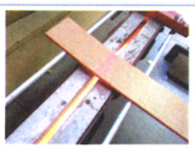
Evaluation of final design solution based on the specification

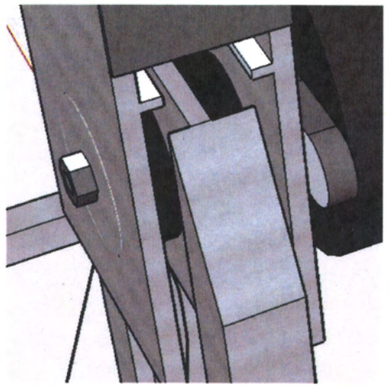
Specification point	Has the specification been met
Function	
1. The log mover must carry a volume of 20L of logs	30x40x25=30,000cm^3 which is equal to 30litres
2. There should be a method of easily loading/unloading the logs	I have designed a log grabber which could be bought, this would make loading and unloading easier. However, this won't be made during production
3. The product must be stable, must meet BS EN 1730 standard	My product has a wide base with two wheels as well as it has been designed so that the weight is evenly distributed. It also has the second function mode which has 6 wheels on the ground at the same time, thus making the product very stable
4. The product must make the logs easy to transport	With large wheels the product should be able to scale any terrain
5. All mechanism must function at all times, even under a strain of 500 Newton's or towards end of life (6 years)	I will test this specification requirement once the design has been made
6. The product must support a total mass of 50 kilograms	I will test this specification requirement once the design has been made as I can't predict how much mass the log carrier can take
7. The product must have some form of adjustability	The design has two forms of adjustability, the adjustable crutch handle and the adjustable mechanism, therefore this criterion has been met
Form	
1. The product must be aesthetically pleasing	Both my client and I believe the design is aesthetically pleasing, I think the design is sleek and well fitting for its environment
2. Ergonomic consideration must happen when designing the product	The handles and wrist support have both been modelled to make them as ergonomical as possible, this has been transferred to the design
3. The product must not offend any genders or religions	As far as I'm a where the product does not offend anyone, it has used neutral colours and has no possibly offensive symbols/shapes
4. The product must fit into all its environments	Both my client and I believe the design is aesthetically pleasing, I think the design is well fitting for its environment
5. The product must be of modern day design	The product uses modern materials, modern techniques, therefore I think it can be considered modern looking
Quality control	
1. Must be made to a ±5mm accuracy	I cannot evaluate this point until after making the design
2. Product must be thoroughly checked before being placed on the market	I cannot evaluate this point until after making the design, however the mechanisms have already been thoroughly tested
Dimensions	
1. The product must be no larger than 600mm x 600mm x 500mm	When the product is in its storage mode it meets this requirement, however in its fully extended mode it breaches this requirement
2. The product must have no jetting out edges of more than 150mm	The product has been designed to have no jetting out edges
3. The product must have a maximum displacement adjustability 0f ±400mm	The product has many adjustments, none of them are over the 400mm requirement
4. The product must have handles with a maximum diameter of 50mm	The handles on my log carrier have a dimension of exactly 50mm so the design meets the specification
Safety	

1. My product should meet the BSI sharpness test	This specification will be tested after the product has been made
2. The product should have a mass of no more than 15 kilograms	The product will be weighed once it has been made
3. All mechanisms must have safety precautions such as avoiding finger traps	The adjustable mechanism and crutch mechanism are both enclosed to fingers cannot reach them
Materials	
1. The log mover must be hard and durable according to BS EN 1730	This specification will be tested after the product has been made, however all materials that have been chosen for my design are considered to be hard/durable
2. The product must use waterproof materials and be resistant to all types of corrosion	All the materials chosen are waterproof, however mild steel is prone to rusting therefor it will need to be finished in a paint or protective layer
3. The product should be made from long lasting and sustainable materials	All the materials are definitely long lasting, they have been chosen especially for this purpose, however mild steel and aluminium are both quite energy intensive to extract and manufacture. Although aluminium and mild steel can be recycled they are not the most environmentally friendly materials to use
4. Low maintenance materials should be used	The material chosen for my product are all low maintenance
Ages	
1. The product must fit the age range of 18-89 years old	The product has been designed to fit all ages however whether this product could be used for some of the ages required is opinionated
2. The product must have no parts a young child could injure themselves on	The product has safety precautions, no finger traps or lose parts therefore it has met this specification point
Cost	
1. The product should cost no more than £100	After doing a parts list for my design and adding the cost of all the material up and adding VAT the total cost was £50.35 which is less than £100
Scale of production	
1. Batch production	Parts of my design have been designed so that jigs can be used if batch production is implemented, I am confident this design could be batch produced without a problem
2. Jigs will be used	I have designed my product with jigs in mind, many parts can be made with repeatable accuracy using jigs
Sustainability	
1. The log mover should be made from long lasting and sustainable materials	All the materials are definitely long lasting, they have been chosen especially for this purpose, however mild steel and aluminium are both quite energy intensive to extract and manufacture. Although aluminium and mild steel can be recycled they are not the most environmentally friendly materials to use
2. Varnishes/sealers used on the product must be eco-friendly and non-toxic where possible	My design is mostly self-finishing for the exception of the mild steel which will covered in a paint, therefore I consider this specification point passed
3. Un-used materials must be recycled if possible	This specification point is more aimed at production so I will evaluate it after the product has been manufactured
4. Machines should be used as little as possible	This specification point is more aimed at production so I will evaluate it after the product has been manufactured
5. Similar materials must be used	My design uses very few materials, however I think that the different material welds will make the product a lot harder to recycle at the end of the products lifespan so I would consider making some changes during production otherwise this specification point will not be met

Risk assessment

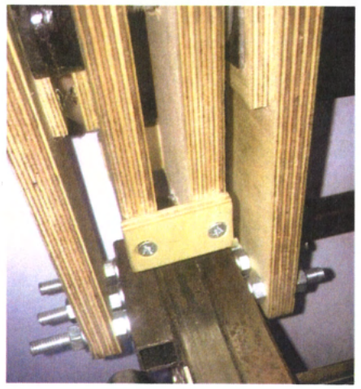
Machine/Process	Likelihood (1-5)	Consequences	PPE required	Safe working practice
Pillar drill 	3	• Pieces flying off into your eyes etc • Hands and fingers can be caught in machine • Hair and clothing can become entangled • Lack of space or concentration around the machine can lead to accidents • Continuous use can cause fire	• Safety goggles • Apron • Use of guards	• Tie all hair and clothing back • Use the machine in breaks and not for long amounts of time • Hold onto work firmly • Wear goggles and use the guard on the drill • Make sure to remove key chuck before use
Metal band saw 	4	• Bits can fly off unexpectedly • Overuse can cause ear damage • Blade can snap un-expectantly • Hair and clothing can become entangled • Lack of space or concentration around the machine can lead to accidents	• Safety goggles • Apron • Heatproof gloves	• Use Goggles • Wear ear defenders • Tie all hair and clothing back • When using the machine give it your full attention and make sure you have room when working.
Band saw 	4	• Bits can fly off unexpectedly • Overuse can cause ear damage • Hands and fingers can be cut • Hair and clothing can become entangled • Lack of space or concentration around the machine can lead to accidents	• Safety goggles • Apron • Use of guards	• Use Goggles • Wear ear defenders • Use a push stick for small items • Tie all hair and clothing back • When using the machine give it your full attention and make sure you have room when working.
Metal grinder 	2	• Burn injuries • Metal swarf flying off • Hair and clothing can become entangled • Lack of space or concentration around the machine can lead to accidents	• Safety goggles • Heatproof overalls • Heatproof gloves	• Use heatproof gloves • Use Goggles • Tie all hair and clothing back • When using the machine give it your full attention and make sure you have room when working
Laser 	1	• Damage to eyes • Hazardous fumes • Possibility of fires	• N/A as computer controlled	• Make sure the fume extract is turned on • Do not look directly at the laser for long periods of time • Set all materials and thicknesses correctly to avoid fires/overheating
Strip heater 	2	• Hazardous fumes • Possibility of fires • Burn injuries	• Heatproof overalls • Heatproof gloves	• Work in well ventilated area • Use heatproof gloves if working with small objects • Tie all hair and clothing back • When using the machine give it your full attention and make sure you have room when working
Brazing/ welding 	3	• Burn injuries/fires • Eye damage • Dangerous fumes	• Heat proof overalls • Welding mask • Gloves • Overalls	• Appropriate training • Work in well ventilated area • Take regular breaks from piece • Use all PPE stated
Pop riveting 	1	• Pin flying off once force applied • Pressure from pop rivet	• Safety goggles	• Make sure work is fully secured before pop riveting • Be aware of flying pins • When using the machine give it your full attention and make sure you have room when working

