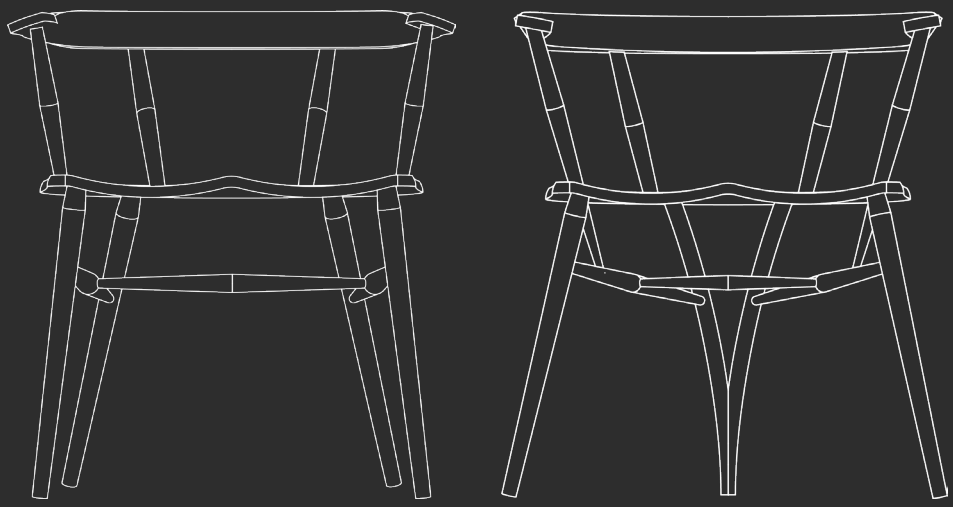
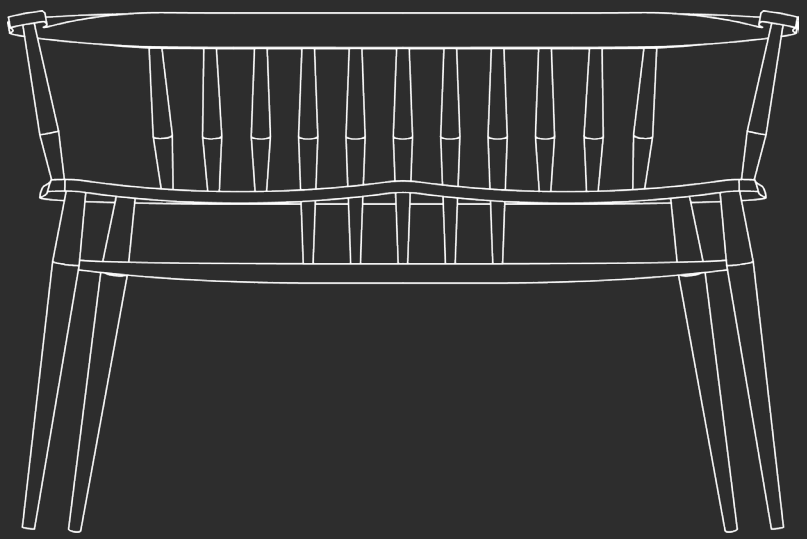
Alexander Robert Key
AD318 Practical PDF
BA(Hons) 3D Design and Craft
University of Brighton 2020





Alex Key (Me) in the Crest chair
Photography: Alex Key

Project outline:

This project seeks to push Ash to its limits as a material, by exploring hand and digital methods of making within furniture design.

I will be researching practical processes such as steam bending and glue laminating in the workshop, alongside CNC 3-axis milling as well as digital model making using programs such as Rhino. These are new areas of my skill set I will be developing for this project, which will see the outcome of furniture that will showcase a harmony between these techniques and methods of making.

Contents:

- 3.3 Legs & Spindles
    - Turning
    - Wedge slot cutting
    - Waste triming
    - Drilling holes

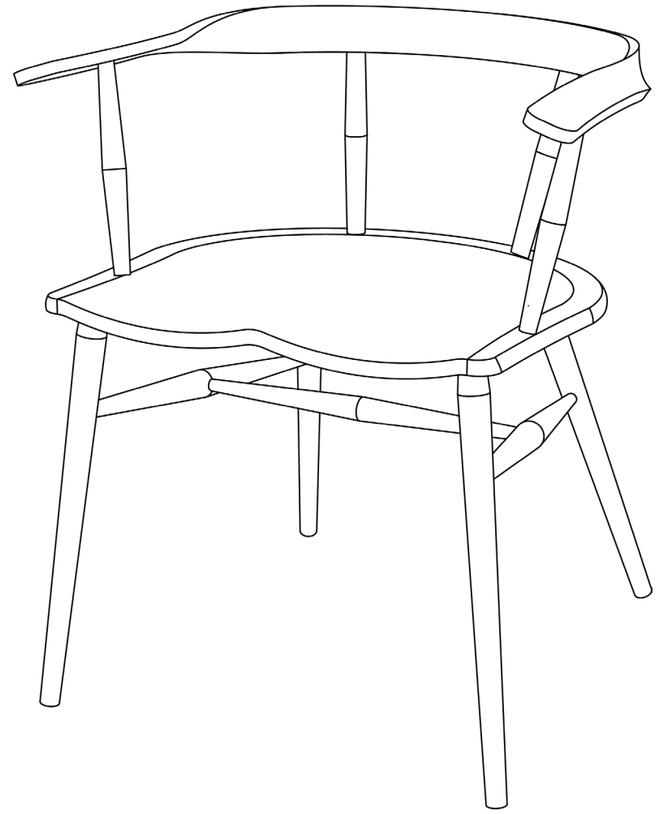
- 3.4 Assembly
    - Dry assembly
    - Shaping the arms
    - Attaching the back
    - Attaching the side spindles
    - Glue up
    - Sanding & finishing

