as they both need to have the bends in the same place. I could also use a jig to make sure that the seat is level on each corner - using a jig to make sure the holes are drilled in the same place	I could use a jig for the side tables to make sure that the tool holes are the same and evenly spaced on each one. I could also use a jig for the curvature at the bottom of the legs to make sure the curve is the same. These jigs would be very useful if the product were to go into batch production as this would ensure that every stool was the same.	Jigs will be used for the shaping of the legs which will also be beneficial if the product goes into batch production as it will help to decrease time and increase productivity.	Jigs could be used to shape the legs as I found it difficult and time consuming trying to make sure that the shape of the legs were the same.
Easy and simple to use	The stool would have a simple folding mechanism and a self explanatory height adjustment	The leg adjustment would be simple to use.	The stool and drawer would be very easy to use	The side tables would be simple to use as you would just pull them up and they would lock in place and then you would simply push the joint inwards to get them to collapse	There are no mechanisms on this design so the stool would be very simple to use.	It would be easy to use with the adjustments being self explanatory, but it may be hard to push them together.
Can be recycled at the end of its life	This would depend on whether I decide to use an alloy or a type of steel. However, the mesh seating and the hinges on the seat could probably be repurposed	I need to figure out which material would best suit the project, but both aluminium and steel can be recycled.	If I use steel tubing, the frame could be endlessly recycled. Also, by using polypropylene for the seat, this could also be recycled at the end of its life.	Polypropylene can be widely recycled.	It may be difficult to recycle since it will be made out of laminated wood.	The steel can be easily and endlessly recycled.

Minimum waste produced	This shouldn't be too hard as most of the frame is made out of tubing, some of which is bent, so it shouldn't produce too much waste	Again, the legs and the handle is made out of tubing so this shouldn't create too much waste. However, I will have to make sure, that when I create the seat, I use materials responsibly.	I would use a pre-made frame meaning that I wouldn't produce any waste, other than cutting off excess material	There would be waste produced by the drilling of the holes and the cutting out of the curves. Also, there could be some waste when getting the legs and seat to the right size.	The whole wood sheet would be used for the lamination meaning there would be minimal waste and the shelves would be accurately measured to prevent waste materials.	There may be waste from cutting the steel parts down to size but this would be prevented through accurate measurements.
Sustainable materials have been used	I will make sure that the type of metal I use will be as sustainable as possible. Steel would be the metal of choice as it can be used over and over again.	If I use steel, this would be sustainable as it can be used over and over again. Aluminium would also be a sustainable choice. However, if I decide to use a thermosetting plastic for the seat, this would be highly unsustainable as it cannot be recycled, this means I may have to look for other alternative materials to use.	The steel part of the stool can be continuously recycled at the end of its life cycle, making it reasonably sustainable since recycling metals saves 70-90% of the original energy used to make the material. The plastic part of the stool however, is not very sustainable due to the fact it can have a lot of negative impacts on the environment when it is transported as crude oil after extraction.	Polypropylene isn't a sustainable product as it is made from crude oil which is a finite resource and can also be a danger to the environment if oil spills occur by harming habitats on land and in the sea. It also releases lots of CO_2 in the transporting and manufacturing processes which is hazardous to the environment.	The wood used would come from sustainable sources like FSC.	Steel can be endlessly recycled.
Safe to use	I will have to think of a way to make it safer because, at the moment, there is a big risk of a finger trap.	This product is safe to use as it has no way of collapsing at the moment - no finger traps. However, the leg adjustment could catch the skin of the user when it is being adjusted. I will have to figure out a way to prevent this.	This product would be safe as there are no mechanisms, but the only possible finger trap is the drawer that will be used for tool storage. I could add some form of stop or rubber addition to help protect the user from getting their fingers potentially trapped.	There is a possible finger trap when the table collapses as the table will	The laminated wood would be safe to use after manufacture (fumes produced).	There is a possible finger trap when using the mechanisms.
Weather/corrosion resistant	If I decide to use steel, I will have to make sure it has a weather resistant coating	Aluminium is the more weather resistant material out of the two, however it would depend on what type of steel I decide to use for this product as different types have different properties.	If I use stainless steel, it will not be fully corrosion resistant, but will withstand being used outside for a while. If I were to use steel (not stainless), I would need to add a form of coating to the metal to make it weather resistant. Polypropylene however, can degrade in UV light, which will most likely happen as the product is used outside. I don't think I could use a different type of plastic so I will maybe have to come up with a way to protect it - maybe a coating or a physical protective layer.	Polypropylene tends to degrade when exposed to UV light so I may need to add a coating or use an alternative material.	Laminated wood can delaminate if wet so I would need to find a way of coating it, or use an alternative material.	The steel would need to have a coating on it to make it weather resistant.
Durable	Steel is a durable material, but so is aluminium so I will have to decide which metal is most suitable for this project	Steel is the more durable material in this setting because it is tougher than aluminium but aluminium is also corrosion resistant.	Polypropylene is a strong and has good fatigue resistance. Stainless steel is a very durable material due to the fact it is corrosion resistant and very hard wearing	Polypropylene is a strong material that has good fatigue resistance so it should be suitable for this stool	The material is strong but may be susceptible to delamination.	Steel is tough, and as shown by my model testing, it is strong enough to hold the weight of a human.

Client Evaluation of Designs

Design 1	Design 2	Design 3	Design 4	Design 5	Design 6
					
This design looks unstable. Would there be a way to make it stable? Also, a round seat on this stool makes it look like it would be too small to sit on.	This design looks as though it would be difficult to store tools. Wheels on this look like a good idea as it would make it easier to move it around. This design could be good for someone who has reduced mobility as it could act as a frame to keep them stable. I really like the idea of the handle, allowing the stool to be pushed along. However, there isn't any storage so could a drawer be added underneath to keep the tools?	Although this design cant collapse, it doesn't look as bulky as design 5. This looks like it would be easily stored in a garage because of the thin frame meaning things could be stored underneath it. It also looks really light and easy to lift and it also looks like it would be a decent height. However, is the drawer big enough to store all the tools I may need to store?	I really like the look of this design. The idea of incorporating handles is really nice as as this will make the product easy to lift. The tables add a nice variation from the other designs and look like they will be good storage places for tools while the product is in use, but where will the tools be stored when it isn't being used? This stool looks really substantial but how heavy will it be? You could possibly incorporate a drawer underneath the seat for storage? Also, you could change the leg shape to help keep the product lightweight and how would the legs collapse?	This design looks quite sturdy and strong. I'm not sure whether the shelves look deep enough for any form of usage? I'd like it if it was collapsible. If there were less shelves, it would mean there was more height to store larger tools. Hooks may also be helpful.	Doesn't look very stable, it might rock. There is no storage. It looks like it could be quite difficult to store and collapse.

When I was talking to my client about the design ideas, she raised the point that, if the product is to be taken indoors after use, does it need to be fully weather resistant? She also said, if the product is left outside, I could make a cover for it to help it be weather resistant. This made me wonder if I could make the product out of a wood or different material that isn't as weather resistant but still can be used outside with a coating? It is possible since some garden tables are made out of wood, along with benches which last for a long time in outdoor conditions. I'm going to have a look and see what changes I can make to my material choices – these could also be more sustainable if I decide to use wood.

Betty Anne

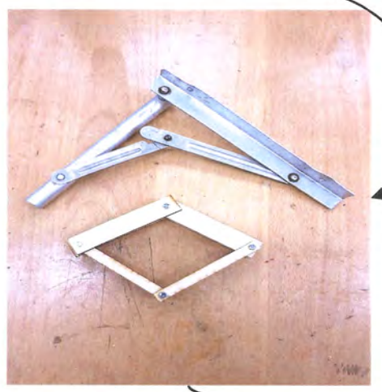
My favourite is Design 4 because I like the fact it looks really sturdy, it can be made larger for resting things which are also collapsible, and I like the handles as they mean I can move it easily. I like that I have a strong seat which can expand. Yes it isn't fully collapsible, but the fact I can use it as a seat and have the added bonus of extending it makes my life easier as I can rest things easily at a height that is useful to me.

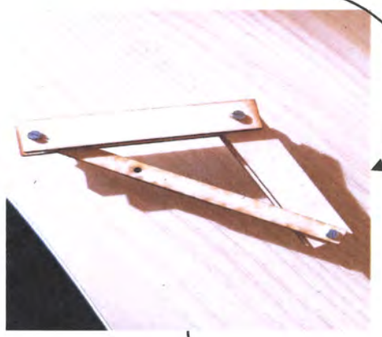
- I'd like there to be a drawer underneath the seat
- Hooks would be useful (Modular)
- Investigate how to add wheels?
- Less angular - more flush
- Taller?
- Design 3 with legs being all one part and more support

9005
Francesca Bartlett, Boohan School, 48349

Development 1 – Folding Mechanism

= client input



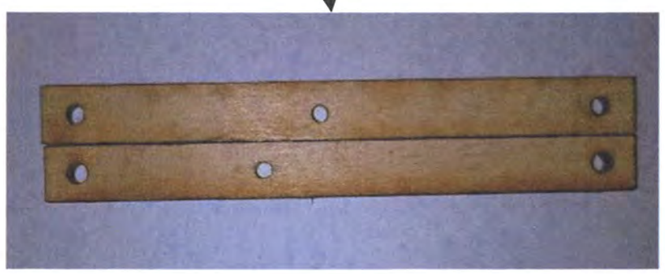


I made a model to figure out how I would collapse the side tables of Design 4.

I took the idea from part of a collapsible table (as seen above the model) and designed it on 2D Design and cut it out on the laser. After joining it with bolts I tested to see whether it worked.

I discovered that I had designed the thinner parts too long and placed the hole in the wrong place meaning that it wasn't possible to fold the pieces up in the same direction.

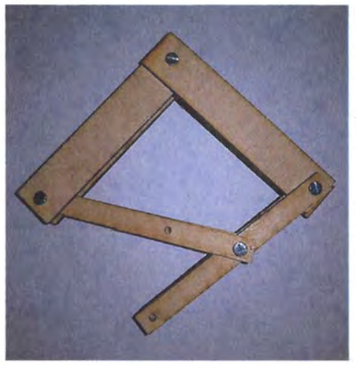
After realising this I began to rethink and redesign the mechanism to make it work. I needed to make the one of the thinner parts shorter than the other and also include something that locks the thinner parts in place.



I made holes at different distances to help me figure out which distance would work the best for this mechanism. One was roughly in the middle of the two original holes (above) and one was about 1/3rd in from the original hole (below).

I experimented with different ways to join the pieces of wood together so that the mechanism would work like the one from the collapsible table.

I found that when joined the different drilled holes together to the original ones that most came up with angles that wouldn't work for my stool since I need it to be a 90° angle so the side tables are straight when lifted up.



After looking at different combinations to make the mechanism work, I found that number 1 was the one that was most likely to work. However, I was unable to fold the thinner pieces fully upwards – as shown in number 2 (as the thin wood on the right was too long, with the one on the left too short). This means I will have to re-drill some holes to allow enough movement space for the mechanism to work.

For my prototype I would most likely make this out of metal, probably aluminium due to it being a lightweight material & a non-corrosive material so would be suitable for this application

1

2

3

Development 2 - Wheel

Whilst evaluating my designs, my client said she liked the use of wheels for my second design so I am going to see if there is a way to add wheels to Design 4.

↓

I carried out further research and discovered that workshops tend to have workbenches on 'retractable castors' to make the bench easy to move. They can be locked down into a mobile position or pushed up so that the bench sits on its legs without moving. This type of product could be useful for my stool as it would allow my client to easily make the stool mobile, preventing the needs for strain while picking it up. However, I discovered that most of these castors are used for heavy equipment meaning that they may not work for my product as it is going to be quite light in comparison.

https://www.axminster.co.uk/axminster-workbench-castors-507151

↓

I looked at some YouTube videos and found one where someone was making a mobile bench base. However, this also looked like it would only work on heavy duty things and it also looked as though it would be quite complicated to make and put together if this product was still wanting to be flat-pack and low cost. Also, the wheels don't look suitable for outdoor use as they are small and are meant for usage on a smooth, workshop floor, not uneven grass.

In addition to this, I am wanting to keep my material usage to a minimum so I think I would be able to come up with a more efficient method for retractable wheels. →

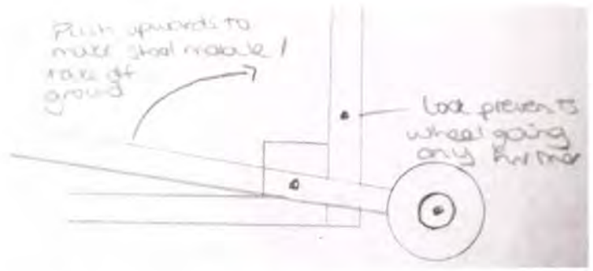
http://lumberjocks.com/projects/325409

Modelling the wheel

I looked at other chicken tractor wheel designs and discovered a very simple one that I decided I would try and make a model of to see if it would work with my design.

http://avianaquamiser.com/posts/wheel_lift_for_a_chicken_tractor/

I came up with a design that would have the same principle, but the lock that prevented the wheel from moving further would be a bit higher up than the one seen above to lift the stool higher.



For the prototype, the wheel mechanism would be made out of metal due to its durability. It wouldn't be made out of wood as it can biodegrade outdoors and some woods can be porous, which wouldn't be good in wet weather. I would probably use aluminium as it is lightweight, durable and corrosion resistant

"I really like the idea of there being a wheel on the stool as this would make it much easier to transport and prevent me from straining. However, this type of wheel mechanism looks like it would require me to bend down to do it, which isn't the easiest thing to do!"