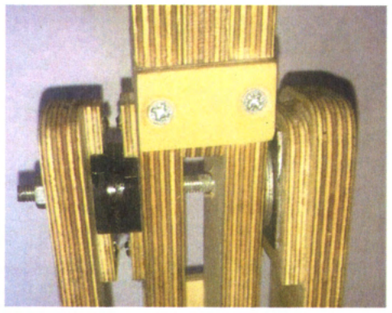
Modifying testing and improving during manufacture

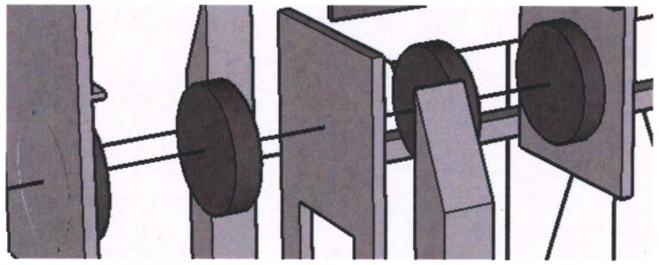


One major change throughout manufacture of my product is that I chose to use pop riveting over welding due to It being a quicker and easier process whilst still providing great strength.

Due to this some parts of my design changed. Whilst the design shows the mid-section as the inside of the adjustable mechanism the final product was different. Due to the mid-section being wider than anticipated I had to make an adaptor to the adjustable mechanism which can be seen from the pictures. It required to flap sections which were then bolted across the mid-section using 3 bolts and the required washers/nuts. This modification made the overall product a little taller than previously stated but had no everlasting changes on the product.

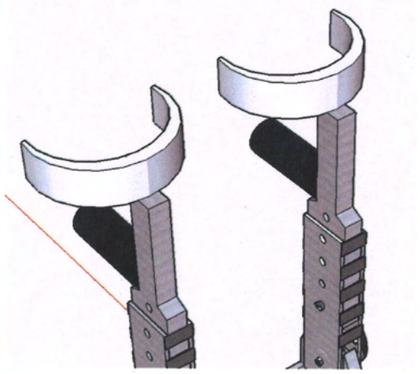






After making the set of adjustable crutch handles I modelled them to see which way round they felt most comfortable. I found that myself and other people included thought the opposite way to the original design felt better and so I decided to swap the way the handles and wrist support went.

I also decided to change the shape of the wrist support to more of an enclosed shape in order to keep more support. This did however have some negative impacts (see evaluation)



As we can see from the photos above the adjustable mechanism itself also changed. In designing I thought four nord lock washers would be sufficient but whilst making I found that they had a tendency to slip under little weight. To fix this I used a pair of Nord lock washers and a pair of plastic lock washers. I found that this gave the product added strength.

Whilst the plastic lock washers where stronger in terms of holding the mechanism together. They often broken free from the flaps. To fix this I placed a piece of plywood tightly inside the plastic lock washers and screwed them into the flaps. This stopped the lock washers from rotating when they shouldn't have.

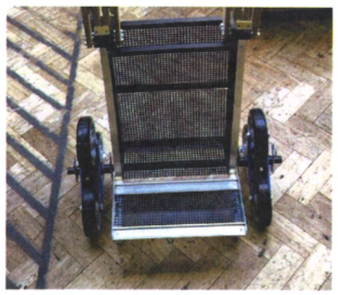
I also made a few minor changes to my overall design. Instead of using many steel support beams for the base frame, which would have added too much weight, I used one support beam and some mild steel mesh.

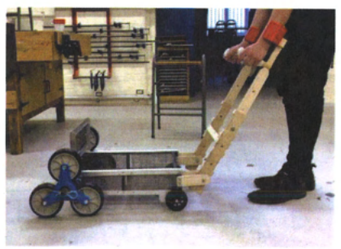
I also attached another support beam across the adjustable crutch mechanisms. This did not affect the mechanism itself but gave the top half of my product more strength as well as it meant that when changing the product to its second adjustable mode, I could change both handles at the same time to the same setting. This greatly reduced the time to reduce the product to its second adjustable mode.

Another small change I made was I replaced the mild steel frame with a mild steel mesh. Not only was it stronger but it was also more effective as it is capable of catching more of the log material. It did however have some negatives (see evaluation)

Another quite important change I made is the addition of support beams. After testing the I initial frame that I created I felt that it did not have the best strength. In order to fix this I pop riveted a series of mild steel bars. I found this made the product much stronger.

The final adjustment I made was that I added a short wooden block on either side so that the trolley wouldn't fall over when left standing up.