Final Photos:

- 4.1 Crest chair - Final photos
- 4.2 Alternate finishes
- 4.3 Proposed contexts

Further designs

- 5.1 Crescent chair
    - Proposed design
    - Alternate designs
- 5.2 Crescendo bench
    - Proposed design
    - Alterntate designs



Chapter 1 - Technical

Material Tests:

- 1.1 Initial steam bending
- 1.2 Steam bending cube
- 1.3 Free-hand steam bending

- 2.1 Initial glue laminations
- 2.2 Glue lamination JIGs
- 2.3 Further glue laminations

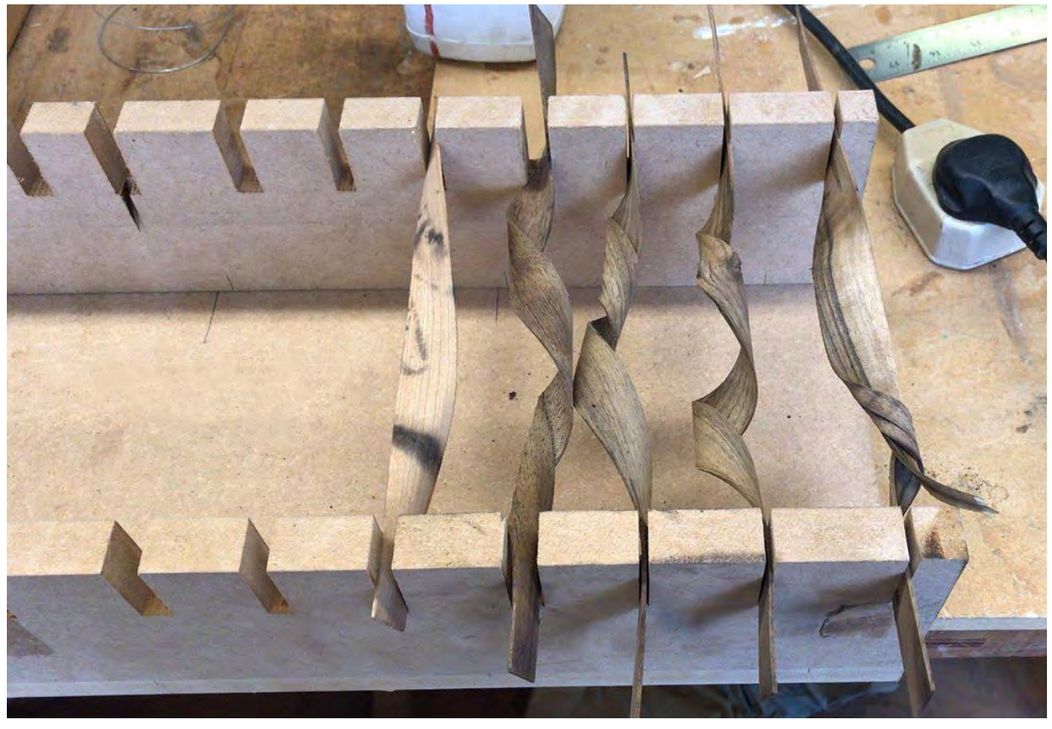
Design Development:

- 1.1 Initial models
- 1.2 Developed models
- 1.3 Developed drawings & CAD
- 1.4 Half scale drawings
- 1.5 Half scale model - Making
- 1.6 Half scale model - Outcome

Material Tests: 1.1 Initial steam bending tests

In my initial workshop experiments I wanted to explore the process of steam bending. This was in aid of understanding the limits of the process and the effects it had on different species of wood. I tried several species such as walnut, ash and oak at various thicknesses getting a variety of results. I found that the thinner the wood strip the more times I could twist it in the JIG, this was especially apparent with the walnut slices which I used.

Overall while the experiment was limited in scope I found the results were an interesting jumping off point for this project. The idea of being able to manipulate wood into flowing shapes, contrasting its original rigidity is something I would like to explore and push further throughout this project.