I needed to find a simpler design for a retractable wheel and came across a mechanism that is used on 'chicken tractors' to easily move the chicken coop without them running out underneath. This design would be suitable for my project as it would enable the user to move the stool easily and also retract the wheels so that it is a stable seat. However, the design seen to the right looks complicated so I am going to make a model to find a way to make it simpler, and cheaper, to use and make.

https://www.youtube.com/watch?v=xT0GJKC4E2w

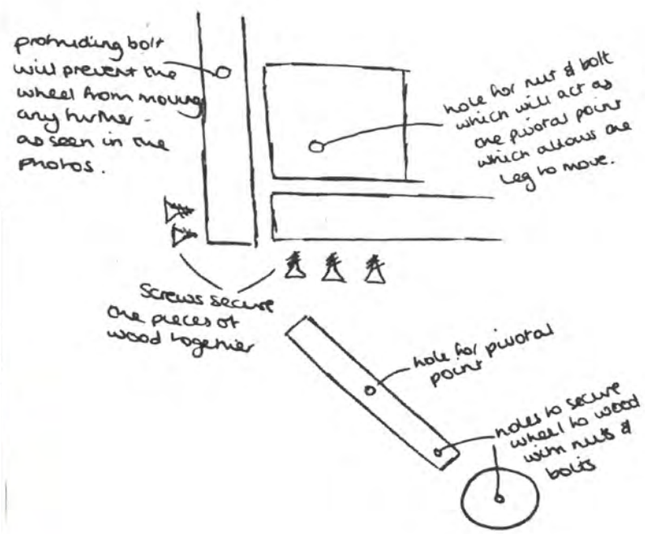
Stool on the ground

I had to join the pieces of this model together using screws which may make it time consuming for my client to build if it was flat pack. However, if I kept this flat pack, it would be cheaper to manufacture and increase productivity as it wouldn't have to be joined together in the manufacturing process.

In the prototype, I would also use nuts and bolts for this mechanism as they worked well and allowed easy movement, which would have worked better if I had used washers as well.

Stool lifted up (mobile)

This model works very well and is easy to use, however, the joint of the leg to the main frame is too high up as it lifts the frame quite high and I could have made the leg a bit shorter to prevent this as well. I also need to rethink the amount of material I am using to make this mechanism as quite a bit of it doesn't have a purpose.



DEVELOPMENT - COLLAPSIBILITY

My client stated that she would like the stool to be collapsible so that she can easily store it. Design 4 was my clients' favourite, which didn't have legs that could fold, only the tables. This meant I had to come up with a way to make it collapsible

BOTH MODELS WERE MADE TO 1/5 SCALE OF THE REAL DESIGN

Scaling down the models

Full size
Width of seat = 320mm
Length of seat = 405mm
Height of legs = 405mm
Width of legs = 50mm

Model
320mm x 0.2 = 64mm
405mm x 0.2 = 81mm
(length and height)
50mm x 0.2 = 10mm
64mm (w) x 81mm (l x h)
10mm leg width

MODEL 1

The model tested a method in which the legs were connected by rope meaning that they would be pulled out to a point where they would stop extending. This also means it would easily collapse.

I made the rope too short meaning that they weren't as extended as I wanted them to be. However this did allow me to see that this design might not work as one of the legs could fall in if there was not enough tension on the rope

I also tried to make the side tables collapse at the same time as the legs but this didn't look as they couldn't fully collapse & there was nothing to hold them in place meaning they would collapse if any weight was put on them

The model used tape to mimic hinges

The model didn't fully collapse because of the rod holding the rope being in the way (as seen above) & the model sprang back up without the added pressure.

IN SUMMARY, this design:
- Could be a hazard for the user
- Doesn't fully collapse.

MODEL 2

Unlike the first model, the table & legs are connected to each other with card, meaning that there is a solid joint so the tables definitely stay up when the legs are extended.

The model uses a hook & hole that is connected to the legs so that when the legs are extended the hook comes down from beneath the seat & fits in the hole. This means the legs are secured in place when it is being used & can then be easily pushed up & secured under the seat so that the legs can collapse.

The tables can't be pulled up or pushed down while the stool is in use so this may be a drawback for the user.

There are slots in the legs meaning that the legs can be collapsed & not stopped by the joints of the side tables

The model doesn't fully collapse as the slots in the legs don't go high enough (I felt if I went any higher, the card would weaken too much). However, if I made the joint of the table thinner, they could be fully collapsed.
9005

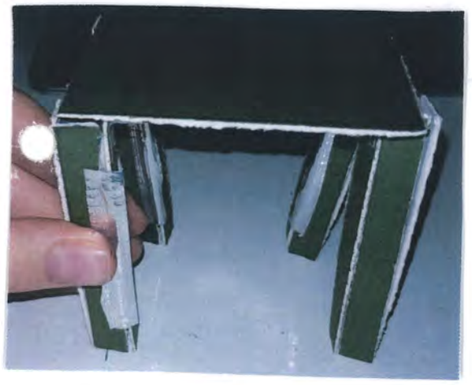
DEVELOPMENT - COLLAPSIBILITY CONTINUED...

I began munking about the leg mechanisms seperately from the side tables so my next two models focus on the leg movements

MODEL 3

this had the legs scaled down by 1/5 as well so I could see how it would really work

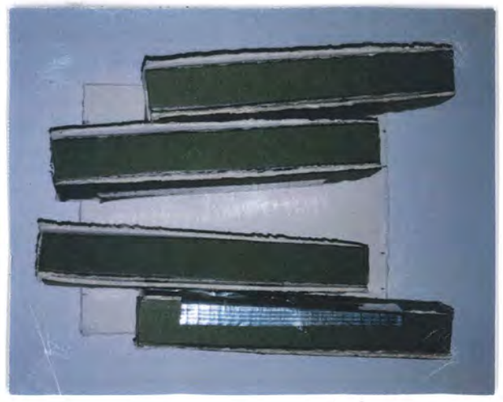
This model has staggered legs with, on one side, two legs on the outer edge & on the other side, two legs nearer the centre.



I thought this design would work for stability & collapsibility. Although the legs collapsed well, the stool was very unstable, especially when weight was placed near the two closer together legs.

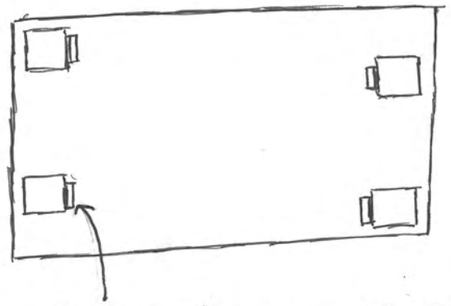
As a result of this model, I changed the positioning of the legs as seen on the next model.

"Would these legs be stable if I were to rock forwards or backwards, with more bodyweight on the legs that are closer together?"

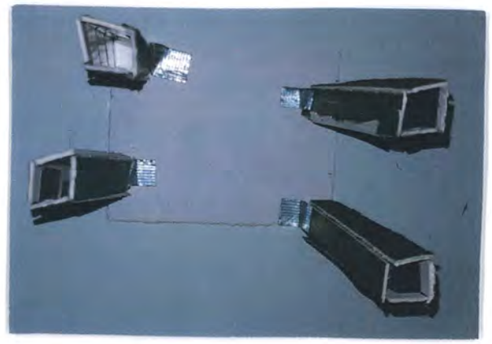


MODEL 4

I decided to space the legs evenly on both sides so that the layout would be stable & still be able to collapse.

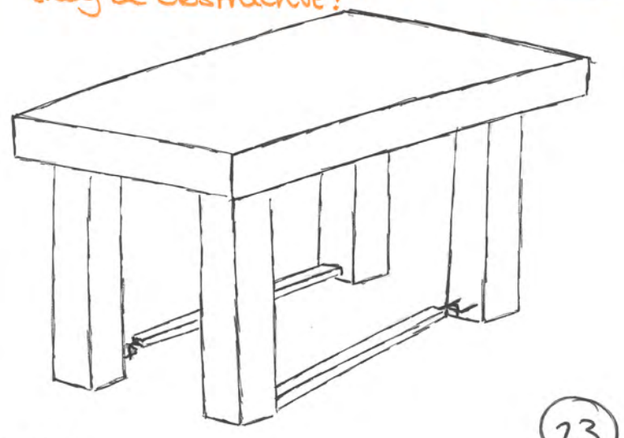


These hinges would allow the legs to be easily moved backwards & forwards to make it quick & simple for the user.



This model was a lot more stable than models 1, 2, & 3 with the collapsibility a lot better than models 1 & 2. However, I did find that there needs to be a form of stopper where the seat & the leg connect in order to make sure that the leg doesn't go too far forwards or backwards.
I could take the hook method from model 2 & use it so that there are two hooks, one on two legs which hook into place on the opposite leg.

"I like that this looks like it would be an easy way to secure the legs in place. These legs also look a lot more stable than all the previous legs. Where would the hooks go when the stool is collapsed? Would they be obstructive?"



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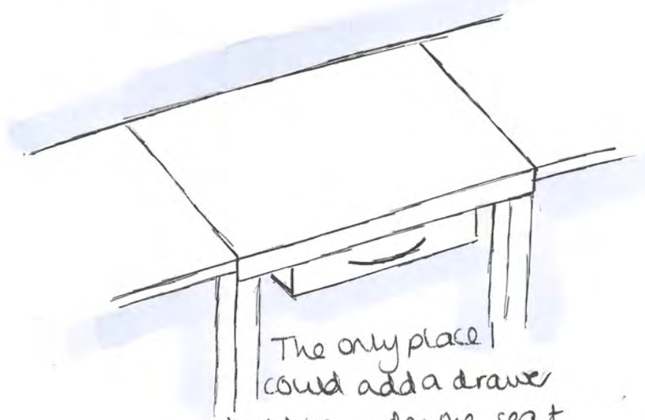
DEVELOPMENT – SIDE TABLES

My Client said that she would like there to be a drawer in the stool which would allow her to not only store the tools while using the product, but to also store the tools permanently, when the stool isn't in use.

Taking this into consideration, I began thinking about how I could add a drawer

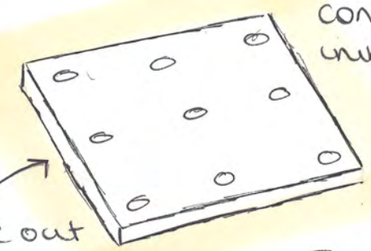


The only place I could add a drawer would be under the seat which could be a problem if I were to make the legs hold up, it may be difficult for the user to pull out if they are sat on the seat and it means more material usage.

Taking these problems into consideration I began thinking of how I could solve them & still have some form of tool storage

Instead of adding a drawer underneath, I could convert the side tables into a storage space that contains a lid to allow for permanent tool storage.

The lid would have the same concept as on the initial design



I need to figure out where the holes are going to go & how large they acchially need to be.

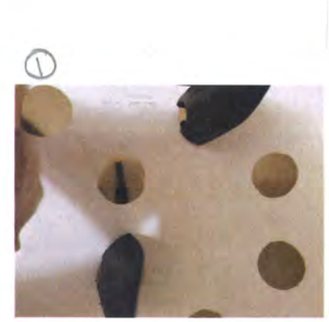
The holes need to be spaced out so the tools aren't too close together & they don't touch eachother.

I designed the side tables differently because I wanted to test each style to see which one would work the best at preventing the tool heads from clashing with eachother.

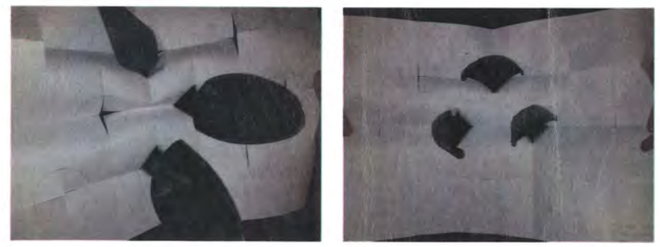
① "50mm holes, spaced randomly"

② "50mm holes, spaced by folding paper into 1/4ths"

③ "50mm holes, spaced by folding paper into 1/8ths"



① 50mm hole too big as this tool slipped through. I will have to test a 40mm hole instead.



This layout seems to be the most suitable for the side tables as the tools were spaced out so they weren't clashing with one another, this design utilises the space better and there doesn't seem to be any weaknesses like in the other layouts.

Although the holes were evenly spaced out, they were mostly clustered in the middle of the paper meaning that the centre was weakened when the tools were put in place. Also, depending on the tools stored, they could clash with each other making this layout unsuitable. ③

Tools were clashing with one another as the holes were too close together ②

The holes were too close to the edge meaning that the paper was bending so this probably isn't suitable for a side table ①

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DEVELOPMENT - SEAT SIZING

I began to investigate further into the sizing of the seat
In 'The Measure of Man & Woman' it stated two different sets of measurements for different types of seat. for an office chair, the width = 406mm - 505/560mm and the depth = 406mm to accommodate for all adults. However, for a dining chair, the measurements were different with a width = no less than 406mm and a depth = no more than 409mm. Office chairs & dining chairs are very different compared to my school project due to padding and the user sitting on these seats for a long period of time.

As a result, I carried out my own research into the average depth of stools by looking IKEA, B&Q and Homebase. I discovered a variation in depths from 270mm to 380mm. I also found a website[1] that provides specialist equipment for elderly & disabled people. Their stools also had a variation in depths which ranged from 270mm to 380mm

In order to make this stool as comfortable as possible for the user, I think the depth should be more than 270mm but less than 380mm in order to lower cost & material usage. I think a 406mm width & a 320mm depth is suitable for my project.

The seat would be made out of pine due to its low costs & it being more sustainable than a hardwood or plastic due to softwoods growing quickly & there are no threats of oil spillages which may impact fragile ecosystems.

The seat would need to have a coating on it to make it weather resistant - an exterior coating rather than interior coating - like a gloss varnish.

[1] https://www.manageathome.co.uk/Around-the-home/Sitting/Perching-stools-chairs/list.htm.