Plan of production

Task	Tools/equipment	Risk 0-5	Safety precautions	Q.C. Enquiry	Q.C. check	Week of production	Estimated time	Changes/notes
Cut out the aluminium blocks and drill the holes for the adjustable mechanism, then weld the two pieces (x2)	• Pillar drill • Metal band saw • File	4	• Training on how to use metal band saw • PPE • Safety goggles • Make sure work is properly secured	• Is the cut the correct size and angle on the adjustable block? • Are there any sharp edges as a result cutting the metal?	• Check dimensions of the cuts and use protractor to measure angle (±2mm) • Use a file if necessary to smoothen the cuts	Week 1	120 minutes	• Material changed to plywood • Screwed together
Cut the dowel handles and wrap them in rubber, use 2D design and the laser cutter to cut out the wrist supports (x2)	• Band saw • Cutting knife • Laser	3	• Use correct PPE, use push sticks • Use cutting mat • Cut away from body	• Are the dowel handles equal size? • Is rubber covering the whole handle?	• Check the dimensions of both handles (±2mm) • Do a visual check to see if the rubber is covering the whole hand	Week 1/2	90 minutes	• Handles finished with polymorph
Drill the holes in the PVC and handles as well as bend the PVC in shape. Then join them using nuts and bolts	• Pillar drill • Strip heater • Nuts and bolts	2	• Clamp work securely • Use correct PPE/follow signage • Use gloves with strip heater	• Do the wrist supports have the correct angles? • Are the holes accurately drilled?	• Use a protractor to measure the angles (±1°) • Check the holes are central and line up with crutch beam (±0.5mm)	Week 2	100 minutes	• n/A
Use the metal band saw to cut the sheet metal beams, sheet metal runners and mechanism stopper and drill the appropriate holes	• Metal band saw • Pillar drill	4	• Training on how to use metal band saw • PPE • Safety goggles • Make sure work is properly secured	• Are the pieces the correct dimensions? • Do the holes line up for the adjustable mechanism?	• Check the dimensions of all the cuttings (±4mm) • Line up the adjustable mechanism to check everything aligns (±0mm)	Week 2	75 minutes	• Material changed to plywood
Weld the mechanism stoppers on, braze the sheet metal runners to the sheet metal beams	• Arc welding set-up • Brazing torch • Flux	3	• PPE • Use Arc welding face shield • Gauntlets • Heatproof overalls	• Are the mechanism stoppers parallel to the sheet metal beams? • Are the sheet metal runs at 90 degrees?	• Use an engineer square to make sure all the angles are at 90 degrees to each other (±0°)	Week 3	90 minutes	• Mechanism held in place using nuts and bolts
Slide the adjustable beam into the slot making sure they slide smoothly, cut the magnetic pins and slide them into position	• Metal band saw • Metal file • Emery cloth	3	• Make sure iron rod is fully secure when cutting • Be careful not to catch fingers in the adjustable mechanism	• Does the adjustable function smoothly? • Do the magnetic pins stay in place?	• Make sure the adjustable mechanism is made to a tolerance of less than 2mm total using a ruler • Leave the pins in and see if gravity displaces them	Week 3	30 minutes	• n/a

Following this create mould and pewter cast the mechanism toggle and place the adjustable mechanisms in place before attaching the mechanism toggle	• Pewter casting • Pewter • Nuts and bolts	3	• Be careful not to spill pewter or overfill mould when pouring	• Does the adjustable mechanism both line up? • Has the pewter casting finished well?	• Do a mechanical check to make sure the adjustable mechanisms have lined up • Check for burrs and structural faults, file smooth any sharp edges (BSI sharpness test)	Week 3/4	90 minutes	• Due to timing I replaced the toggle with wingnuts
Cut out all the parts for the lower section using the metal band saw and drill the appropriate holes required	• Metal band saw • Pillar drill	4	• Training on how to use metal band saw • PPE • Safety goggles • Make sure work is properly secured	• Does the base frame make 90 degree angles to each other? • Do the holes line up where appropriate?	• Use an engineer square to check the angles ($\pm 0^0$) • Line up all the parts where holes overlap to make sure they align	Week 4	100 minutes	• n/a
Weld the base frame together, pop rivet the raised section before welding the mid-section to the raised section	• Arc welding set-up • Pop rivet gun	3	• PPE • Use Arc welding face shield • Gauntlets • Heatproof overalls	• Are all the parts parallel to each other? • Is the raised section fixed to the base frame correctly?	• Use an engineer square to check the angles ($\pm 0^0$) • Make sure the pop rivets have fully formed and are strongly joined (Tensile strength test)	Week 5	90 minutes	• I used pop riveting instead of welding
Attach the secondary wheels using nuts/bolts, weld the main axel to the base frame	• Arc welding set-up • Nuts and bolts	3	• PPE • Use Arc welding face shield • Gauntlets • Heatproof overalls	• Is the axel aligned correctly with the base frame? • Do the wheels spin smoothly on the bearings?	• Use an engineer square on both side of the base frame to make sure the axel is at 90 degrees • Check the bearings are clean and spin smoothly	Week 5	90 minutes	• Axel was pop riveted to main frame
Attach the cargo net hooks using the nylon rope and braze the mesh frame into place	• Nylon rope • Brazing torch • Flux	2	• Gauntlets • Heatproof overalls • PPE	• Does the mesh frame fit inside the lower section? • Is the nylon rope attached securely?	• Check the mesh frame directions allow it to fit in the lower section (±5mm) • Apply pressure to the net to make sure it holds in place (Young's modulus test)	Week 6	60 minutes	• Cargo net was not made due to timing • Mesh was pop riveted in place
Put the second-hand wheels on the axels and use locking nuts to hold them in place	• Nuts and bolts • Spanner	1	• The wheels have possible finger traps so be careful to avoid this	• Do the wheels support the trolley? • Do the wheels rotate smoothly and up/down stairs?	• Wheel the trolley to make sure the trolley is support by the wheels • Use the wheels on the stairs to make sure they function	Week 6	25 minutes	• n/a
Clean the metal parts and fully tighten all nuts and bolts where necessary	• Spanner • Wire wool • Emery cloth	0	• No safety issues	• Are there any scratches marks on the product? • Are there any lose nuts?	• Do a visual check of the product and use emery v Cloth to remove marks • Tighten all the nuts until they can't move	Week 7	120 minutes Total time: 1080 minutes (18 hours)	• Black paint and danish oil were used for finishes

Gantt Chart

Projected time

Task	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Cut out the aluminium blocks and drill the holes for the adjustable mechanism, then weld the two pieces (x2)							
Cut the dowel handles and wrap them in rubber, use 2D design and the laser cutter to cut out the wrist supports (x2)							
Drill the holes in the PVC and handles as well as bend the PVC in shape. Then join them using nuts and bolts							
Use the metal band saw to cut the sheet metal beams, sheet metal runners and mechanism stopper and drill the appropriate holes							
Weld the mechanism stoppers on, braze the sheet metal runners to the sheet metal beams							
Slide the adjustable beam into the slot making sure they slide smoothly, cut the magnetic pins and slide them into position							
Following this create mould and pewter cast the mechanism toggle and place the adjustable mechanisms in place before attaching the mechanism toggle							
Cut out all the parts for the lower section using the metal band saw and drill the appropriate holes required							
Weld the base frame together, pop rivet the raised section before welding the mid-section to the raised section							
Attach the secondary wheels using nuts/bolts, weld the main axel to the base frame							
Attach the cargo net hooks using the nylon rope and braze the mesh frame into place							
Put the second-hand wheels on the axels and use locking nuts to hold them in place							
Clean the metal parts and fully tighten all nuts and bolts where necessary							
Testing and final quality control							

Actual time

Task	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Cut out the aluminium blocks and drill the holes for the adjustable mechanism, then weld the two pieces (x2)							
Cut the dowel handles and wrap them in rubber, use 2D design and the laser cutter to cut out the wrist supports (x2)							
Drill the holes in the PVC and handles as well as bend the PVC in shape. Then join them using nuts and bolts							
Use the metal band saw to cut the sheet metal beams, sheet metal runners and mechanism stopper and drill the appropriate holes							
Weld the mechanism stoppers on, braze the sheet metal runners to the sheet metal beams							
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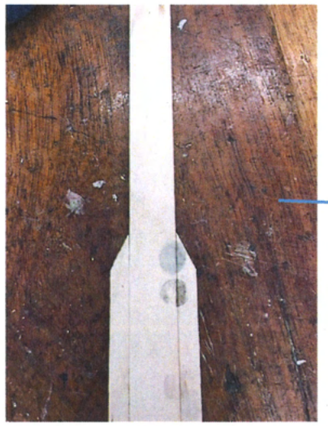
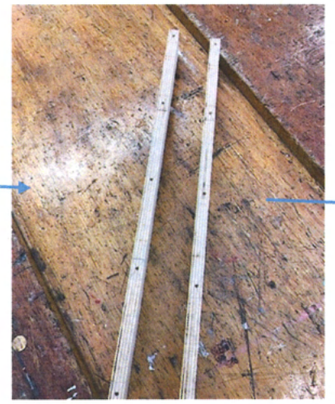
Put the second-hand wheels on the axels and use locking nuts to hold them in place							
Clean the metal parts and fully tighten all nuts and bolts where necessary							
Testing and final quality control							