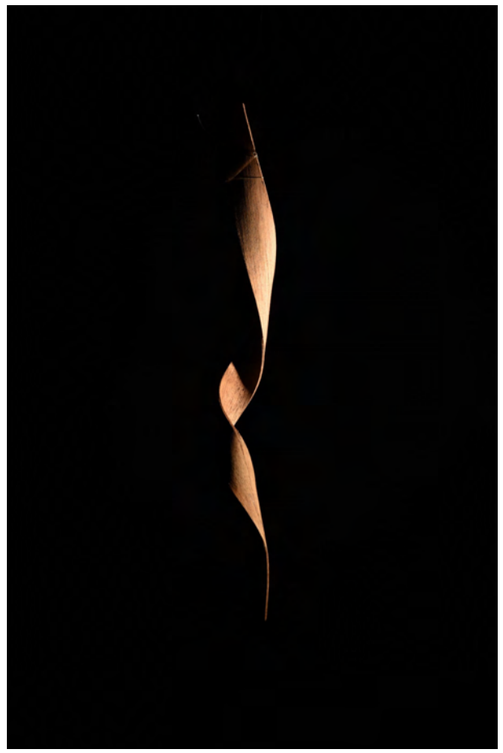


Initial steam bending tests in the workshop
Photography: Alex Key
Date: Oct '19

Tripple Walnut twist
Photography: Alex Key
Date: Nov '19

A series of Walnut twists
Photography: Alex Key
Date: Nov '19

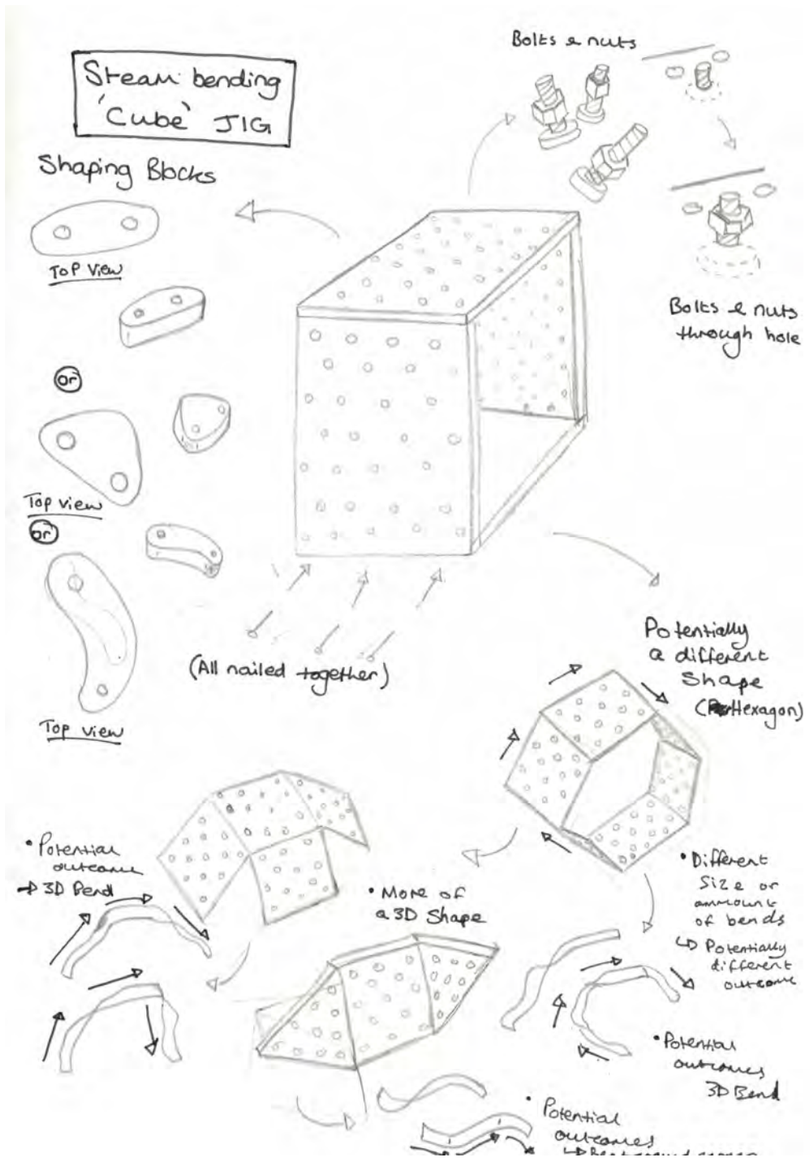
Tripple Walnut twist
Photography: Alex Key
Date: Nov '19



Double Walnut twist
Photography: Alex Key
Date: Nov '19

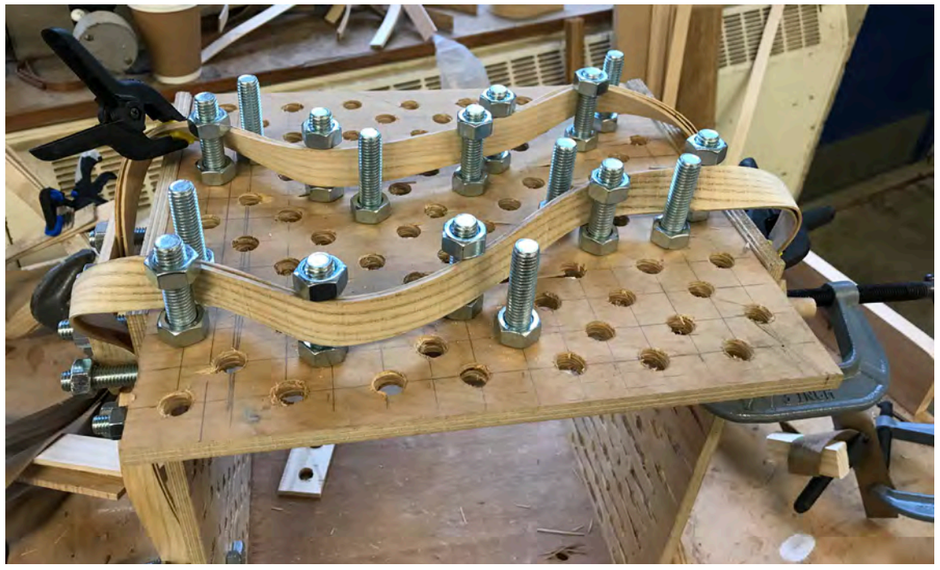
Material Tests: 1.2 Steam bending cube

I continued to experiment with steam bending in the workshop by exploring how I could use it to manipulate wood in multiple directions. This resulted in the 'Cube' which manipulated wood to bend on 3 sides. This rough JIG created some interesting shapes in Ash and Oak. While the results were a little too fluid to be used in furniture this did open me up to developing more complex JIGs to further push the process of steam bending.