SIDE TABLES - CONTINUED

They would be constructed out of pine (due to its resistance to shrinking & swelling & it being easy to work) or Acrylic (durable lightweight & recyclable) but this material has a more significant environmental impact than wood

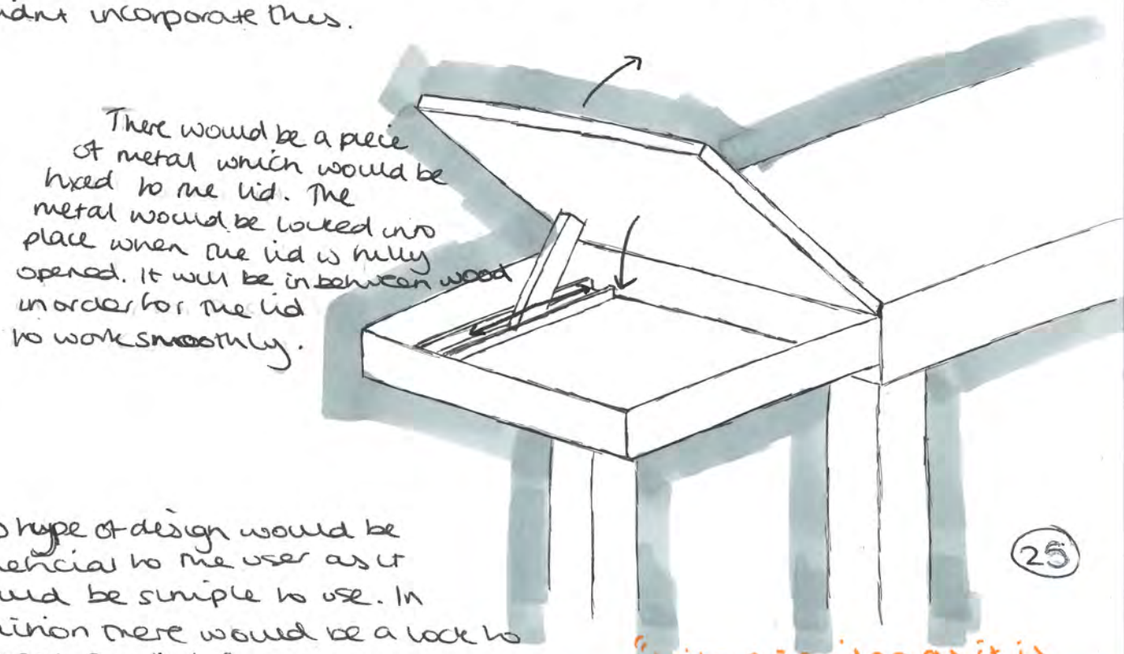
After testing the two initial layouts. I found multiple issues such as the holes being too large for the tools going to be stored & the holes not being spaced out properly As a result, I designed & tested a new layout which worked well.

This layout had 40mm diameter holes which prevented the tools from slipping through like in the first 3 models. The placement of the holes are the same as layout 3 which worked well as no tools clashed.

If in batch production, these side tables would be produced using jigs to make the process easier & more productive - as stated in my design ideas.

My client stated that she would like storage for her gardening tools but my initial design didn't incorporate this.

I took inspiration from school desks that are used in American schools due to their easy lift design

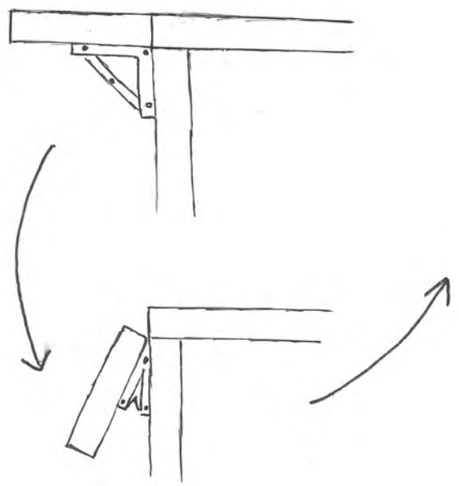


This type of design would be beneficial to the user as it would be simple to use. In addition there would be a lock to prevent the lid from opening when the stool is collapsed.

"I like this idea as it is a simple mechanism & it would allow me to store pegs & seeds when the stool is being stored, meaning I wouldn't need to take things

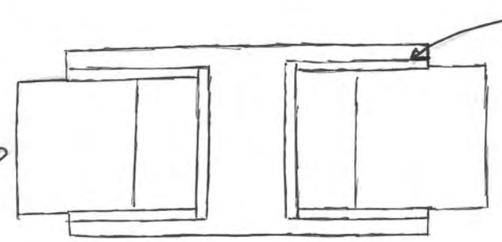
DEVELOPMENT - SIDE TABLE MECHANISM

My initial idea was to have a 'folding table' mechanism as seen on my first development sheet. I found that this mechanism probably wouldn't work because the mechanism would most likely break if the tables & the legs were collapsed as the hinge would be unable to cope with the degree of movement.



The side table would be completely broken away from the seat so the joint would be weak.

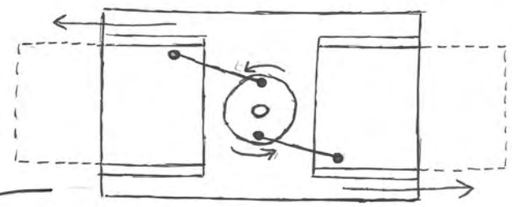
As a result, I decided to look into a different method to adjust the side tables.

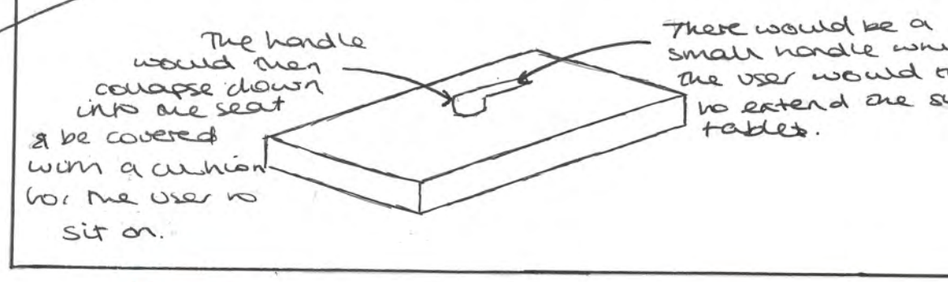


Side tables slide on the runners & are pulled out by the user.

The tables would have to be staggered in order to compensate for the legs.

I decided to make this design slightly more complex & easier to use.





After deciding the type of mechanism I wanted to use, I proceeded to make a model out of acrylic cut on the laser cutter.

I cut out the 'seat', 'side table', a range of different arm lengths & a variety of cranks. This would allow me to figure out which arms & cranks worked the smoothest & which allowed the side table to be fully extend & fully closed

After trying out the mechanism a few times I realised that I needed some barriers to prevent the side table from wobbling & some extra pieces of acrylic to keep the side table propped up.

The 11mm crank was too small & it caused the arm to get caught on the acrylic joint/rod. I couldn't physically turn it so the table didn't move out or in.

The 14mm crank allowed slightly more movement but it would only extend so far & then get caught & stop moving like the 11mm crank.

15mm

The 15mm crank allowed slightly more movement but it still got restricted by the acrylic rod/joint of the crank.
The 40mm arm was too short so didn't extend the table very far.
The 70mm arm was too long so didn't bring in the table enough.

18mm

The 18mm crank worked a lot better than the previous three despite from having the same limitation.
The 60mm arm pushed out the right distance but didn't pull in far enough.
The 70mm arm pushed out too far.

I did not make this model to any scale so it may be hard for me to work out all the dimensions of my final design

20mm

The 20mm crank worked really well but it still wasn't quite large enough enough for the arms to work properly
The 50mm arm went fully in but not fully out.
The 60mm arm didn't go fully in but went fully out.

22mm

The 22mm crank worked the best out of all those tested. The arm could move freely & smoothly.
The 50mm arm went fully in but it didn't go out far enough.
The 60mm arm went nearly fully in & fully extended.

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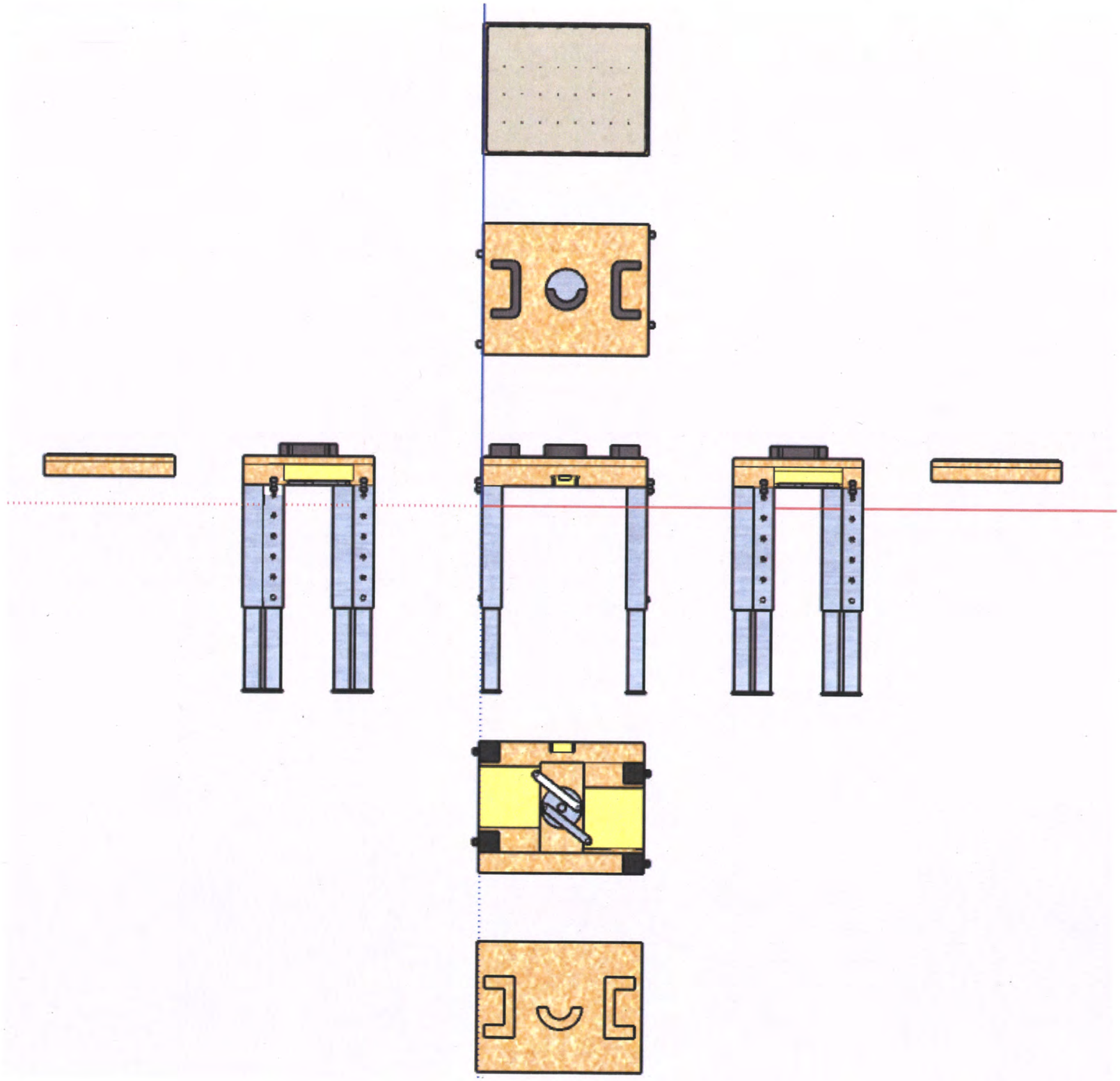
Evaluation of development ideas