Photographic evidence of making

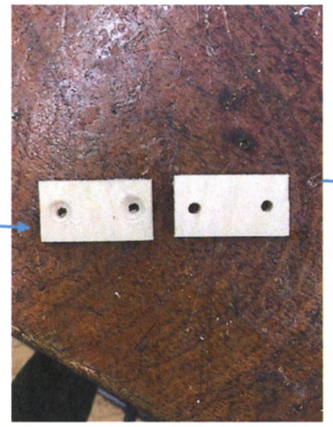
Cutting the crutch beam and block for the adjustable crutch mechanism



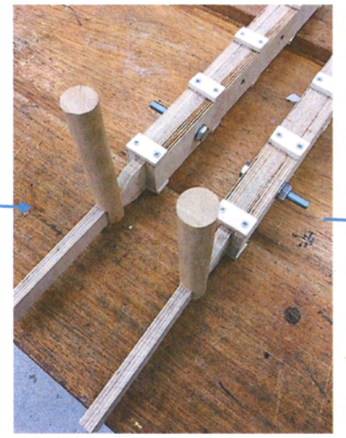
Marking the wholes for the sheet metal runners and drilling pilot holes



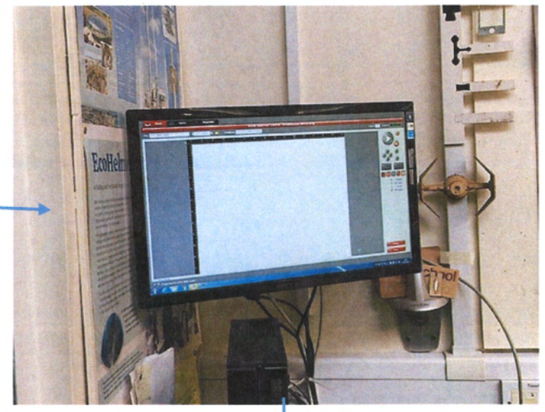
Cutting the sheet metal runners and countersinking the holes to provide a flush finish with the screws



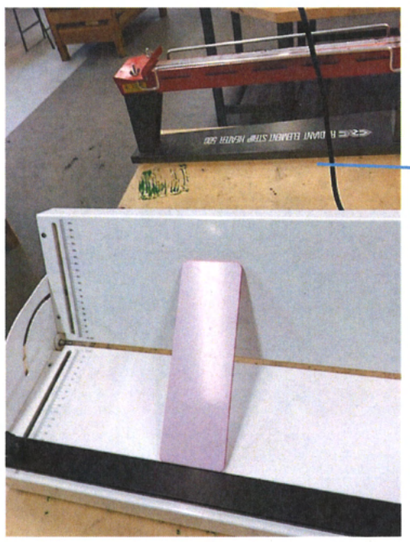
I then cut the dowel handles and drilled them into place



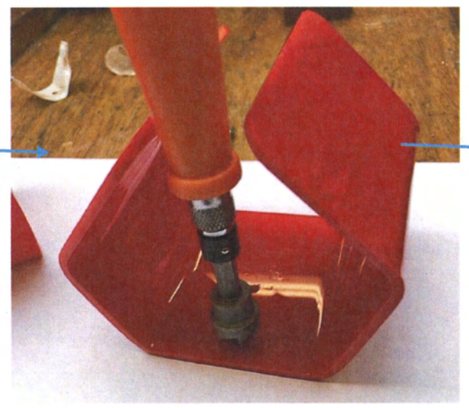
Next, I used techsoft 2D design to produce my wrist supports. I then cut them out using the laser



I then used an angled line bender and strip heater to make the angles for the wrist support

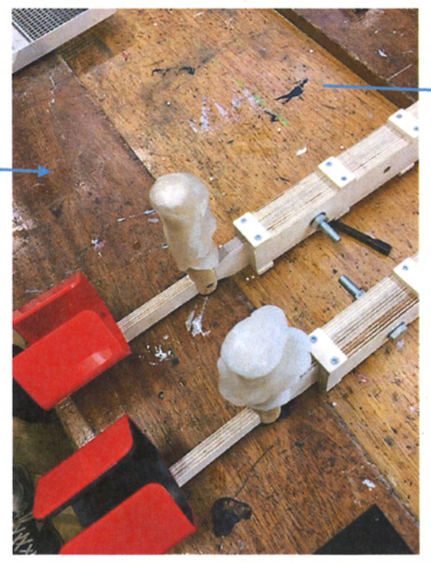


I then drilled and countersunk two holes for each wrist support and attached them to the crutch beam



I then boiled some water and used polymorph to create my ergonomic handles from my development

Following this I added some rubber grips to the wrist support which left me with the top part of the product completed



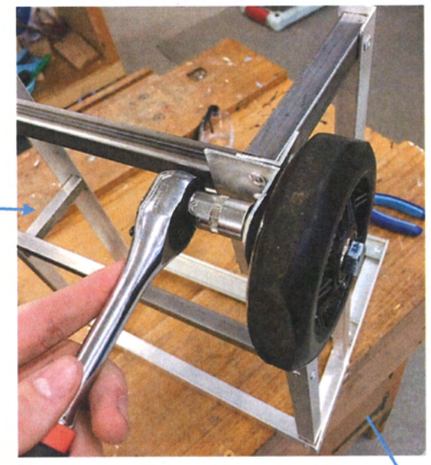
After this I created the base frame using four metal sheets and pop riveting

I then cut the metal for the raised section before pop riveting it all together (including the support beams

Throughout this process I made sure to file flat any of the beams being joined at 90 degrees

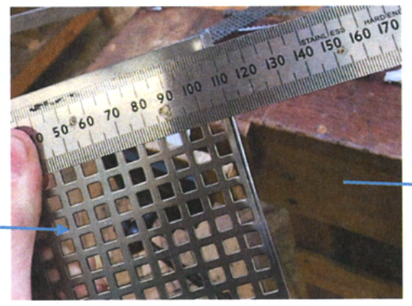
Following this I cut out two L-brackets and drilled multiple holes (for strength) and pop riveted them to the main frame

I then attached the wheels using a locking nut and a spanner set making sure the ball bearings where well lubricated



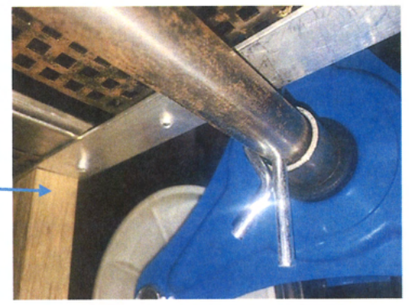
I then used the shear press to cut the pieces for the mesh frame and mesh sides