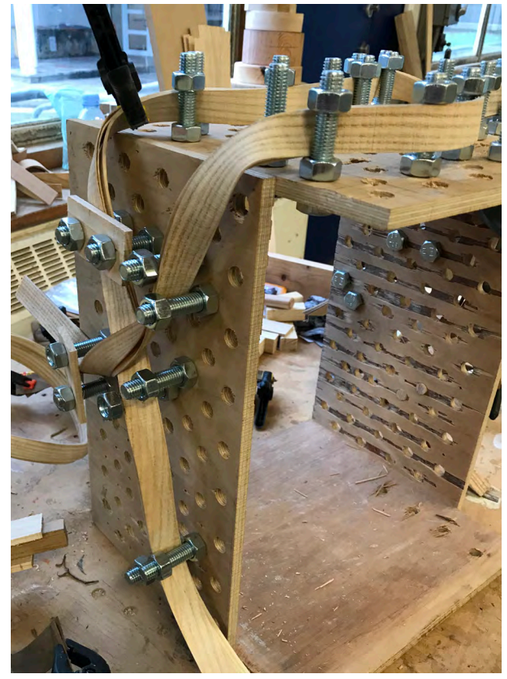


Steam bending 'Cube' JIG sketch
Source: Alex Key
Date: Nov '19

The ‘Cube’ steam bending JIG
Photography: Alex Key
Date: Nov ‘19



Ash in the ‘Cube’ JIG
Photography: Alex Key
Date: Nov ‘19



Ash in the ‘Cube’ JIG
Photography: Alex Key
Date: Nov ‘19

Oak outcomes
Photography: Alex Key
Date: Nov ‘19

Material Tests: 1.3 Free-hand steam bending

Once I had experimented with Ash and Oak using the 'Cube' JIG, I decided to go back to exploring free hand steam bending. This was to research a more free-form aesthetic by using fewer rigid techniques and formers. In these experiments I also explored how multiple strips could interact with one another, weaving in and out as well as twisting to interact with eachother. This resulted in me generating a series of results which varied in effectiveness and execution of my initial intentions.

I found the pieces that work best were the ones that had all the strips closer together, this was because they had less negative space between them resulting in them being far more visually pleasing. These series of tests taught me about how letting the material dictate the outcome could result in a different style of work. This is a method I was initially hesitant of as it isn't usually how I work, but it taught me that there is some validity to exploring ideas out of your comfort zone as it can lead to interesting results.

Free-hand walnut steam bending in the workshop
Photography: Alex Key
Date: Nov '19

Free-hand walnut steam bending
Photography: Alex Key
Date: Nov '19

Free-hand walnut steam bending
Photography: Alex Key
Date: Nov '19

Free-hand walnut steam bending
Photography: Alex Key
Date: Nov '19

Free-hand Ash steam bending
Photography: Alex Key
Date: Nov ‘19

Free-hand Ash steam bending
Photography: Alex Key
Date: Nov ‘19

Free-hand walnut steam bending 1
Photography: Alex Key
Date: Dec ‘19

A Series of free-hand walnut steam bending
Photography: Alex Key
Date: Dec ‘19

Free-hand walnut steam bending 2
Photography: Alex Key
Date: Dec '19

Free-hand walnut steam bending 3
Photography: Alex Key
Date: Dec '19

Free-hand walnut steam bending - Close up
Photography: Alex Key
Date: Dec '19

Material Tests: 2.1 Glue laminations

The next technique I decided to explore was glue lamination, this was because I wanted to research how to add strength to the ebbing and flowing shapes I was creating. I explored this process through practical research, which started to develop my understanding of what was and wasn't possible.

These experiments were very rough and un-refined, leading to a very quick development time from idea to execution. I started by making a rough shaped back out of Ash strips using a block curved JIG. In contrast to this I also made a large laminated free-hand and clamped curve which was then shaped using a spokeshave.

These large-scale experiments helped me explore a new technique and shapes, which also lead to developing my skills with hand tools such as the spokeshave. This was by using the tool to clean up the edges and shape the piece to a more refined curve.

2nd Glue lamination - Chair back
Photography: Alex Key
Date: Dec '19

Large glue lamination test - Glue up
Photography: Alex Key
Date: Dec '19

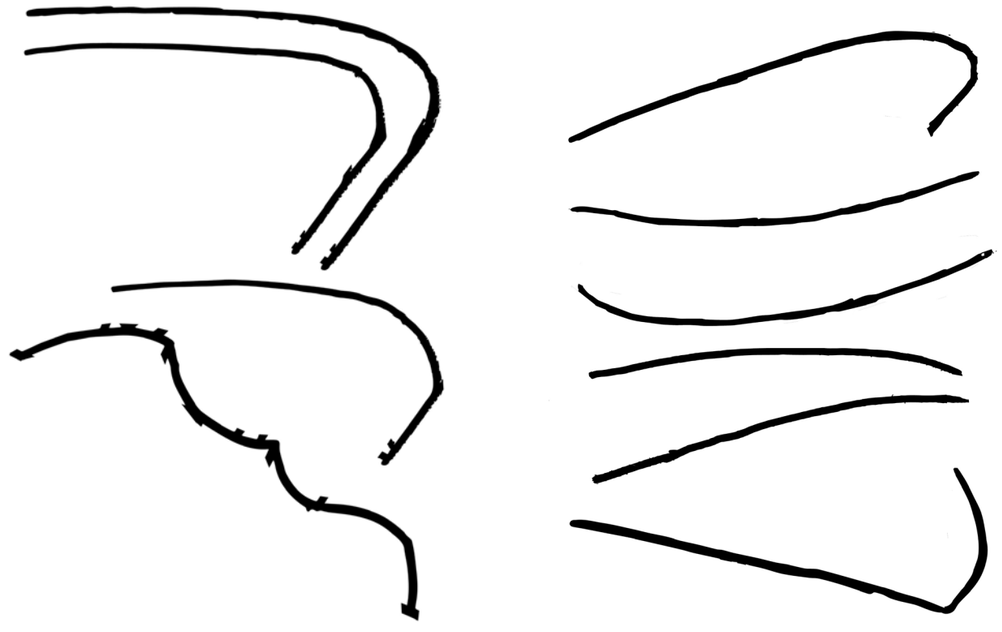
Large glue lamination - shaping
Photography: Alex Key
Date: Dec '19

Initial glue laminated back piece
Photography: Alex Key
Date: Dec '19

Material Tests: 2.2 Glue lamination - JIGs

I decided to continue my exploration into glue lamination further by implementing the JIG aspect which I had explored earlier with steam bending. I decided to develop the shapes for the JIGs from the photos I had taken on my primary research trip to London (See p67-72). These were shapes which I had highlighted from the photos (See p73-76) and used to create A and B halves in MDF to glue laminate with using compression clamps.