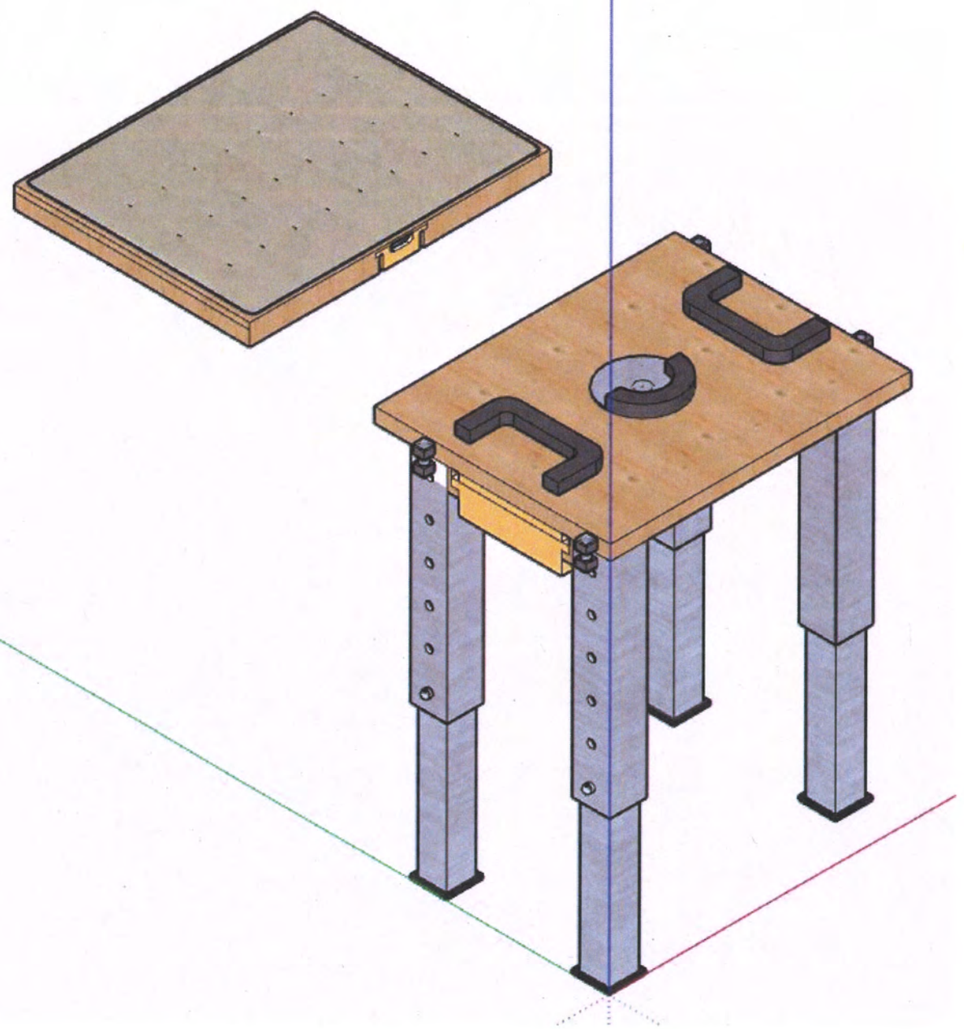
I found that development 1 was irrelevant as I decided that it would be much easier to make the side tables into drawers which could slide under the seat as this would be much easier to use, and would also remove the risk of a finger being trapped.
I also decided not to incorporate a wheel into my prototype because this probably wouldn't add anything to the product, other than make it difficult for the user as they would need to bend down, which would be difficult for someone who had recently had their hip replaced. I also thought it might be difficult to do as the base of the legs would have been single, rather than joined together, as can be seen on the development sheet, so I decided that, going forwards, I would not add wheels to the project.
After doing all the development for the side tables, I decided that a lid with holes in it would not be needed. It would have been an unnecessary use of material since the side tables would be converted into drawers, which wouldn't need a lid as they would go under the seat on runners. It would also create quite a lot of waste as there would be lots of holes cut out of a piece of wood, which would not be repurposed for any other part of my project.
After creating all of the models, I decided to go for model 4's design as this would allow the drawers to be larger so more could be stored within, and with the change from side tables to drawers, this would hopefully make the crank mechanism work smoothly.

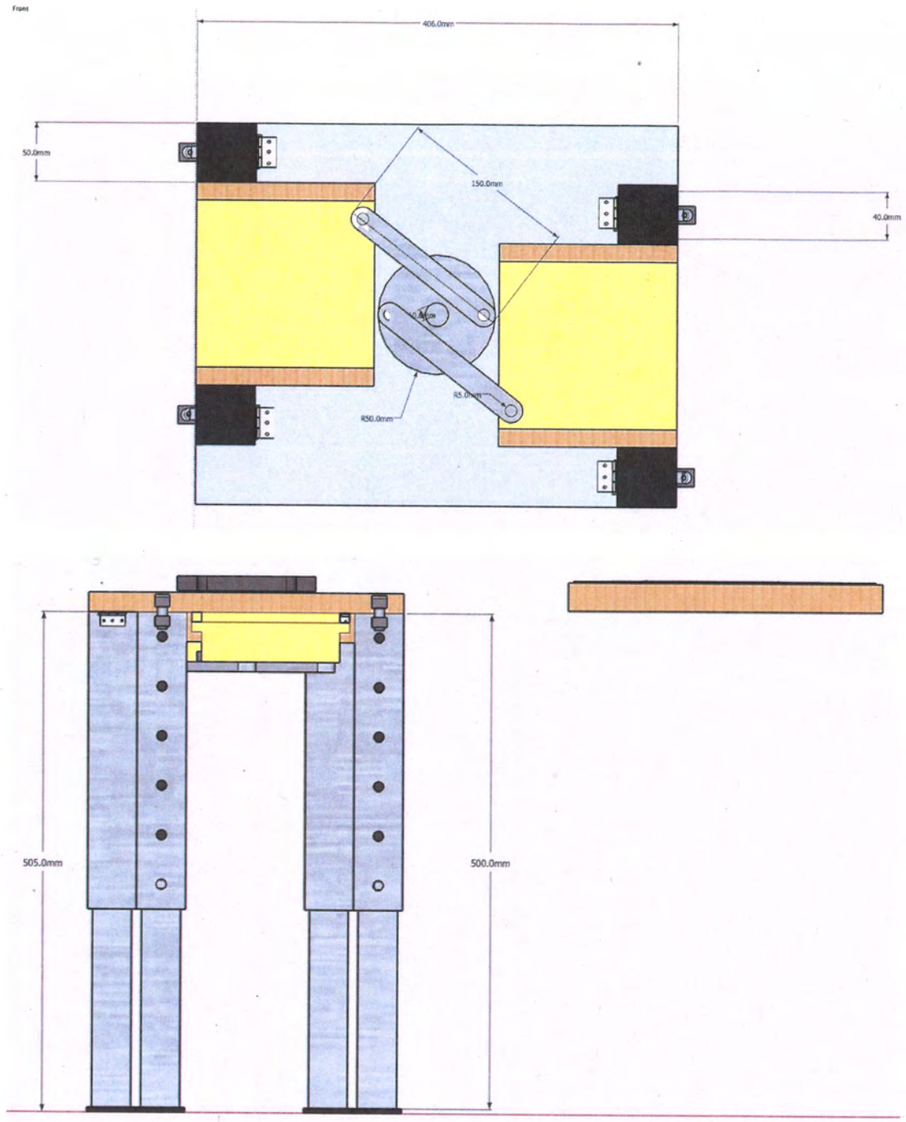
Overall, the development brought out some very good ideas, such as the crank and the way the legs would be placed, but once I came to develop my final design, I found that some of the development pages were irrelevant.

Final Design

An orthographic projection of my final design.

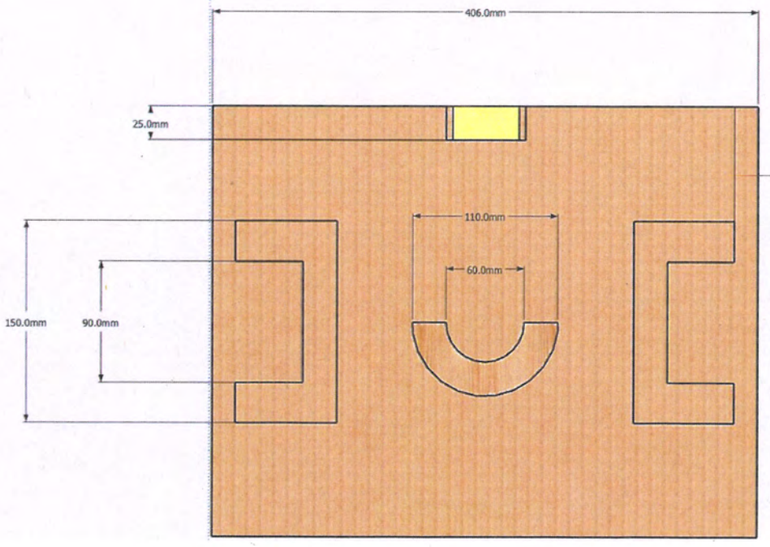


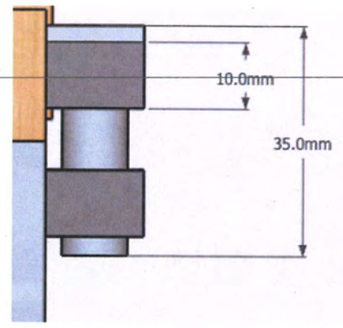




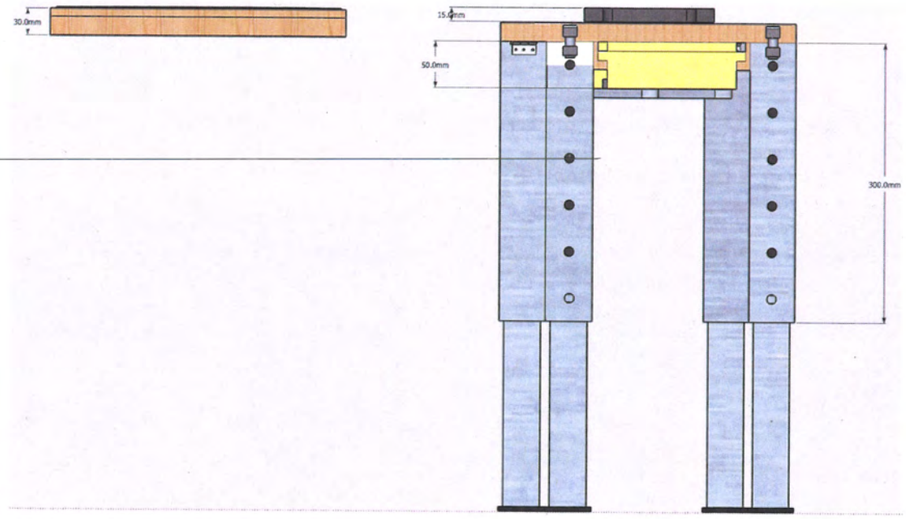
A view of the underneath markings of the garden stool.

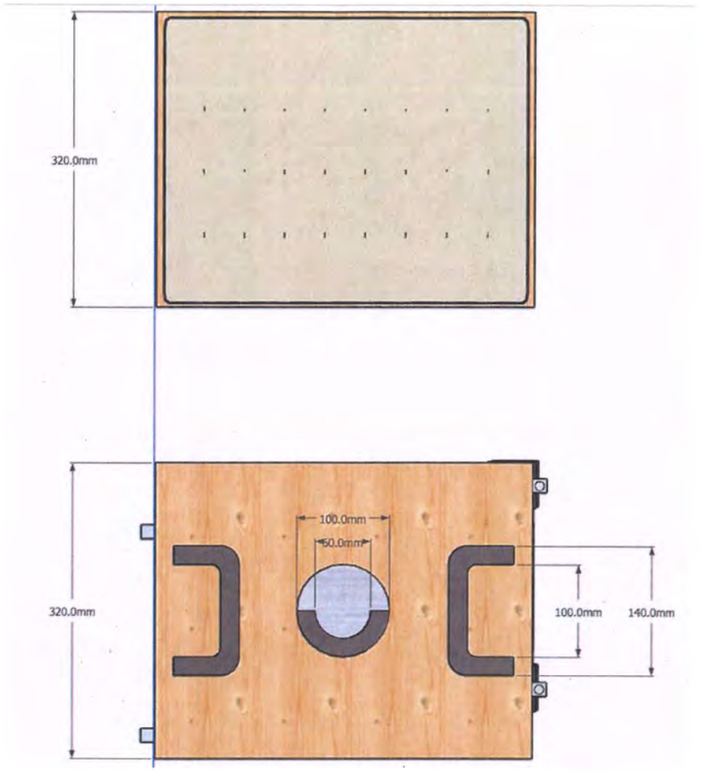
A view of the underneath of the hopper.

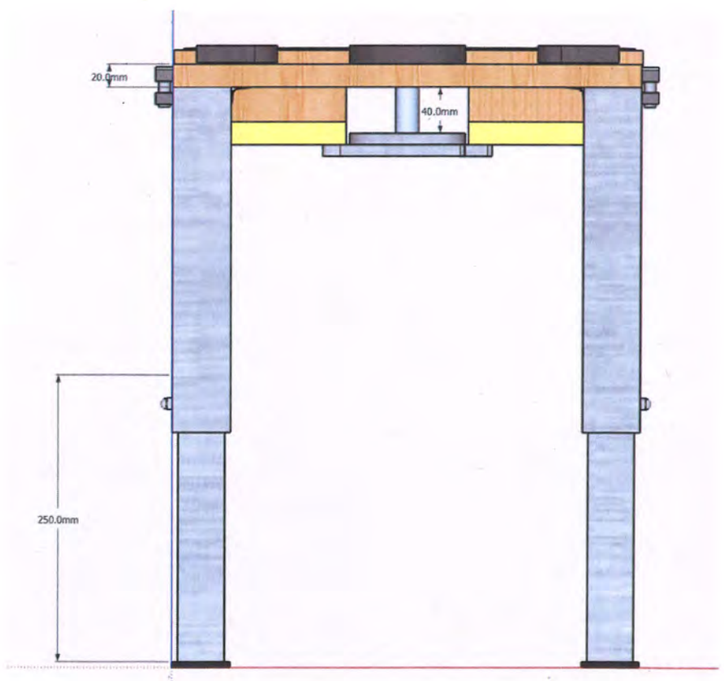




The proposed mechanism that will hold the legs in place, using a bolt







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Client evaluation of final design

- I like the fact the drawers come out so I can access my tools that I'd store inside at the same time but I notice that I'd only be able to do this before I sit down.
- The topper might be a bit of a nuisance to take on and off every time I want to move the stool with the handles or move the tables in and out.
- The pop adjustment on the legs look like a really good idea as they look easy for people with arthritic hands to use and it looks useful for everyone to use as the height can be adjusted. However, it looks as though they would have to be adjusted individually. Would it be light enough for me to rest it on a bench or something similar so that I could adjust it more easily instead of crouching as this would not be good for my replacement hip?
- The drawers look really convenient but Is a lid for them really necessary when the drawers would go underneath the stool when they aren't being used? If there wasn't a lid, my tools and packets of seeds would be easy to reach.
- The feet would need to have a bigger surface area to prevent the legs from sinking into grass or soil while I sit on it or the tubing could be made to have a solid base as this would eliminate the weight being spread over four separate sides of the narrow tubing.
- The bolt mechanism on the side of the legs look as though they might be a nuisance as well as the bolt pieces could get easily lost, despite there being a drawer for them. In addition, by looking at the diagrams I can see that they protrude which may be a bit of a hazard if someone walked into the side of it and grazed themselves. This issue can also be raised regarding the seat itself which could have rounded edges to prevent this problem from occurring.