Throughout this process I made sure the dimensions where correctly cut (±2mm)

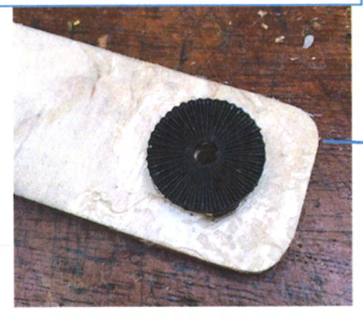


I then placed all the mesh frame pieces in place to make sure they fitted snuggly

I then pop riveted the axel on before attaching the wheels



After making my improved mechanism I attached it to the adjustable crutch and attached this to the main frame



After making some small adjustments (central support beam) the product was finished

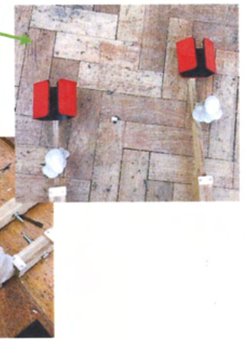
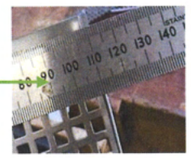
Testing against specification

Specification point	Has the specification been met
Function	
1. The log mover must carry a volume of 50L of logs	After measuring I found the volume to be 0.0525m^3 which is equivalent to 52.5 litres
2. There should be a method of easily loading/unloading the logs	I believe this is the one serious fault with my design, although the logs are somewhat easier to load, the user is still required to bend down, if I had more time I think a log grabber attachment would have been perfect to fix this problem
3. The product must be stable, must meet BS EN 1730 standard	The product can take myself standing on it therefore I would consider it stable, with the wooden support blocks the product is unlikely to fall over
4. The product must make the logs easy to transport	My client found it easy to carry the logs up the stairs as well as around the house
5. All mechanism must function at all times, even under a strain of 100 Newton's or towards end of life (6 years)	Using the Newton metre, I found that the adjustable mechanism could carry a strain of over 150N
6. The product must support a total mass of 50 kilograms	The product can take my mass, which is over 50kg therefore this specification point has been passed
7. The product must have some form of adjustability	My product has many forms of adjustability, one form is given here in the photo
Form	
1. The product must be aesthetically pleasing	Speaking to my client she believes that the product looks good considering the intension of which it is meant to be used
2. Ergonomic consideration must happen when designing the product	Throughout manufacture I attempted where possible to make the product as ergonomic as possible
3. The product must not offend any genders or religions	Me and my client talked and agreed that the product didn't offend any genders
4. The product must fit into all its environments	Me and my client agreed that the product was fairly neutral in its environment and therefore didn't look out of place
5. The product must be of modern day design	Me and my client talked and agreed that the product had a modern day feel about it
Quality control	
1. Must be made to a ±5mm accuracy	Throughout manufacture I always tested against my set tolerances
2. Product must be thoroughly checked before being placed on the market	After I finished manufacturing my product I meticulously checked it for any faults or errors
Dimensions	
1. The product must be no larger than 600mm x 600mm x 500mm	When my product is in its 'storage mode' it fits within in the required dimensions, however when the product is in its working mode it is greater than these dimensions
2. The product must have no jetting out edges of more than 150mm	If you include the handles as jetting out then this specification point would not be met, however depending on opinion this point has been met
3. The product must have a maximum displacement adjustability 0f ±400mm	My product is adjustable however it never passes over the 400mm requirement
4. The product must have handles with a maximum diameter of 50mm	The handles I made fit within this specification point

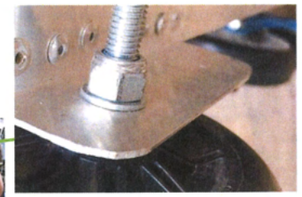




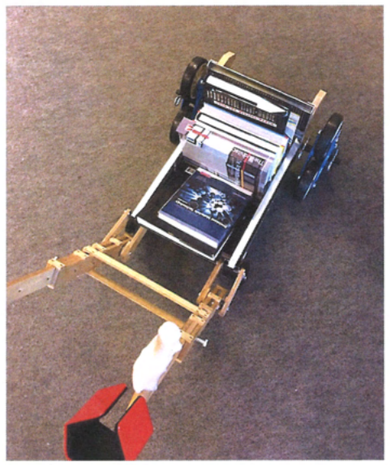


Safety	
1. My product should meet the BSI sharpness test	Any sharp corners I found with my product were rounded off, as a result my product meets the BSI sharpness test
2. The product should have a mass of no more than 15 kilograms	After using 4 newton metres and dividing by g I found the weight was 11.2Kg which was below the maximum weight
3. All mechanisms must have safety precautions such as avoiding finger traps	Due to the mechanism design change, there was a slight risk of a finger trap injury, this could be fixed easily in a second prototype
Materials	
1. The log mover must be hard and durable according to BS EN 1730	I used the Rockwell hardness test on my product, finding that it was resistant to drops and bangs without structural faults arising
2. The product must use waterproof materials and be resistant to all types of corrosion	My product was finished in black paint and Danish oil, paint is waterproof and protects from corrosion, Danish oil is also water-resistant
3. The product should be made from long lasting and sustainable materials	Aluminium and mild steel are very durable materials, they are resistant to corrosion with required finishes and so are long lasting. Plywood is another great material, it is a composite material with great strength and so it long lasting
4. Low maintenance materials should be used	All materials that I used all have a lifespan of well over 10 years
Ages	
1. The product must fit the age range of 18-89 years old	Due to the component of the weight about the centre of gravity the actual strength required to use this product is low, although opinionated believe this product fits the age range
2. The product must have no parts a young child could injure themselves on	Although there are no small parts a child could easily access, if a nut or washer was too fall off this could become a potential hazard
Cost	
1. The product should cost no more than £100	After doing a parts list for my design and adding the cost of all the material up and adding VAT the total cost was £50.35 which is less than £100
Scale of production	
1. Batch production	Use a FMS system I believe my product could be automated, making it suitable for batch production
2. Jigs will be used	Many manufacturing processes I used during product can easily be recreated using jigs (such as the drilling of holes)
Sustainability	
1. The log mover should be made from long lasting and sustainable materials	All the materials I used are durable, with a finish they will last even longer
2. Varnishes/sealers used on the product must be eco-friendly and non-toxic where possible	Whilst I would say my product is eco-friendly I did use paint as a finish. If possible next time if would use a low VOC paint
3. Un-used materials must be recycled if possible	Material I didn't use has been sent back to the workshop so it can be used for other products in the future
4. Machines should be used as little as possible	Although I did use machines, I changed my main joining method from welding to pop riveting and nuts and bolts
5. Similar materials must be used	Throughout the manufacture of my product I used two metals and one wood, therefore I believe this point is met