Utalising compression was an element I had wanted to explore from the start of this project, outlined in my RFD. Using these glue lamination JIGs allowed me to add strength to my designs with the cleaner more flowing and curved shapes that I desired in a variety of wood species.



Series of shapes extracted and outlined from primary photos taken in London (See p67-72)
Photography: Alex Key
Date: Dec '19

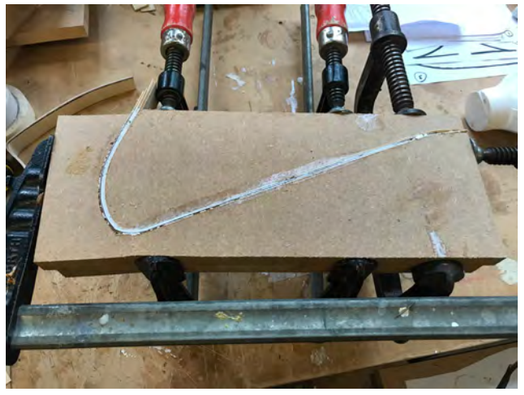
More shapes extracted and outlined from primary photos taken in London (See p67-72)
Photography: Alex Key
Date: Dec '19

2-part compression JIG C
Photography: Alex Key
Date: Dec '19

2-part compression JIG C - Walnut strips
Photography: Alex Key
Date: Dec '19

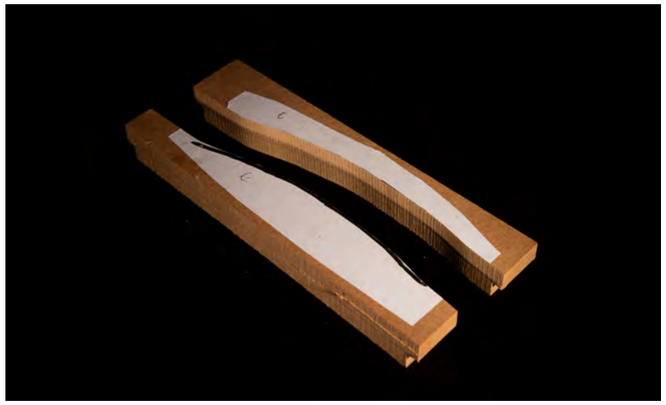
2-part compression JIG D - Mahogany strips
Photography: Alex Key
Date: Dec '19

2-part compression JIG B - Oak strips
Photography: Alex Key
Date: Dec '19



2-part compression JIG D - Oak strips
Photography: Alex Key
Date: Dec '19

2-part compression JIG E - Ash strips
Photography: Alex Key
Date: Dec '19

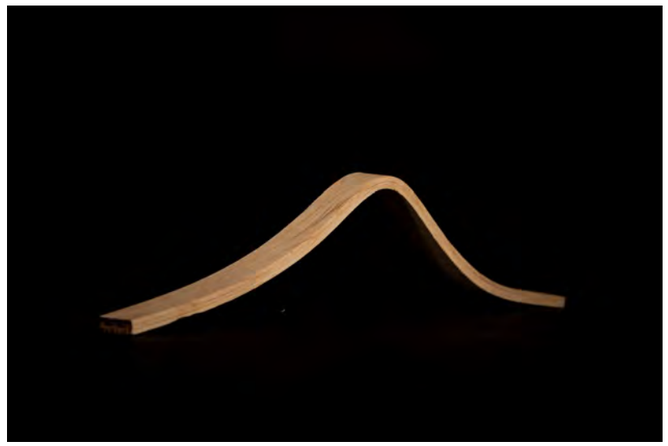


2-part compression JIG A
Photography: Alex Key
Date: Dec '19

2-part compression JIG B
Photography: Alex Key
Date: Dec '19

2-part compression JIG
Photography: Alex Key
Date: Dec '19

2-part compression JIG B outcome - (Oak)
Photography: Alex Key
Date: Dec '19



2-part compression JIG F outcome - (Ash)
Photography: Alex Key
Date: Dec '19

2-part compression JIG C outcome - (Walnut)
Photography: Alex Key
Date: Dec '19

Variety of 2-part compression JIG outcomes - (Oak, Walnut, Ash, Mahogany)
Photography: Alex Key
Date: Dec '19

Material Tests: 2.3 Further glue laminations

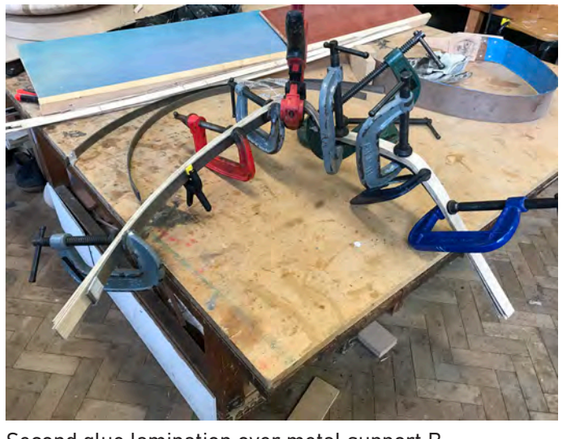
Once I had refined glue laminating on a small-scale I decided to push it further on a larger scale. This was by using mild steel supports which were free form heat bent into rough chair back like shapes. Ash strips were then clamped to it and glued together. Initially I struggled to get the ash wood to follow the tight bends of the mild steel, so I decided to combine this test with steam bending.