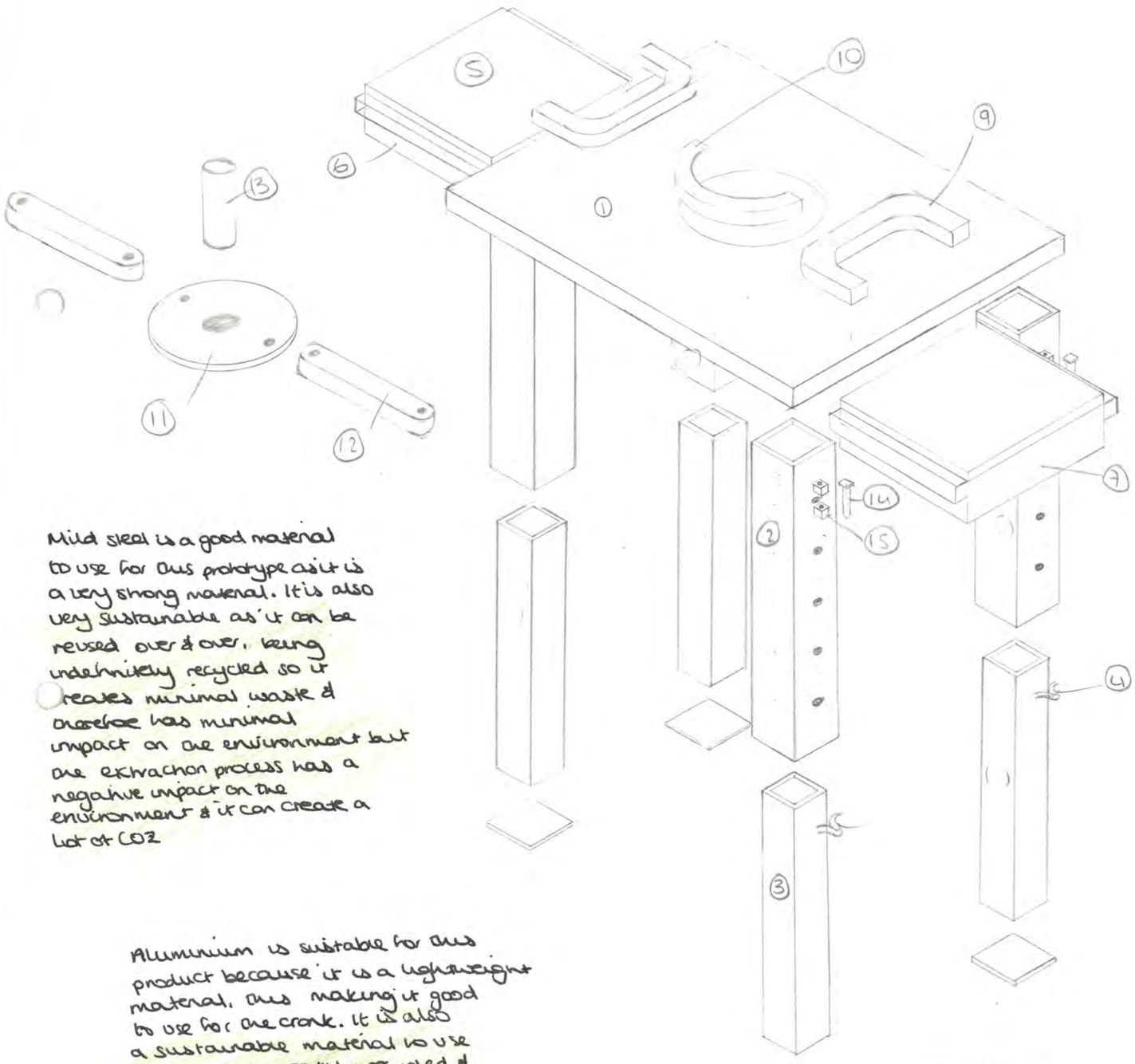
Betty Ann

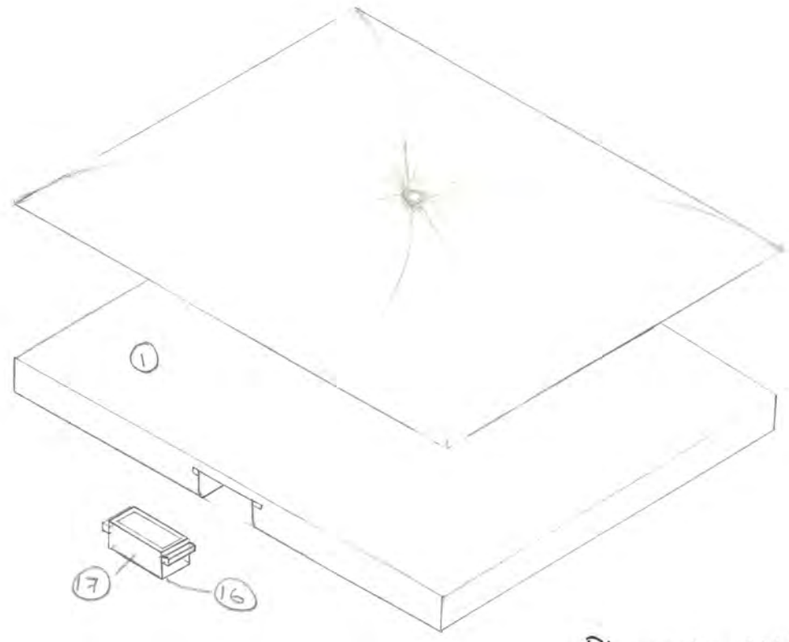
Response to client feedback

- In response to the feedback from my client I have decided that I will round the edges of the seating so that it will be less hazardous to the user.
- I also have decided that I will change the way in which the legs get locked into place, instead of the separate use of bolts, because, as my client stated, they may get lost despite having a separate drawer for them.
- I will carry out tests in which I will place my weight onto a piece of steel that I will use, making a solid base for one of the tests to see whether or not the stool legs would stay above ground, rather than sink into it. If I use feet, this may hinder the collapsibility of the legs.
- As my client brought up, the drawers wouldn't need a lid if they are going to retract back under the seat. This would also mean that less material is used, thus lowering the cost of the overall materials needed to make this stool.
- I need to think of a way in which the topper can be eliminated, like my client said it may be a bit if a nuisance to keep taking on and off. This would also help to keep the weight, along with the cost of the product down and definitely make it easier for the user.
- I've also decided that I need to connect the legs together, possibly with a bar, to make the adjustment process easier for the user. This may require me to come up with a different type of adjustment, possibly a nut that unscrews to allow a swift change in height, rather than a fiddly pop of the adjustment at every hole in the leg.

Positives Negatives

EXPLODED DIAGRAM





Plywood will be used because it is a strong material (alternating grains) also, the plywood that is used will be FSC certified & reused at the end of its life cycle. However, it can be a hard material to recycle due to the glue in the material.

Mild steel is a good material to use for this prototype as it is a very strong material. It is also very sustainable as it can be reused over & over, being indefinitely recycled so it leaves minimal waste & therefore has minimal impact on the environment but the extraction process has a negative impact on the environment & it can create a lot of CO_2

Aluminium is suitable for this product because it is a lightweight material, thus making it good to use for the crank. It is also a sustainable material to use as it can be easily recycled & reused. The ore extraction process does have an impact on the environment due to the large amounts of CO_2

HIPS COST

Stock size = 457 x 305 x 1.5

$\frac{(150 \times 160 \times 1.5)}{(457 \times 305 \times 1.5)} \times 100 = 17\%$

£1.30 x 0.17 = 22p

PARTS & CUTTING LIST

part no	description	material	no. off	size/item	length	width	thickness	unit cost	total cost
1	Seat and topper	Plywood	2	18 (mm)	406 mm	320 mm		£12.60 per sq m	£3.28
2	Leg (outer)	Mild Steel	4	50 x 50 x 3 [angle]	300 mm			£4.20 per m	£5.04
3	Leg (inner)	Mild Steel	4	40 x 40 x 3 [angle]	250 mm			£2.75 per m	£2.76
4	Leg (mechanism)	Spring Clip	4	6mm				12p each	48p
5	Drawer (lid and base)	Plywood	4	6 (mm)	160 mm	150 mm		£4.05 per sq m	40p
6	Drawer (sides)	Plywood	4	6 (mm)	160 mm	50 mm		£4.05 per sq m	12p
7	Drawer (front and back)	Plywood	4	6 (mm)	150 mm	50 mm		£4.05 per sq m	12p
8	Feet	Plywood	4	15 (mm)	50 mm	50 mm		£9.45 per sq m	8p
9	Handle (laser cut)	Plywood	2	15 (mm)	135 mm	70 mm		£9.45 per sq m	18p
10	Handle (laser cut semi-circle disk)	Plywood	1	15 (mm)	100 mm	100 mm		£9.45 per sq m	9p
11	Crank (wheel)	Aluminium	1	10 [round]	100 mm			£3.45 per m	35p
12	Crank (arm)	Aluminium	2	20 x 3 [strip]	150 mm			£3.36 per m	£1.00
13	Crank (rod)	Aluminium	1	8 [round]	75 mm			£2.40 per m	18p
14	Bolt	Bolt, coach	4	M6 x 30mm				3p each	12p
15	Bolt holder (leg mechanism)	Plywood	8	9 (mm)	10 mm	10 mm		£5.70 per sq m	0p
16	Bolt drawer (base)	Plywood	1	6 (mm)	50 mm	25 mm		£4.05 per sq m	1p
17	Bolt drawer (sides)	Plywood	4	6 (mm)	50 mm	25 mm		£4.05 per sq m	4p
	Vacuum formed tray	HIPS	2		150mm	150mm	1.5mm	£1.30	22p

Total = £14.50

+ VAT (20%) = £17.40

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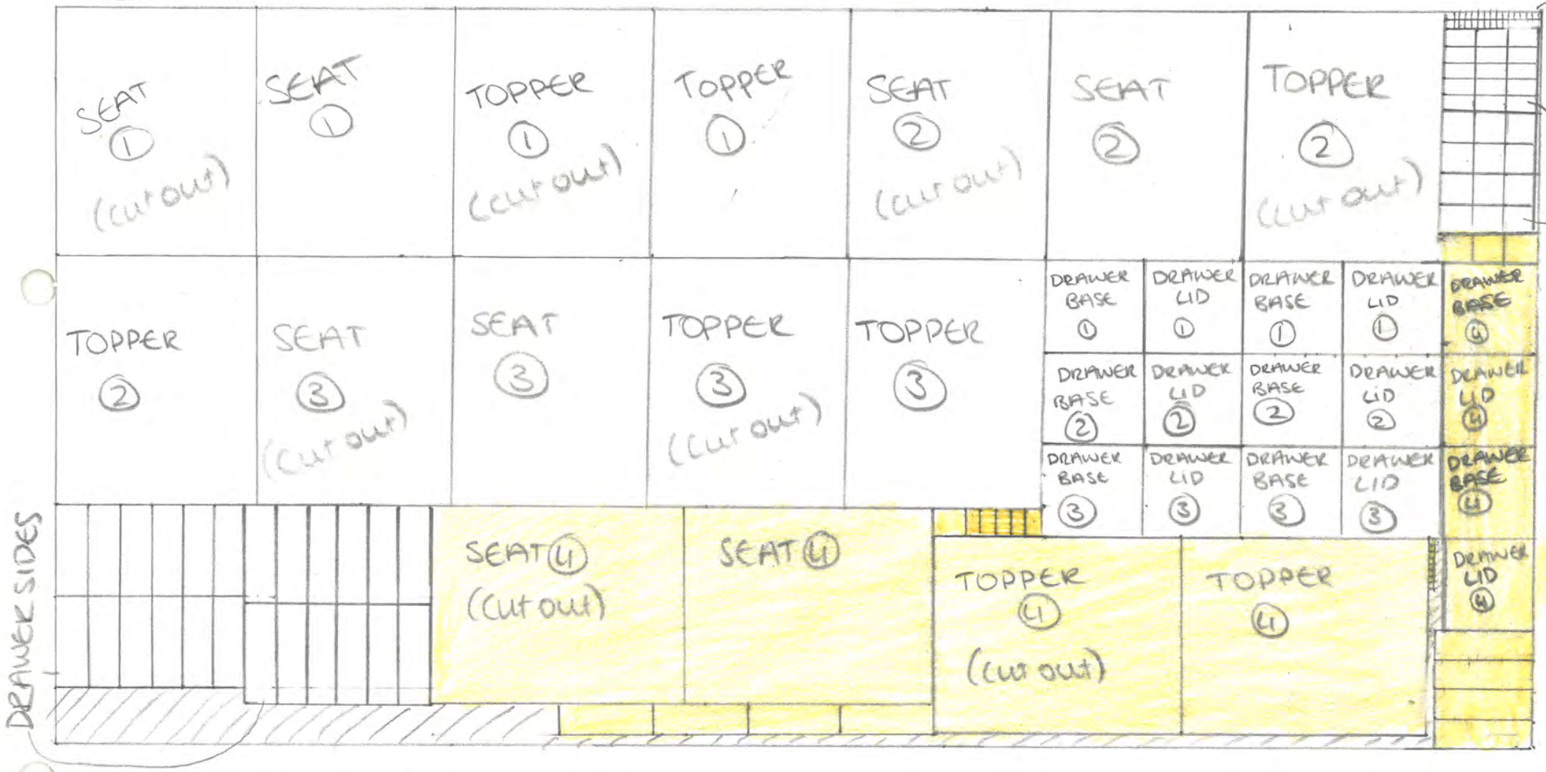
CALCULATIONS - BATCH PRODUCTION

Using the process of nesting to plan the most effective & efficient usage of materials

- Seat & topper will need two pieces of 9mm ply glued together to make 18mm
- 1 of the seats & toppers will have the handles cut out (laser) to reduce waste



SEAT & TOPPER = 406mm x 320mm

DRAWER = 160 x 150 (x2), 160 x 50 (x2), 150 x 50 (x2) mm (x2)

FEET = 50mm x 50mm (x4)

BOLT HOLDERS = 10mm x 10mm (x8)

BOLT DRAWERS = 50mm x 25mm, 50mm x 25mm (x4)

BIRCH PLYWOOD = 2440mm x 1220mm x 9mm

= £27.20 (excluding VAT)

I will use the same thickness plywood to make the drawers* to reduce the amount of wastage & reduce the unnecessary use of another piece of plywood which will increase the environmental impact of the stool.