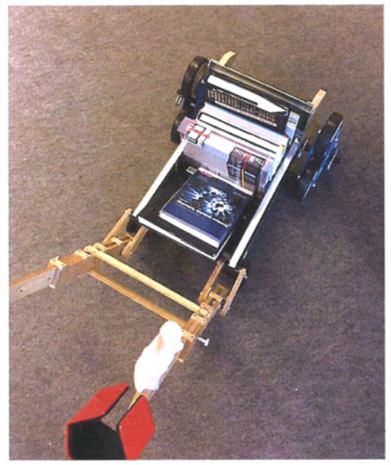
Testing against specification 2

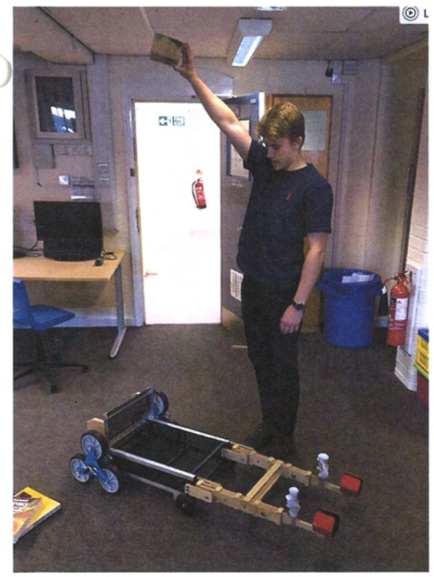


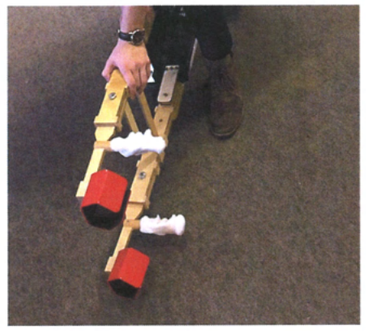
Here I am testing BS 4875-1 and BS EN 1728. In the first mode to product reached test level 3 according to the data tables which suggests to me the product has been made sufficiently strong and is also stable under the force applied. The second mode reached test level 4 in the table due to the four-wheel base making the product more stable and spreading the weight over a larger area. This reduce the component of the force through the centre which allowed the product to carry more mass

The second test for this BSI standard is looking one again at the stability of the product on an inclined slope. Both product reached test level 4 however I would say that once again the second mode of the product looked and felt more stable at this incline. Again, probably due to the wider base. Again, due to test level four being met my manufactured product has passed this specification point as it was only required to meet test level 3. As a result, I can say the product is more stable than I anticipated.

Below I am performing a workshop related vertical static load test. Both modes of the product reached test level 3 for the mesh frame, however the mild steel bars themselves reached test level 4 due to their increased strength. I didn't set a specific requirement for the vertical static load however level 3 for both modes are sufficient to meet my other specification points such as strength and durability.







Although it was hard to simulate a horizontal static load test I tried my best to replicate the conditions. Applying the force horizontally had little effect on my product and the product felt strong. I think guessing a test level would be difficult to predict so I won't pass or fail this specification. However, I would say my product definitely passed test level 1 so it can still meet the BSI standards to be sold in the UK

The final BSI performance test I carried out was BS 3963-6, the impact test. Unfortunately, I could not find a 2kg steel fall so I used a 2kg brick as a substitute to this. I dropped the brick from a height of 2m from the impact area. I found that my product reached test level 5 as the product did not dent from the impact of the brick. Therefore, this specification point has been met.

End user evaluation/ Client evaluation

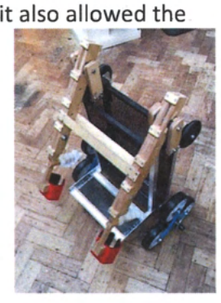
Modifications

I made many changes to my final design to both improve its form and function. Many of these changes had a positive impact on my design, however, a few also had a few drawbacks

The first change I made to my design was that I changed the materials of the product. The top half was meant to be made from aluminium, but due to the nature of the prototype I used plywood. This greatly increased the speed of production allowing me to rapidly produce a prototype. Due to using plywood I did however lose some strength. I also believe an all-aluminium design would be more aesthetically pleasing. However, the benefits of changing to plywood outweigh the negatives

Another critical material addition I made was the mild steel support beams. I added these to provide greater horizontal and vertical strength to my design. By adding these beams my product became a lot stronger, enough to support my body weight. It also provided an anchor point for my adjustable mechanism.

Another change I made was the adjustable mechanism was slightly redesigned in that the mechanism was basically flipped upside down. This was as a result of the raised section being wider than expected. This change actually had a few positives, it allowed the product to fold up into a compact box shape, it also allowed the range of angles for the second mode to be increased.



I also changed the shape of the wrist supports in an attempt to give the user more support. Although these provided great strength it did make it harder for the user to actual get their hand inside the wrist support to grab the handle. This is because many peoples handed are a lot wider than their wrists. If I was to modify this I would look into a wrist support that can be adjusted to fit the persons comfort and sizes.

Another change I made was to use a large mild steel mesh instead of a more open version, this greatly improved the amount of log debris being caught. It also made the product more rigid as it increased horizontal strength. It did however have one key drawback, it was very heavy. Although my product did not exceed the 15kg limit the mesh made it a lot heaver. An alternative solution would have greatly reduced the weight. Evaluating this, I would change the mesh to a lighter metal such as aluminium, this would reduce the mass of the product by over a kilogram, meaning the product would then have a mass of less than 10kg

The final major change I made was that I reversed the direction of the handles and wrist support. After making the handles I experimented with them and surveyed people asking them which they found more comfortable. Almost everyone preferred the reversed version and so I decided to change this part of the design.

I slight adjustment I made to my final product was that I decided to paint the mild steel in black instead of a sealer. This was due to the mild steel being slightly rusted before I could apply the sealer. I feel this improved the aesthetics of the product without hindering its function

Strengths and weaknesses with improvements if necessary

The main strength of my product is that it works as intended. It is able to carry many logs, well over the required amount from specification. The raised mid-section also keeps the logs tightly together so that they can't fall out easily. Although my product carries the required 15 litres I think this could be improved, if I were to make a second prototype I think I would try to increase the volume of the logs up to 30 litres. One way I could do this would be to raise the mesh frame higher up so that it covers more surface area. This of course would add to the weight of the product.

Another great strength of my product is the three-wheel system. This allows the product to easily be carried up vertical inclines such as stairs. Due to the wheels, the mass of the product and logs doesn't need to actually be carried. The component of the weight about the pivot on the three-wheel system is less than the normal reaction, therefore the force needed to lift the logs is less. The three-wheels also allow the product to easily traverse rough terrain. The only disadvantage of this three-wheel system is it makes the product quite hard to turn with heavy weights

Another strength of my product would be its range of adjustability. These features such as the crutch handles or varied handle angle allow the user to fit the product to their needs. This greatly increased the comfort for the user without sacrificing strength to the product. The range of angles that are achievable is over 120 degrees to meet the user's ergonomic requirements. The second mode achieved with this adjustability provides greater stability for people who may struggle to carry the weight of the logs. A four-wheel base also allows less weight to be carried for the user. It also allows more logs to be transported at once although this weight may become too heavy for some people

A weakness of my product would be the way the adjustable mechanism connects the two parts of the product together. Although the mechanism works, I found that it can be quite complex to change the angles. Due to the nature of the mechanism it has many nuts and bolts that held it in place. These could be quite hard to adjust at times and so I would say this part of my product needs improving

If I were to improve this part of my product I would consider using metal for the flaps. That way they could be welded on which would not only increase the strength of the joint but would mean the product would not need as many nuts and bolts. The

adjustable mechanism itself would still be the same but it would now be stronger than before. The locking washers themselves are made from plastic and metal for my product. If I were to redesign them I would die cast them. This way they would be stronger and the mechanism would work better. I think I would also reduce the number of teeth for the lock washer and make the teeth deeper. This way the adjustable mechanism would have less discrete angles but would have greater strength at these angles. The overall range of adjustability would not be effected and would still be over 120 degrees.