This was the right move, as it not only brought together the two processes I had been working with, but it also allowed me to get tighter bends with the Ash. Combining these processes benefited me in pushing the material further, which is what I wanted, as well as allowing me to be more ambitious with my designs. Combining glue lamination and steam bending makes my pieces structurally stronger but also allows me to achieve flowing shapes and opens a new variety of curves to explore.

Glue lamination over metal support A
Photography: Alex Key
Date: Dec '19

Glue lamination over metal suppot B
Photography: Alex Key
Date: Dec '19

Glue lamination over metal support C
Photography: Alex Key
Date: Dec '19



Second glue lamination over metal support B
Photography: Alex Key
Date: Dec '19

Glue lamination over metal support A
Photography: Alex Key
Date: Dec '19

Glue lamination outcome from metal support A
Photography: Alex Key
Date: Dec '19

Design Development: 1.1 Initial models

The next phase in this project was design development, this is where I implemented knowledge from my material tests into my initial designs. I decided to experiment with a variety of materials to try and mimic the fluid shapes I was attempting in wood. Using wire, cardboard and lamination tests I created a variety of models which seeked to explore aspects such as a single body design, large single piece design as well as a two person bench.

While I had fun making these pieces, I do not think I will be taking any forward in their current iterations. I will however be taking aspects forward such as the one-piece back to arm rest feature of model 1 & 2. As well as the idea of a bench which will be explored later on in this project.

Initial chair model 1 - Wire
Photography: Alex Key
Date: Dec '19

Initial chair model 2 - Cardboard
Photography: Alex Key
Date: Dec '19

Initial bench model 1 - Glue lamination tests
Photography: Alex Key
Date: Dec '19

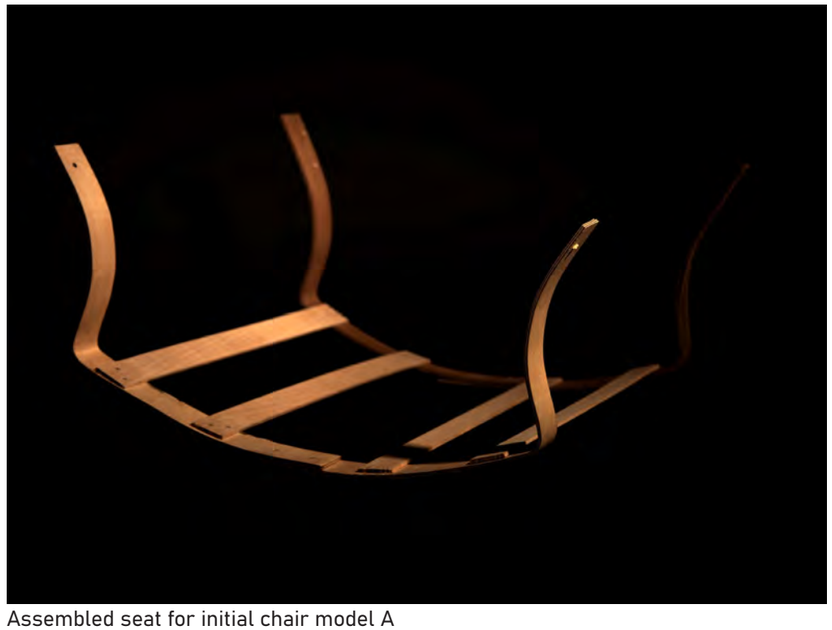
Design Development: 1.2 Developed model

The next step in my design development was to explore a larger scale of models. This was achieved by utilising the glue lamination outcomes of my two part JIGs from earlier. I started by playing around with them by changing the orientation as well as joining some of them together to create larger pieces. I then continued to develop these by combining them together with other pieces to create larger structures, resulting in an initial seat framework. I then created a rough version of the shape I wanted to achieve for the back using glue lamination, then shaped it with the spokeshave. These were then attached and placed atop some turned legs.

This model was a good visual representation of what I wanted to achieve in this project. However, the proportions were all over the place resulting in it looking clunky. This model taught me a lot about the structure and sizes of chair design so it will look a lot better with some tweaks and refinement.

Glue laminations prototyping for initial chair design
Photography: Alex Key
Date: Dec '19

Spacing test for initial chair model seat
Photography: Alex Key
Date: Dec '19



Assembled seat for initial chair model A
Photography: Alex Key
Date: Dec '19

Assembled seat for initial chair model B
Photography: Alex Key
Date: Dec ‘19

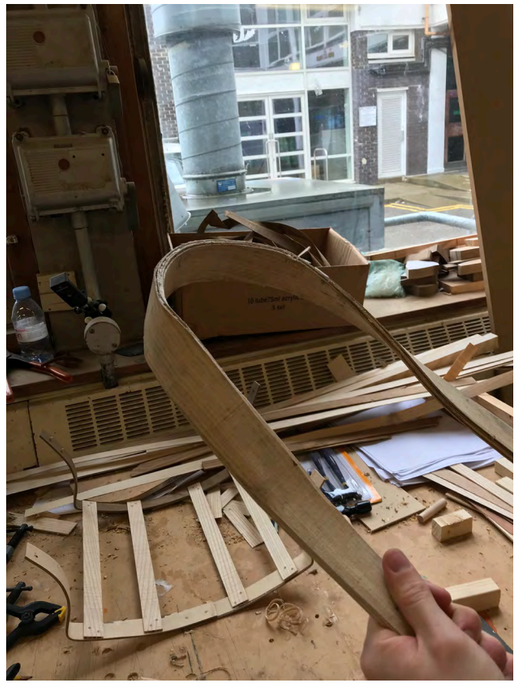
Assembled seat for initial chair model C
Photography: Alex Key
Date: Dec ‘19