* and feet

Area of plywood = 2976800mm²

= SET 4

AREA

Seat & topper = 2078720mm²
Drawer base & lid = 360000mm²
Drawer side 1 = 128000mm²
Drawer side 2 = 120000mm²
feet = 40000mm²
Bolt holders = 3200mm²
Bolt drawers = 25000mm²
OVERALL = 2754920mm²

Percentage of board used = 92.5%

Cost to make 4 stools = £25.16
+20% VAT = £30.20

Using 1 stock size piece of birch plywood, I could make 4 sets of seats, toppers, drawers & bolt holders for £30.20 (inc VAT) with only 7.5% of the board wasted.

Justification of materials

Material	Part of stool	Justification	Sustainability issues
Plywood	Seat and topper	This is a very strong material due to the alternating grains and it suitable for this part of the project as it will distribute the weight of the user evenly.	Plywood can come from FSC, which is an organisation that promotes sustainable resourcing of woods. Despite it being recyclable, it may be difficult to do so as the adhesive cannot be removed, so it may require lots of heat to remove the glue, and therefore release a lot of CO2 into the atmosphere due to the electricity needed
Mild Steel	Legs	This material is strong so will be able to withsand the pressure applied to it. It is also has a high tensile strength, so it will not break under tension. It is also easily recyclable which is good as it reduces the impact the stool has on the environment at the end of its life cycle.	It requires a lot of CO2 to extract the iron ore and this also damages the environment as a result. However, this is balanced out by the fact steel can be endlessly recycled at the end of one lice cycle as it does not lose any properties, so stays the same quality.
Plywood	Drawers	This is a suitable material as it can withstand lots of movement, which will happen along the runners and it is strong so it should be able to withstand the items, such as hand tools, that my client puts in them	Plywood can come from FSC, which is an organisation that promotes sustainable resourcing of woods. Despite it being recyclable, it may be difficult to do so as the adhesive cannot be removed, so it may require lots of heat to remove the glue, and therefore release a lot of CO2 into the atmosphere due to the electricity needed
Aluminium	Crank	This is a lightweight material meaning it should be easy to move the drawers in and out. It is also durable so it should be able to withstand long-term usage.	It can require a lot of CO2 to extract bauxite from the earth, and it can also damage the surrounding environment and ecosystems. Despite this, the recycling of aluminium requires 95% less energy than it does to produce primary metal, therefore meaning it does not create more greenhouse gases.

Evaluation of final design based on specification

	Specification	Justification
Scale of production and cost	The prototype, if being sold, would have to be priced between £20 - £30	Based on the cutting list with VAT, the cost to make the product is £17.10, meaning that the product could easily be priced within this margin, in order to make a profit
	If the prototype were to be batch produced and sold, it would have to be made using jigs in the process	Jigs could easily be used in batch production. Jigs could be used to help drill the holes in the legs and also to cut the exact length of the legs. The use of jigs would also reduce the amount of material wastage as all of the processes that included jigs would be done accurately every time.
User Requirements / Size Requirements	The height of the product should be a minimum of 406mm and maximum of 560mm	The height of the product matches the specification as it is height adjustable, up to 560mm
	The seat must be 405mm wide, and wider if necessary	The seat is 406mm wide
	It must have tools storage with holes at least 50mm wide	The tool storage has been modified to have drawers, that do not need lids as they will be 'closed' when they retract under the seat. The drawers act as tool storage as well as storage for seeds and other necessities for gardening.
	The stool must be lightweight, with a maximum weight of 5kg, and easy to transport	The stool will be made out of plywood which, itself, is not particularly light, along with mild steel, which again, isn't lightweight The legs collapse under the seat and there are handles which will make it easy to transport.
	The handle size must be between 70mm and 90mm	The handles are 100m wide, with a thickness of 40mm so they are easy to grip, and this size allows them to be inclusive of all hand sizes
	The stool must have a maximum footprint of 500mm	The stool has a footprint of 406mm as the legs are 90°, rather than the 70° angle I worked out. This is because I felt the stool looked better like this, and I couldn't figure out how I would secure the legs to the seat if they were angled.
Sustainability	The product must be easily disassembled.	The product will be assembled using nuts, bolts and screws, thus making it easy to disassemble but it may be fiddly to do
	The product must be able to be repaired, and maintained to extend its life.	All of the parts used are nuts and bolts meaning that these pieces can easily repaired as they are standardized. In addition to this, the
	The finish of the product, should be done with the minimal amount of VOC.	Only varnish, oil or wax will be used on the finished product
	The material used should be used effectively, with little waste created.	The seat will be laser cut, causing minimal waste. I will use all materials as effectively as possible, and try to use the nesting method to reduce the amount of waste material that is created in the manufacturing process
	The product must be made with sustainably sourced materials.	All of the plywood that will be used for the seat and topper will be from FSC so I am confident that the wood will be sustainably sourced. However, this is not the same for steel as the extraction of iron ore damages the environment greatly so this cannot be labelled as sustainably sourced. This is the same for aluminium.
	The materials must be locally sourced.	Plywood is the only material that is guaranteed to be sourced locally. The steel and and bauxite however cannot be sourced locally, are most likely going to be sourced overseas, so this will impact the environment as CO2 will be emitted in the transportation process.
Safety	The must be able to withstand the tests stated in BS EN 1728.	The testing will be done after the product is completely manufactured
	The mechanisms must be able to be adjusted with ease and safely.	The legs will be adjusted with a nut that has good grip, but all have to be done individually so that may make it difficult to do. The collapsible mechanism should be easy to do as well
	The product must be stable when it is in use.	The legs are at 90° angles, so the stool should be stable but it could be beneficial if I made the legs angled as this would lower the centre of gravity and therefore make it more stable.
	The product should be quality controlled through out the manufacturing process	The plan of production contains all QC questions and solutions which will be followed throughout the manufacturing process
	The product must not sink into the ground while it is being used	The feet should prevent this from happening, however the feet may not have a large enough surface area, so it may be beneficial if I make them larger so that the weight of the user can be evenly distributed so the stool doesn't sink into the ground.
	The stool must be able to withstand at least 85kg.	I will have to test this when the product is completely manufactured
Form and Function	The prototype must be an effective garden stool which carries out its function well.	The product will be made to be as effective and as functional as possible, as can be seen in the final design
	The product must be able to withstand the tests and body weight so a suitable material must be used.	I have chosen materials that are known to withstand the body weight applied to the seat, such as plywood and mild steel.
	The product must have an adjustable leg height	The legs, as seen in the final design, have an adjustable mechanism
	The product must be collapsible	The product will be easily collapsible

Predicted time taken

Actual time taken

Plan of production

Task	QC enquiry	QC check	Time taken to complete task	Reasons for change?
Using 2D design, draw out the handles that need to be cut out of the seat and also the size of the seat	Are the measurements correct and is everything marked out in the necessary way?	Make sure to type in exact measurements and double check them. Mark the parts that need to be cut out in red	10mins 15mins	It took longer to accurately measure out the lengths on the software
Glue the two plywood pieces together to make the seat and allow to dry	Is the piece being glued in the correct place? Is all the excess glue wiped off?	Make sure that the piece has a sufficient amount of glue, leave gaps at every edge of the seat and wipe away the glue with a wet cloth	10mins 10 mins	
Sand down the edges of the handles so they can be used smoothly	How will I know when I've sanded them enough?	Keep testing in the space where the handle goes, with masking tape holding the handles in place when you are testing them	10mins 30mins	When testing, I realised there were more edges to curve than I had expected
Cut steel tubing down to size	Is the cut going to be in the right place?	Bring the blade down, when not in use, to make sure that the blade will cut in the correct place	15mins 20mins	It took me longer to measure out the sizing accurately
Drill the holes into the smaller pieces of steel tubing with one for the large tubing	Will the drilled hole be in the right place?	While the drill is not in use, get the centre punch in the metal in line with the drill piece and keep in that position to the hole will be in the correct place	15 min 25 min	I had to cut out another piece of tubing because I drilled the holes inaccurately
Braze a nut over the hole to create the leg height adjustment mechanism	Will the nut be brazed in the right place?	Make sure to line up the nut before its heated and that it isn't knocked out of place when trying to melt the brass onto the nut	20 min 20 min	
Grind down the edges on the legs so the legs can fold smoothly	How can I make sure that all of the legs have the same ground-down shape?	Mark out a circle on the ends of the legs using a template and use that as a guide when shaping the leg	15 mins 25 mins	It was hard to make sure the edges of the legs were smooth
Cut out an extra bar of tubing for the joining of the legs	Will the steel tubes be long enough to suit the width I need the legs to be?	Measure and draw out where the legs will be when folded up on the floor to make sure I have cut it at the right length	5 min 5 min	
Weld the extra tubing to the legs	Will the piece be at a perfect right angle and in the right place?	Use the right angle welding clamp and use a scribe to mark on all sides of the legs	25 mins 60 mins	It was hard to weld the legs as the metal was so thin so it kept creating holes that needed to be filled
Mark and cut out comb joints for the drawers	Will the comb joints be cut evenly and in the correct places?	Use the measuring guard on the band saw to make sure they are cut correctly, and don't move it between cutting so the joints are accurate and equal	15 mins 15 mins	
Cut down another piece of plywood to make the base of the drawer	How will I make sure that the base is the correct size?	Keep sanding and testing the piece until it fits in the groove of the drawer	10 min 20 mins	It took a while to sand both pieces of plywood to the right size

Tolerance of ±1mm from the middle

for this there can only be a tolerance of ±0.5mm as the brazed nut needs to be directly over the hole.

Tolerance of ±2mm.

Tolerance ±1mm

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Plan of production - continued

Task	QC enquiry	QC check	Time taken to complete task	Reasons for change?
Glue two strips of plywood together to make the runners, cut out and glue to the base of the seat	How will I make sure the runners are glued in the correct place?	Place the drawer where it needs to be on the project, glue the runners so they are in line with the sides of the drawer	20 min 30 min	I had to cut grooves out of the runners so they would fit over the fittings for the legs
Glue beech to the front of the drawer and make an inlay in the wood	How will I make the inlay the correct size and put it in the right place on the front of the drawer?	Measure out and create the design on 2D design, cut it out on the laser cutter and also accurately measure out where the centre of the front is before creating the space for the inlay	25 min 25 min	
Create a handle from the circular cut-out by cutting into 3 with finger holes	How will I know where to cut and how big to make the finger holes?	Try to measure out the cut-out points as accurately as possible. Drill holes in a piece of scrap plywood with different sized drill pieces and then test the sizes.	20 min 30 min	I had to test more hole sizes than expected, and had to get other people's opinions on which size to use
Cut out the crank arms and wheel	How will I make them the right size?	Test the lengths and size of the wheel beforehand, as can be seen in the development stages	20 min 10 min	It didn't take as long as I had expected as I based the sizing of the model I had made earlier
Create vacuum formed trays for the drawers	How will I make sure the mould allows the process to work correctly?	Make sure the mould has draft angles, tiny holes to allow the air to be sucked out, and make sure the moulds aren't placed closely together, to prevent webbing	20 min 20 min	
Turn two handles for the drawers so there is another method to open them	How will I make sure the handles are made to the right size and are the same?	Keep referring back to Vernier callipers and using them on the first turned handle	30 mins 30 mins	
Shape and glue blocks next to the base of the legs to prevent them from moving outwards when the user is sat on them and using the product	How will I make the blocks the right angle for the legs, since they need to be more than 90° so the seat is stable?	Use the angle guide on the belt sander to shape the block to the correct angle, also making it accurate and the same for all four blocks	15 mins 10 mins	It took a shorter amount of time because I found an easier way to make the blocks - using an L shaped bar
Clean and begin paint coating the metal parts of the prototype	How will I make sure that every part is evenly coated?	Keep rotating and moving around the metalwork whilst spraying to make sure that everything is covered, and evenly	60 mins + dry time 70 mins + dry time	It took me longer because I had to make sure everything was evenly coated
Sand and varnish all wooden parts of the project	How will I make sure there are no drips and the coats of varnish are even?	Only apply thin coats of varnish and allow it to dry before applying another coat	45 mins + dry time 45 mins + dry time	

Tolerance for finger hole ± 1mm from centre

Tolerance of sizing ± 0.5mm.