Another slight weakness of my product would be its upper rigidness. Although the product is incredibly stable from following over I think the upper handles could be more secure. One way this could be improved would be to make the adjustable mechanism stronger, which I discussed above. Another way I could improve this strength would be to add a support beam between the wrist supports. Not only would this increase the rigidness, it could also provide more place the user can hold the product. This would be especially helpful for someone who does not need the wrist supports. It would also allow the trolley to be attached onto the back of a lawnmower or quadbike allowing for even more logs to be carried.

Another change I would make would be to the aesthetic appeal to my product. One such example of this would be to change the handles of my design. Although they are very ergonomic I think I could improve their aesthetic appeal. By giving them a more rounded edge finish and giving them a streamline look I think they would look better. I would also cover them in a rubber polymer layer. By doing this it would also improve the ergonomics of the product

One final change I would make would be to slightly adjust how the three-wheel system works. If I were to remake my product I would design an axel system that allows the product to turn at least 45 degrees on the axels. This would allow for a pivot turn. This would make it easier for the user to turn when carrying the weight of the logs without sacrificing stability.

Client evaluation

After showing my client my final product and allowing her to use it for some time and get a feel for the product she evaluated it and said the following.

"Firstly, I would like to say the product is fantastic and has made moving logs a lot easier for me, of course there is a few areas for improvement but the overall product is good."

"One feature of the product I have found helpful are the stair climber wheels, they allow me to go up my stair easily without much effort. However, when I was half way up my stairs and had to turn 90 degrees I did struggle a little bit. I had to do lots of little turns to make one big turn. If it was possible I think you should make it easier to turn the trolley on the spot without having to move it"

"Another success of your product is how stable the logs are, when I moved the trolley the logs felt securely fitted in-between the raised section, unlike my previous solution where they would often fall out when moving the trolley over the gravel. Along with this the wire mesh holds the logs and stops them falling out the back like my previous solution. The wire mesh is also very good at catching the log debris. I really like this aspect of the design."

"A slight flaw to this product is the wrist support. I was able to use them fairly well however they were quite uncomfortable at times. When my husband used the trolley he simply could not get his hands through the wrist supports as they weren't wide enough. I think next time the wrist supports need to be larger."

"My last slight complaint is with the adjustable mechanism. Although it has some great aspects I would like to see a quick release system implemented. This would allow me to easily change the mechanism without much struggle."

"That said overall I think the product is fantastic and I look forward to using it."

Signed: Wendy

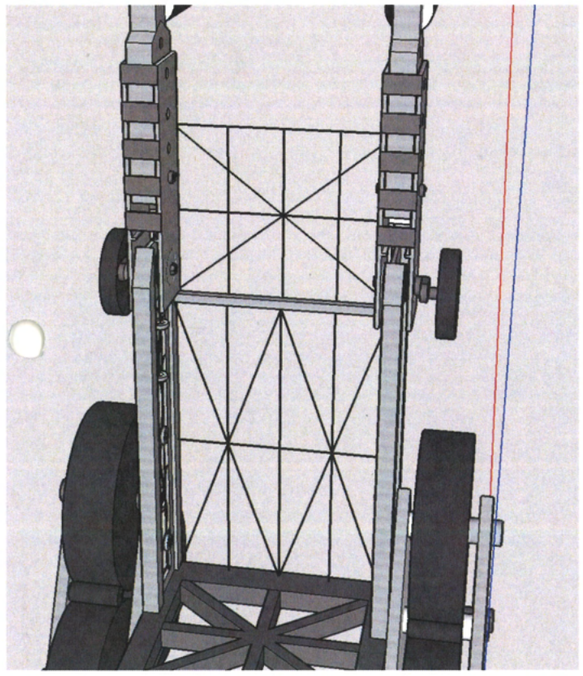
Response to client evaluation

In response to my client's evaluation I think her points are justified. Whilst I have addressed most of these points already there are a few new points I wish to discuss.

I think my client was right in saying that the adjustable can be quite difficult to use. Whilst my initial design had a quick release mechanism I was not able to implement it during manufacture due to the complexity of the design.

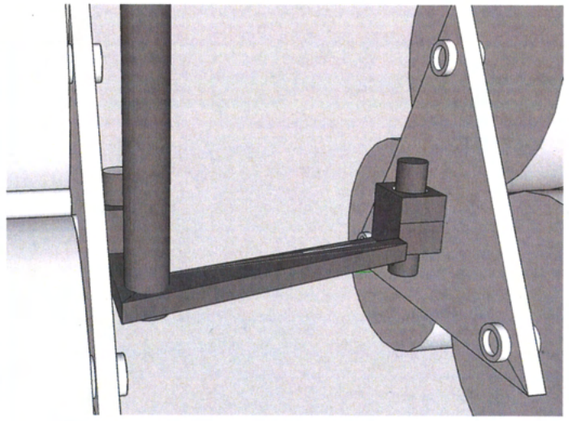
If I was to look at making a second prototype I would look to develop a quick release mechanism. This way it could be easily manufactured and would benefit the user greatly. Apart from this fault I believe the client had no other major issues that I hadn't addressed.

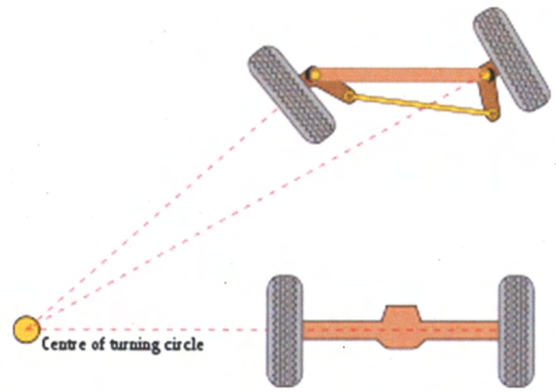
Improvements based on client feedback/evaluation



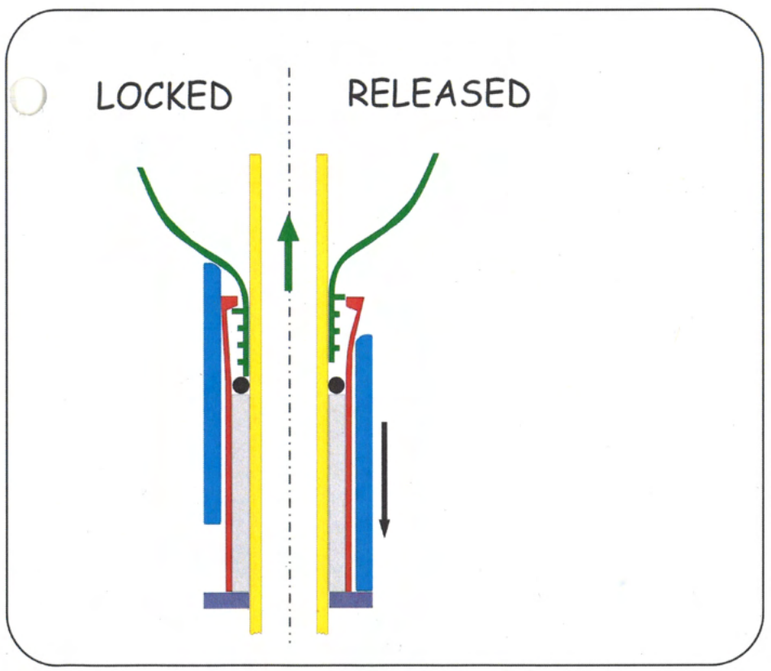
One point I received from the evaluation of my product was that I could increase further the capacity of logs that could be carried. The way in which I could achieve this would be to add another mesh frame further up the product. As seen by the diagram. My prediction is that this design would increase the capacity of the logs that can be carried by 50%. This added mesh frame would also mean that when the product is in its second mode the logs would be able to be stacked higher, further increasing the volume of the logs.