First glue lamination back test - Clamp up A
Photography: Alex Key
Date: Dec ‘19

First glue lamination back test - Clamp up B
Photography: Alex Key
Date: Dec ‘19

Test back - Outcome A
Photography: Alex Key
Date: Dec ‘19

Test back - Outcome B
Photography: Alex Key
Date: Dec '19



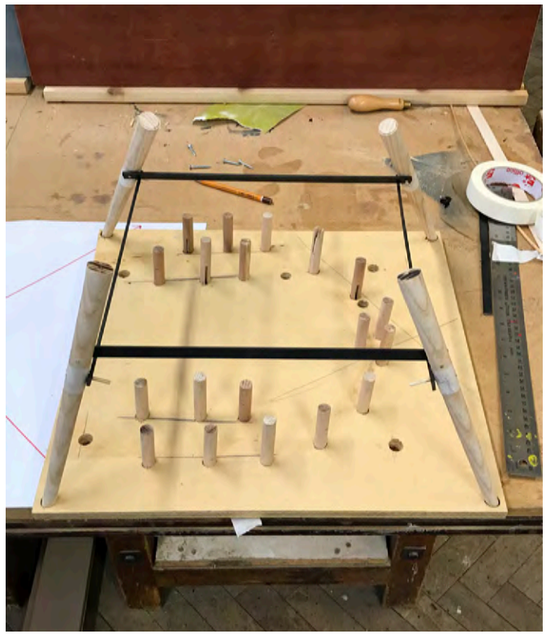
Test back - Outcome C
Photography: Alex Key
Date: Dec '19

Test back - Outcome D
Photography: Alex Key
Date: Dec '19

Test back attached to seat frame
Photography: Alex Key
Date: Dec '19

Fully assembly seat frame
Photography: Alex Key
Date: Dec '19

Close up of test back joint to seat frame
Photography: Alex Key
Date: Dec '19



Leg spacing and frame assembly
Photography: Alex Key
Date: Dec ‘19

Legs attached to seat frame A
Photography: Alex Key
Date: Dec ‘19

Legs attached to seat frame B
Photography: Alex Key
Date: Dec ‘19

Seat to legs attachment
Photography: Alex Key
Date: Dec ‘19

Underframe joined to legs
Photography: Alex Key
Date: Dec ‘19

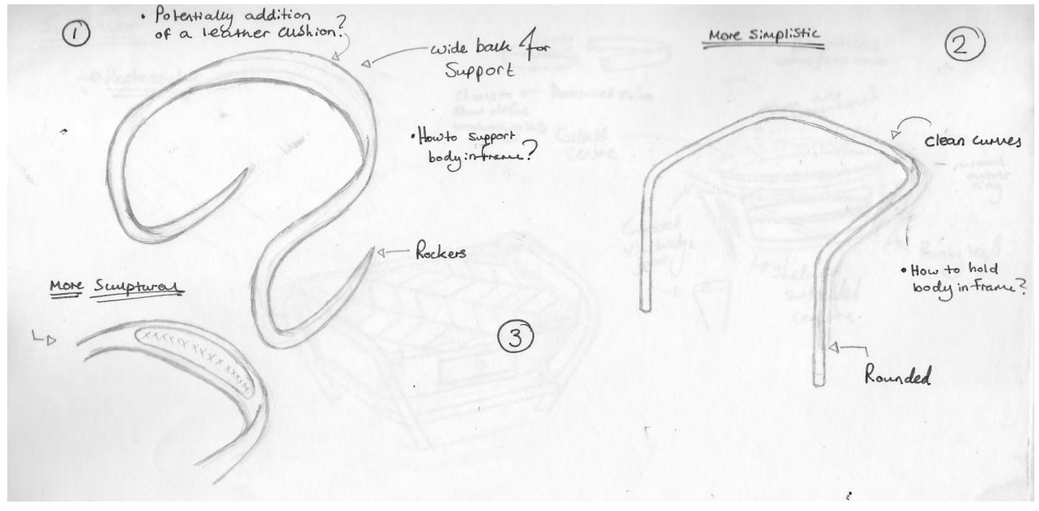
Fully assembled initial model A
Photography: Alex Key
Date: Dec '19