Proposed time taken: 405 mins (6 hours 45 mins)

Total time taken to complete the project: 515 mins (8 hours 35 mins)

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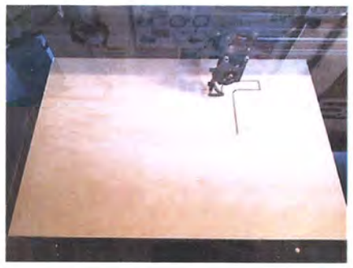
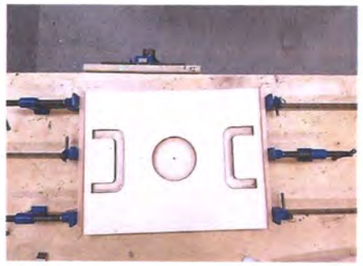
Risk assessment

	Severity	Probability		
Tools/equipment	**(1-5) 5=severe**	**(1-5) 5=likely**	**Calculated risk**	**Precaution**
Band saw	3	1	3	Use dust extraction, wear and apron, wear goggles and tie hair back
Metal band saw	3	1	3	Wear goggles, don't stand close to blade as pieces of cut metal could fly away
Pillar drill	2	1	2	Wear goggles, use the guard at all times, wear an apron, tie hair back
MIG welder	5	4	20	Make sure to wear a UV mask to prevent arc eye and wear a leather apron so the balls of steel don't burn through clothing or yourself
Belt sander	2	2	4	Make sure the guard is at a suitable height and make sure that fingers are kept away from the sanding surface. Wear goggles.
Brazing hearth	4	3	12	Wear an apron and keep the flame at a suitable length. Make sure the feed metal is long enough so you don't burn yourself. Pick the work up with pliers to prevent burning yourself
Metal grinding wheel	3	2	6	Wear an apron, wear goggles, make sure to keep fingers away from the abrasive surface and don't apply too much pressure, to lessen the quantity of sparks

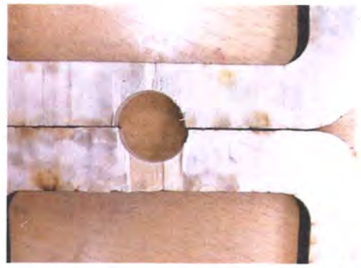
Photographic evidence of manufacture



Laser cutting the seat



Gluing beech onto the sides of the seat to create a frame

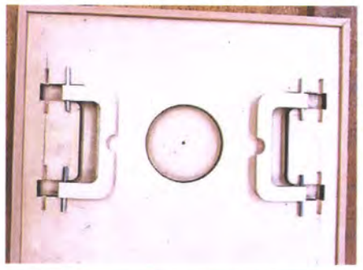


Testing drilling a finger groove in scrap handles

Sanding down the harsh edges of the handles

Testing the handles by securing them with masking tape

Chiselling out the space where the mechanism will be fitted



After chiselling the space for both handle mechanism

Securing the handles to the seat with glue

Brazing a nut onto the leg for the height adjustment mechanism

After brazing nuts onto all the legs

A sketch on the floor to work out where to braze a bar to the legs

Curving the base of the legs so they don't get caught on the seat

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Photographic evidence of manufacture - continued

Testing to see that the legs move smoothly

Brazing the bar to the leg, which failed as the brass kept reaching melting point before the bar secured to the leg

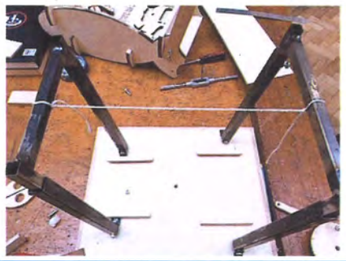
As a result, I had to MIG weld the mild steel bar to the legs

The drawers glued together

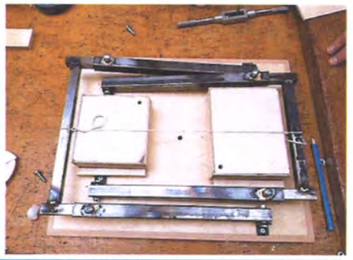
The proposed handle that will turn the crank to then move the drawers outwards

Testing the handle for the drawer mechanism

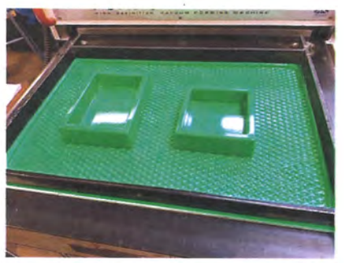
Removing the brass from inside the brazed nut



Testing a string method for preventing the legs from moving further outwards while in use



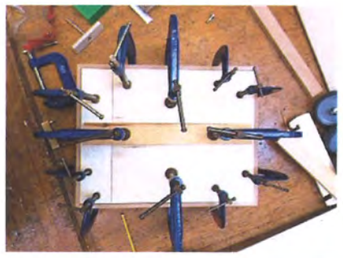
Making the mould for the vacuum formed trays



Vacuum forming the trays

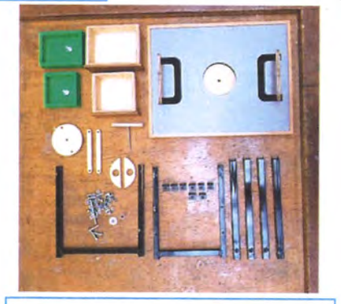
Metal turned handles for the drawers

Applying the metal spray protector on the metal parts of the project



Gluing the formica laminate onto the seat

The seat with the laminate and one coating of Danish oil



All of the components of the prototype laid out

Securing the stoppers to the base of the legs to keep the legs in place when the stool is in use

The fully constructed stool with its legs extended

The fully constructed stool with its legs collapsed

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- Form and Function
- Scale of production and cost
- Safety
- User requirements/size requirements
- Sustainability

On the shortest setting, the legs cannot fully collapse, as seen in the picture, because of the handles on the drawers.

The product must not sink into the ground while it is being used

This stool does not have feet as I did not have time, however, when I was testing it, it did not sink into the ground, therefore meeting the specification

The product should be quality controlled through out the manufacturing process

Throughout the manufacturing process, stated in my plan of production, I used quality control measures throughout to make sure that standards were maintained and the end product would be as high quality as it possibly could be. I stuck to the plan of production and followed all of the quality control checks I had written down, so it did meet the specification

The stool must be able to withstand at least 85kg.

The stool withstood 75kg of weight but I didn't want to test it any more as I didn't want to risk breaking it. As a result, I am uncertain the stool meets the specification

The product must be easily disassembled

The product, as can be seen by the photo, can be easily disassembled due to the usage of screws, nuts and bolts, so it does meet the specification. However, the inner part of the legs cannot be disassembled since they are welded together

The product must be able to be repaired, and maintained to extend its life.

This product can be easily repaired as all of the securing parts are standardised so the user can easily repair any broken components, so the prototype does meet this part of the specification. In addition to this, if the paint on the leg gets scratched off, the user can easily spray another coat onto it. However, this may not work as effectively as the coat will be thinner than the rest of it so it will be very hard to make it evenly coated.

The product must be made with sustainably sourced materials.

The wood in the product has been sourced from the Forestry Stewardship Council so I know that it has been sustainably sourced, with the correct management and cutting techniques to ensure there has been minimal impact to the environment. However, it is hard to sustainably source steel as the iron ore needs to be extracted which damages the surrounding environment and can damage ecosystems where the ore is located. So the stool failed to fully meet this part of the specification.

The materials must be locally sourced.

The FSC sourced wood is locally sourced, but the steel is not as the ore was extracted abroad and therefore had to be shipped or flown over to the UK which in turn has a negative impact on the environment as lots of CO_2 emissions enter the atmosphere and therefore increase the carbon footprint of my prototype, meaning this only partially meets the specification.

Evaluation of final prototype against the specification

The mechanisms must be able to be adjusted with ease and safely.

The leg mechanisms can be adjusted safely, but there is always a risk of trapping fingers due to the fact the legs retract into each other, so if the user had their fingers near the base of the outer leg, they could catch their finger when it is being moved. The way of adjusting height isn't easy due to the amount of turning needed to do to allow the leg to move up and down. This may be particularly difficult for someone who suffers from arthritis and it can only be adjusted when the stool isn't being used and it would have to be turned upside down. In addition to this, it is hard to tell where the holes are for the adjustment, so it may be useful, if placed into batch production, to mark on where the holes are and how far out the leg needs to be to be able to place the bolt back in. This both does and doesn't meet the specification, as it depends on the user

The stool must be lightweight, with a maximum weight of 5kg, and easy to transport

The stool, because it is made from plywood and steel making it heavier than the client would have liked it to be, however it is 4kg so meets the specification. If it were to go into batch production, it would be made, most likely, from aluminium. Aluminium is a lightweight material that can be easily recycled, but I decided not to use this material because I wasn't sure if the material would be able to withstand bodyweight on four hollow tubes.

The finish of the product, should be done with the minimal amount of VOC

The prototype failed to meet this point in the specification due to the fact the legs and other metal components had to be finished with a metal protector spray, thus making it have more of an impact on the environment than I had hoped. If I had used a polish, this would have been extremely time consuming. If the prototype were to go into batch production, using a spray would be the only quick way to finish the product, meaning a lot of volatile organic compounds would be emitted into the atmosphere. 'Metal Protekt' was used.

The product could be made using steel, which is a sustainable metal.

All of the metal components of the product have been made using steel, which means it should have a minimal impact on the environment as it can be endlessly recycled and made into new products, so it does meet the specification. However, the protective coating may make this difficult.

The material used should be used effectively, with little waste created

During the manufacturing process, I tried to produce as little waste as possible. Any waste I did make was recycled as scrap material for the workshop that will be reused for other projects, meaning it did meet the specification

The product must be stable when it is in use.

The stool was stable on the lowest and middle setting, due to the lower centre of gravity. However, when it was on the highest setting, the stool felt more unstable than it had before on the lower settings, so it would be risky for someone if they were to lean back too far, meaning it does and doesn't meet the specification

The must be able to withstand the tests stated in BS EN 1728.

I could only do the rocking test and the static load test. The stool withstood my bodyweight and could be rocked forwards and backwards, whilst still feeling stable (as seen in the photos). I could not do the other tests as the legs are not fixed into place, like they are on a chair, so I was unable to carry out these tests as the legs would have moved inwards.

The handle size must be between 70mm and 90mm

The handle size is 35mm thick, with a width of 85mm, so the handle meets the specification.

The stool must have a maximum footprint of 500mm

The stool has a footprint of 490mm so it meets the specification

The seat must be 405mm wide

The seat is 430mm by 340mm, therefore meeting the specification

When testing whether the stool was easy to transport, the handle broke off due to the thin piece of material around the metal for the hinge

The height of the product should be between 406mm and 560mm

When on the longest setting, the stool reaches a height of 520mm, and when the leg is on the shortest setting, it is 360mm. This means it doesn't fully meet the specification as it is too short. However, when on the middle setting, the stool is 430mm high.

It must have tools storage with holes at least 50mm wide

The stool has failed to meet this point in the specification as I thought this would be an unnecessary feature when there are drawers that do the same job. It also means that less material was used, thus making less of an impact on the environment.

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Evaluation of final prototype against the specification - *continued*

Form and Function
Scale of production and cost
Safety
User requirements/size requirements
Sustainability

If the prototype were to be batch produced and sold, it would have to be made using jigs in the process

The stool could easily have jigs incorporated. The holes for the legs could have a square tubular jig, in which the metal tubing slides in and is locked into place, with three pre-drilled holes which would make the process quicker and accurate. There could also be a jig for the bar which is welded into place, this would make sure the bars were welded in the correct place, for all of the stools produced. This means it would meet the specification if it was in batch production.

The prototype, if being sold, would have to be priced between £20 - £30

The prototype, if in batch production, could be priced between £20-£30, as the materials cost £17.40 (with VAT), meaning a profit could easily be made if the product went into commercial manufacture, and that it meets the specification

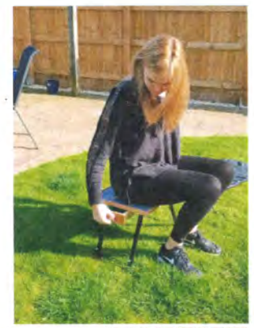
The product must be able to withstand the tests and body weight so a suitable material must be used.

The stool definitely withstands bodyweight, meaning it meets the specification, however, when the legs are at the highest setting, the stool becomes less stable due to the higher centre of gravity.

Pictures of me testing the stool while on the highest leg length, which I found was more unstable than the lower heights

The prototype must be an effective garden stool which carries out its function well.

The stool, at the middle and highest height, is effective at its function. The shortest height is too low for someone to sit on as it requires quite a bit of lowering on to, which wouldn't be suitable for someone who had recently had their hip replaced, like my client, meaning it does and doesn't meet the specification



Testing the stool on the lowest setting, along with the drawers which moved in and out smoothly. However, the drawers do not open all the way out, which is a drawback as it would be difficult for the user to store lots of things in them

The product must be collapsible

The prototype is fully collapsible, so it meets the specification, but the legs do not stay in place when the legs are collapsed. This would be different if the product were to be made again. I would incorporate some kind of clasp that allows the bar joining the legs together to clip into place, preventing the legs from extending when the user transports it.

The stool also works well on the middle height setting

The product must have an adjustable leg height

The stool has an adjustable leg height, with 3 different height abilities, meeting the specification

Pictures of me adjusting the heights of the legs from the lowest setting, to the middle setting. The mechanism is quite fiddly and it would be beneficial if there was a larger head on the bolt so there was a larger surface area, with more mechanical advantage, which would make it much easier to do

Evaluation of prototype by client




My client testing the handles on the prototype, and turning out the drawers

Strengths

I like how compact the product is, its not as bulky as I thought it was going to be. The drawers are useful for putting small things in, and they'd also be good to store small seeds, pegs and garden ties when I am not using the stool, so I don't need to keep taking things out to put them back in again. They also allow things to be all in one place. I like how eye-catching it is, with the contrasting materials and the fact that is different, with all the working components and innovation so clearly a lot of work has gone into it. It also looks a lot different to the ones that are in shops, and those that are already available. The different leg heights make the stool quite versatile. I like the incorporation of the handles so I can easily transport the product, without having to tuck it under my arm, and also how they sit flush when they aren't in use. I really like the fact it folds down flat, as this makes for easy storage, and also that this could be a flat pack product, as the parts are put together with nuts, bolts and screws.