If I were to make this mesh frame for a second prototype I think I would make it an attachment that can be taking of depending on how many logs you want2 to carry and what weight you can carry.





Another improvement I think I could make to my prototype would be it ability to turn on the spot. I looked at a few possibilities to do this and decided that running an axel rod below the base frame would be the best idea. The axel would be off centred so the turning rod could be replaced as a handle for one side of the product. This would allow the product to turn a lot easier under the weight of the logs. This mechanism would not interfere with the three-wheel system and so they could combine each feature to improve the product.



Whilst searching for solutions to my quick release mechanism problem I found one that could be applied to my crutch mechanism. Pulling the two green sliders apart allows the outside part (red) to slide up and down. This mechanism would be perfect for quickly changing the heights of the adjustable crutch mechanism.

I believe this mechanism could also be applied to the angle adjuster on the product with some redevelopment built still using the same concept, pulling to spring loaded handles apart.

The last change I would make to my product would be to slightly change the wrist support. I would either chose an alternative more flexible material to allow bend in the wrist support to fit the user or I would use attachable sliders to the inverted wrist support apart allowing it to open up and fully close around the user's wrist.

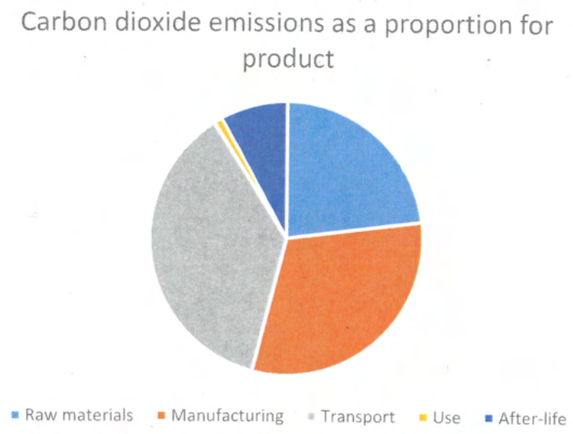
Life cycle analysis

Raw materials

Birch plywood- Plywood is obviously a wood material and therefore is not a finite resource. However, birch plywood takes a long time to grow and therefore can be energy intensive. As well as this using birch plywood for manufacture is likely to contribute to deforestation which has many environmental impacts such as increased level of CO_2

Aluminium- Aluminium originates as bauxite ore. This ore is difficult to extract and is energy intensive to do so. However, Aluminium can be recycled multiple times without much effect to its properties. Therefore, these two aspects almost cancel each other out.

Mild steel- Mild steel is a mix of iron and carbon. Iron come from iron ore and is extracted using a blast furnace. This process is energy intensive. It is then mixed with a specific amount of carbon to make it into mild steel. Steel can be recycled over and over again without losing any of its properties and therefore makes it a good raw material to use over and over



Plastics/Polymers-
Plastics/Polymers originate from crude oil. Oil is a finite resource and so we will eventually run out of it. Crude oil is an energy intensive material to extract and can also cause many environmental issues like oil spills therefore it must be used sparingly

Manufacturing

During manufacture, I limited my use of electronic machinery where I could. The use of pop riveting and using nuts and bolts would have reduced my energy usage dramatically. However, I obviously did use some machines, such as the pillar drill and metal band saw. When I did use machines, I made sure it was absolutely necessary to use them. This way my energy consumption during the manufacture period should be relatively low.

Transport

If my product where to be batch produced I would have to consider how I would distribute my product to the wider community. Firstly, I would use bulk transport to reduce the number of journeys needed to distribute my product. I would also, where possible use "greener" transport methods. This could include the use of electric vehicles or bio-diesel vehicles. If I were to distribute international I would use the UK's freight train infrastructure to reach Europe and Asia, whereas I would use cargo ships to reach the Americas.

Use

The use of my final product has very little if no impact on the environment. It has no parts that require a fuel source. The only area I can think where my product may contribute to emissions is if a part needs to be replaced such as the wheels.

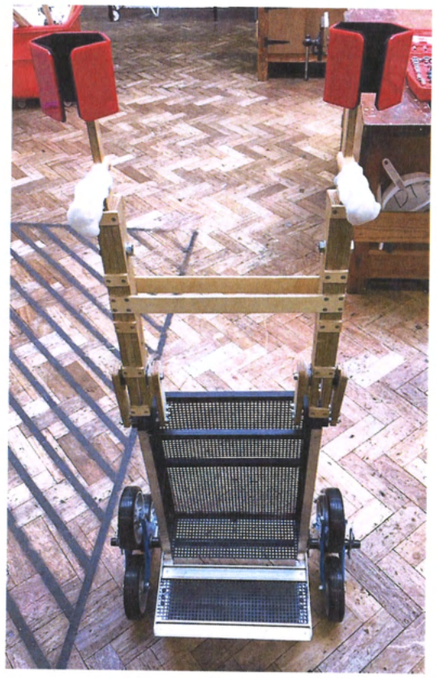
After life

Most of my product is joined using temporary methods. Therefore, it can be disassembled easily making recycling easier and less energy intensive. This way the emissions from end of life are low. All the materials I used can be recycled at the end of life, therefore this aspect of the product has low carbon emissions.

Social, moral and ethical

Social, moral and ethical impacts

Social- The social impacts of this product are minimal, but there are a few. By designing my product for the elderly and a wide range of ages the design has become more inclusive. Whilst designing and manufacturing I always looked at how I could include as many people as possible. Whether this was through the range of adjustable heights or by making the product easier to use for people who struggle.



Moral- Throughout the design and manufacturing process I always tried to do the morally right thing. This was mainly done by using sustainable methods and reputable suppliers for materials. By doing this you can be assured the employees have been paid a fair wage and have been treated fairly. I also attempted to produce a project that was as inclusive as possible to all kinds of people. One slight moral issue with my product would be the use of my paint finish which contains VOCs. These can affect the environment in a negative way. In the future, I should use a paint that does not have VOC as they are now readily available. Another positive of my product is that it can easily be recycled, that way the user can feel better about themselves and that they are doing their bit for the environment. Another moral issue with my product is whether it is safe to use. Due to its stability and safe carrying of logs I would say it is. However, it is not suitable for ages under 18 due to the possibility of catching your finger in the mechanism.

Ethical- Throughout manufacturing and designing I always considered how the product might be interpreted by different ethnicities. I tried to use neutral materials and colours in the hopes to not offend anyone. By doing this I believe I have achieved a neutral product. I was careful to avoid bright colours such as red which can represent both luck and death depending on what country you are in. I would say my product is culturally neutral meaning it shouldn't offend any cultures or people in different countries.