Weaknesses

The base of the legs are hollow, meaning they will most likely sink into the grass when I am using the stool. If it was in a lighter weight material it would be much easier to transport. I'm not sure whether an elderly person would be able to turn the nuts for the legs as they are quite small and could be fiddly. I'm not sure whether the seat is big enough because, I know id want to hold onto the seat, or have something to hold onto when I sit on it or get up from it. It's a shame that the drawers don't come all the way out so I can't reach into them if something goes all the way to the back. It's a shame that the handle for the drawer crank doesn't work properly. If I were to move the stool around the garden, the legs move in, rather than stay in one place which could be quite dangerous, especially if the user is unstable as they may get their finger trapped. Also, it would be nice if the legs stayed in place so I could transport it safely. If it was a flatpack, it could be a drawback as this could be too intricate for someone who has arthritis. It's a shame that the corners aren't rounded.




Photos of my client adjusting the leg mechanism. She found that the bolts used to adjust them were a bit fiddly, which made it harder to do. She also felt that it was hard to see where the holes in the inner leg were and when they were aligned, so it was hard to gauge when to screw the bolt into place

Photos of my client transporting the prototype, which she found was a bit heavier than she expected

Betty Ann




My client testing the drawers of the prototype with something she would store in the stool

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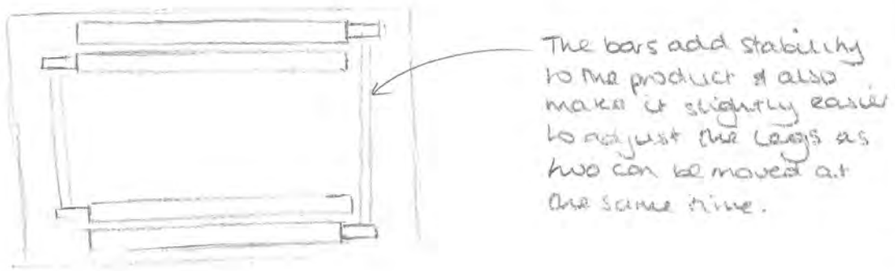
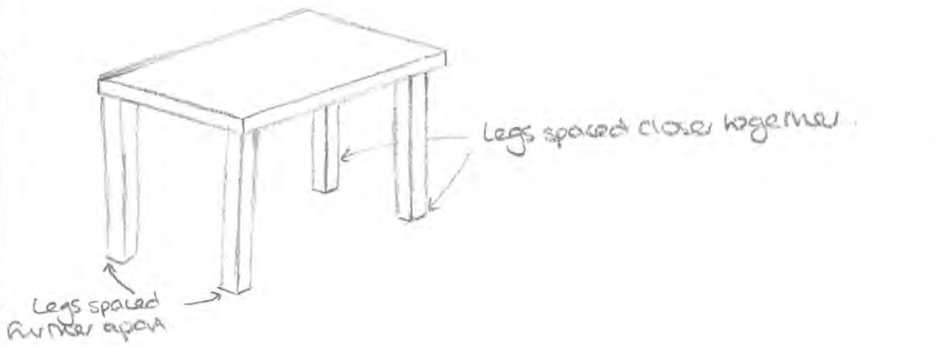
Modifications made during manufacture

During the manufacture, I had to modify quite a few things in order to make sure the prototype would work and would meet the clients needs as much as possible.

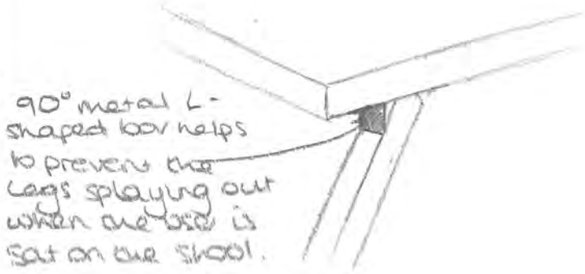
Legs
I changed the structure of the legs. After beginning manufacture, I realised that the legs would be very unstable if they were single and would also be difficult to adjust them all individually, and collapse them individually. For this reason, I decided to weld a bar near the base of the inner legs as this would add structural strength, prevent the legs from wobbling and be easier for the user to collapse and adjust the height.



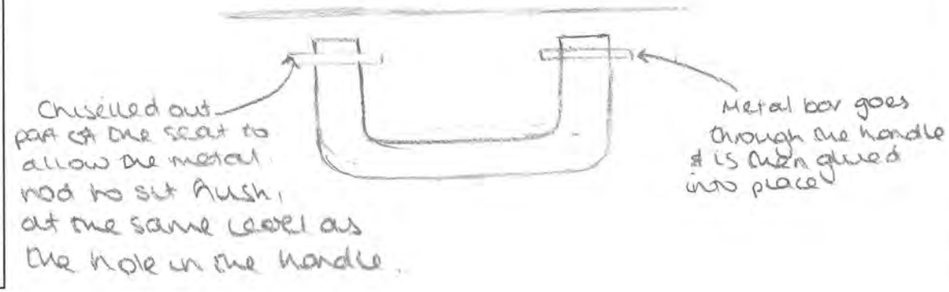
Legs
I changed how the legs were placed because I felt that, with them being staggered, they may have been less stable, especially if the user places more body weight on one corner than the other.



Legs
I removed the use of bolts to keep the legs in place as it was an unnecessary use of material and man hours. As a result, I decided to cut down a steel L-shaped bar to size and screw it near the base of the legs so that it prevents the legs from moving outwards when the user is sat on the stool. In addition to this, I made the angle of the legs greater than 90° as this would make the seat more stable, with a larger footprint and slightly lower centre of gravity.



Handles
Although the final design didn't have any mechanism to allow the handles to come up and down, I was thinking of using a small hinge. I realised when I was making the product that this wouldn't be possible as it would protrude from the project, as a result I used a steel bar, which went through the base of the handles, and glued into the seat.



Legs
I decided to change the legs slightly. The mechanism was changed because I felt that it may be harder for an older person to pop in a tiny button to adjust the legs. It would also be harder to do if they had arthritis, so I opted for a nut and bolt approach, which is also a stronger way to adjust the legs.

Topper
I did not make a topper for the stool because I felt it was unnecessary, especially when the handles sit flush in the seat. It would have been a waste of material and doesn't add to the product as there is now nothing to cover.

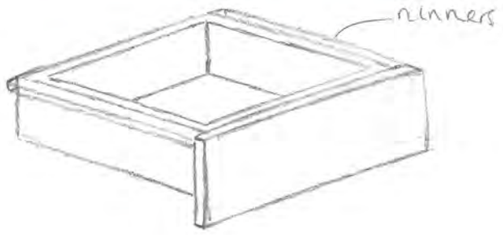
Crank
I decided to make the crank mechanism from plywood instead of aluminium which made it easier, quicker and more accurate to produce as it was cut out on the laser cutter. It also has less of an impact on the environment when compared with aluminium due to the fact the ore needs to be converted into a metal which produces a lot of CO_2 as a result.

Drawers
I also removed the lid from the drawers, as pointed out by my client, it would be difficult and fiddly for her to have to keep lifting. It would also be a waste of material as the drawers go under the seat, which itself, effectively makes a lid.

Drawers
The drawers didn't need to be staggered as the legs were changed, however they did need to be different sizes to compensate for where the legs were - as can be seen in the photo

Drawers
In response to my clients feedback about the drawers only being able to be adjusted before she is sat down, I decided to add handles to the drawers, which mean they should be able to open while the stool is being used.

Seat
I decided to add a frame around the seat made out of beech which added to the aesthetics of the stool as well as adding the laminate to the seat which not only added aesthetics, but also made sure that the seat could be easily cleaned if it got dirty



Life cycle analysis

Raw materials

Birch plywood – Birch is a hardwood which is a slow growing wood, meaning it will have taken lots of energy to grow. It also means that it will require lots of energy to grow back, which can take many years, unlike softwoods.

High Impact Polystyrene (HIPS) - This is a form of plastic which originates from crude oil, which can have a devastating impact on the environment if spilled. It also emits a lot of CO_2 into the atmosphere when it is being manufactured into plastic.

Steel – This is formed from an ore of iron which can severely damage the environment, and it also requires a lot of energy to manufacture steel as the iron ore requires lots of melting in a furnace.

Manufacturing

The majority of machines I needed to use to manufacture this prototype required electricity, meaning lots of energy will have been required, especially with the laser cutter. Hand tools were used for small parts of the project, such as the chisel used to allow the handle mechanism to work, and junior hacksaws to cut down screw threads and other small metal parts.

Distribution/transport

The end product had no packaging as it was easy to carry and I felt it would have been unnecessary to place it in a box for such a short travelling distance. This product can easily fit on the backseat of a car which eliminates the need for large transport vehicles which emit more CO_2 than the average car.

Assembly

Little to no energy is required to assemble the product as only nuts, bolts and screws hold the pieces together. This means only a screwdriver is needed, along with some strong glue and a spanner to tighten the nuts.

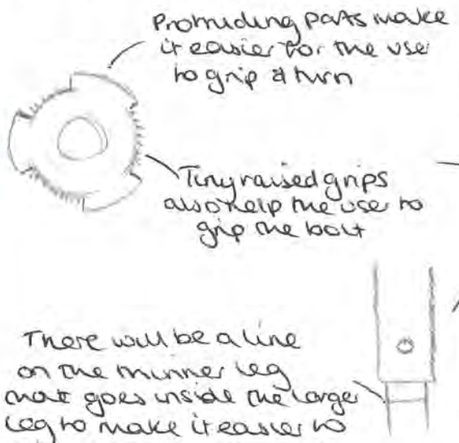
Use

It may be likely that the wood will get dirty while being used in the garden, however, the Danish oil coating is dirt resistant meaning it can be simply wiped off. The wood will probably be susceptible to scratches, and so will the laminate top on the seat, but this too will be dirt resistant so it can be easily cleaned. The metal paint will probably get scratched off after some adjustment of the legs, which could be easily re-sprayed over, but it will not be even and it will most likely be a very thin coating. The securing components (nuts, bolts and screws) are standardised meaning they will be easy to buy if one gets worn down, and they can be bought locally, reducing the transport costs, but it is unlikely parts will wear down.

End of life

The product can be easily disassembled and separated into its material categories for recycling, however, the laminate on the seat has been glued on with PVA so it may be hard to get off. Also, the paint on the legs may make it more difficult to recycle the steel, and the removal of this requires lots of energy. However, the plastic trays, drawers and crank mechanism can be easily recycled, as well as the handles.

Current seat size = 415 x 330mm
Future seat size 15% larger
415 x 1.15 = 477.3mm
330 x 1.15 = 379.5mm
Future seat size = 477mm x 380mm.



Impacts of final design

Social and economic issues

If this prototype went into batch production, it could provide employment opportunities for individuals. The colours and shapes I have used in my product are fairly neutral, so it shouldn't be offensive to large groups of people, however it is hard to please everyone so there may be some individuals that find the project offensive, despite trying to be as neutral as possible. All of the materials used in the prototype can be reused at the end of the stools life cycle, meaning that the user can feel better about buying and using the product as they know the materials can be repurposed. This product is generally safe to use, however there is a risk of a finger trap as the legs are not held in the same position, meaning when the stool is lifted up and turned upside down, there is a risk of them trapping a finger. The prototype has tried to be as inclusive as possible, due to the fact it was designed for an older person, however, the bolts on the legs could make it difficult for someone who has arthritis or a different kind of hand difficulty. I made my project slightly smaller than I hoped it would be, which is actually beneficial because this means less material was used, so it will be cheaper and have less of an impact on the environment.

Environmental issues

The materials used for my project were all sourced as locally as they could possibly be to reduce air miles and the amount of CO_2 emitted into the atmosphere. The plywood used in my project came from the Forestry Stewardship Council which works to promote responsible management of the worlds forests, by setting standards on forest products. The wood I used was marked as eco-friendly so I knew it came from a sustainable source. Another reason why plywood was used was because it can last between 30-40 years, which balances out the energy it requires when it is manufactured. Steel comes from a finite resource (iron) and wood doesn't as it can be regrown. I used the laser cutter to cut out the shape of my seat and the laminate to go on top which will have required a lot of energy to cut out, thus resulting in an emission of CO_2 into the atmosphere, also the other electrical tools I used will have done the same. The end product requires no packaging, thus reducing the amount of further impact it has on the environment. The stool also complies with the 6 R's as it can be recycled, rethought, refused to be thrown away, repurposed/reused, repaired and reduced as all parts can be easily disassembled.

Improvements that could be made if sent into batch production

If this was sent into batch production, different materials would have to be used because it is much heavier than it should be (**the product weighs 4kg**), due to the dense materials I chose to use - plywood and mild steel. I would probably use aluminium and maybe plastic (although this has a huge impact on the environment) as this metal should allow me to reduce the weight by around half, if I make the entire stool out of aluminium and plastic. I would have to test the strength of the aluminium before constructing a stool out of it.

I would make the seat larger for the user as it feels too small and like the stool would be more stable if there was a larger footprint. This would also allow me to make the drawers bigger, to store hand tools and other gardening items.

I would add feet to the legs to prevent the legs from sinking into the ground and damaging the grass, although I didn't notice this, it may happen on saturated soils, and areas that are just soil.

I would make the crank out of aluminium because it would make the project lighter, and it would probably work a lot smoother than the wooden crank

The leg height mechanism would definitely need to be changed. It was too fiddly and there was not enough mechanical advantage when trying to unscrew it. I would make the bolt head much larger, with grips and pieces sticking out so that the user could easily find a place to grip and make it easier to turn. The screw thread would also need to be much shorter, and the point at which the holes line up would need to be marked somewhere

I would want to make the stool more ergonomic by adding grips and finger grooves to the handle and possibly adding a cushion to the seat so it was more comfortable to sit on. The cushion would need to be weather and dirt resistant, so a plastic fibre would need to be used. I could also make the grips on the handles modular so the user can use which ones to use, and when they want to use them

I could add hooks to the project so the user can hook bags and other items onto the stool so the user doesn't have to keep bending over to put weeds in a bag

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