Fully assembled initial model B
Photography: Alex Key
Date: Dec '19

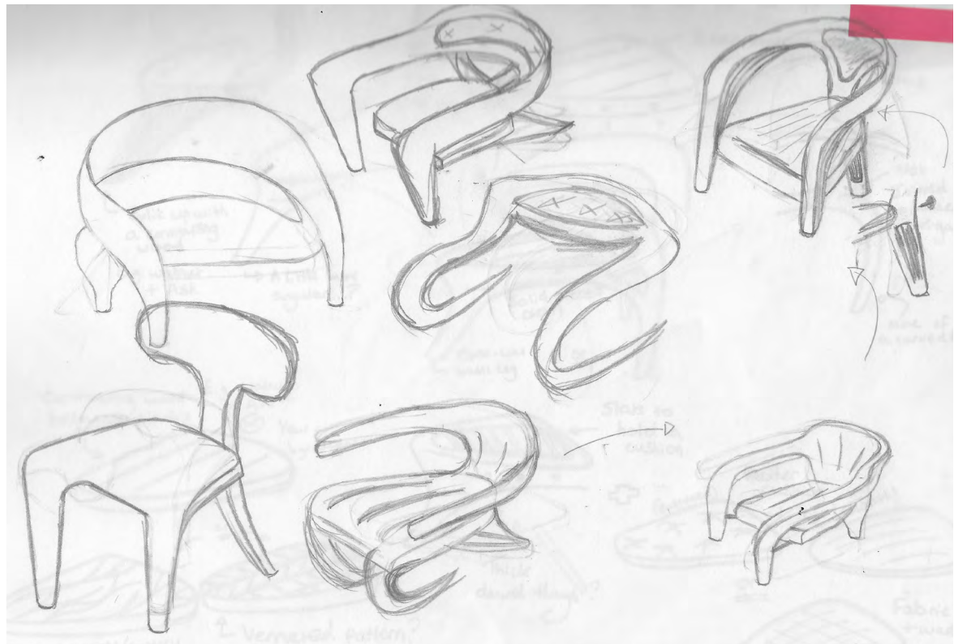
Design Development: 1.3 Drawings & CAD

Alongside model making I was also exploring ideas through sketching and CAD, this was with the intention of creating shapes quickly and in more depth. My sketches were very rough and quick but resulted in some interesting ideas and use of shapes. I explored a variety of different combinations of shapes as well as styles of chair, from dining to loungers. I also explored a few asymmetric designs which had one arm rest, as well as how the body of the chairs could be one piece. This would be achieved by bending the wood in multiple directions and is directly inspired by my research into other designer-artists such as Marc Fish (See p89).

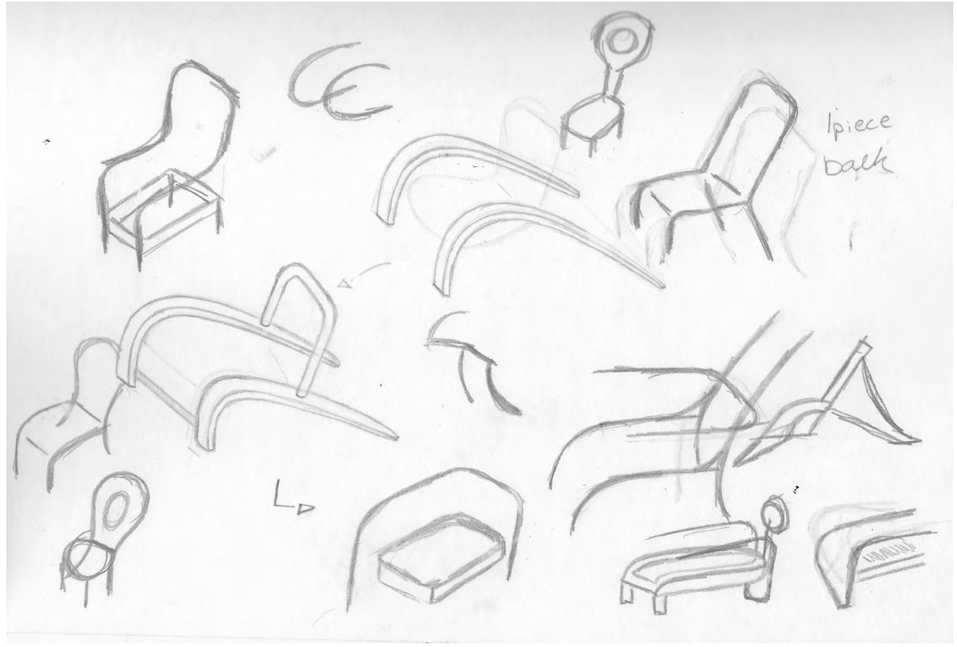
My initial ventures into Rhino modeling resulted in some clunky CAD designs, which needed to be improved via learning about the program more as well as experimenting with the tools. At this point I was still exploring shapes and ideas as well as refining my direction by implementing the knowledge that I had learnt in the workshop previously. Overall I liked the direction but felt I needed to find a clearer visual identity for this project.



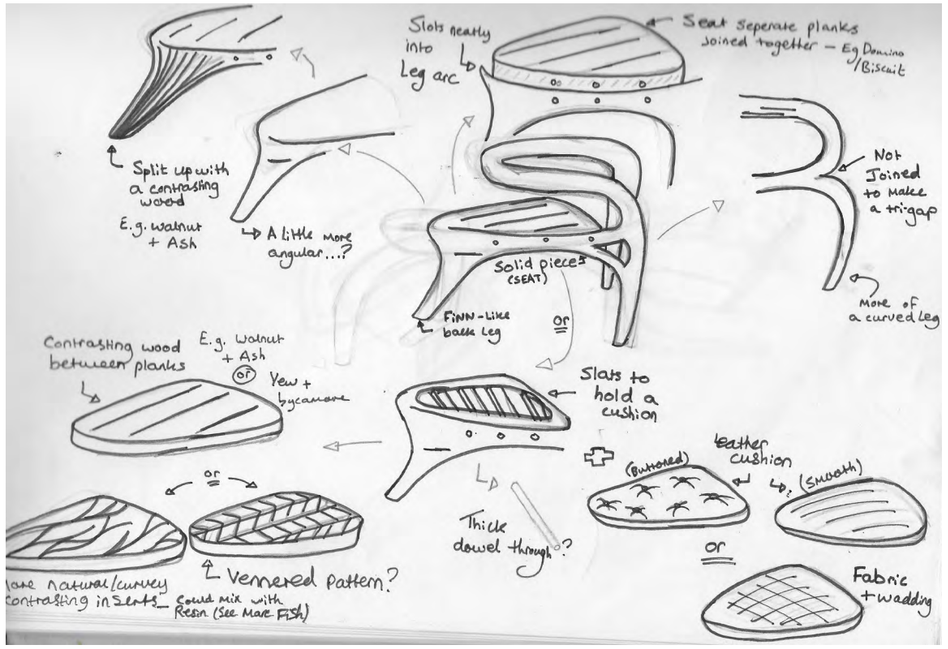
Initial chair sketches 1
Photography: Alex Key
Date: Dec '19



Initial chair sketches 2
Photography: Alex Key
Date: Dec '19



Initial chair sketches 3
Photography: Alex Key
Date: Dec '19



Initial chair sketch 4
Photography: Alex Key
Date: Dec '19

Initial chair CAD A
Photography: Alex Key
Date: Dec '19

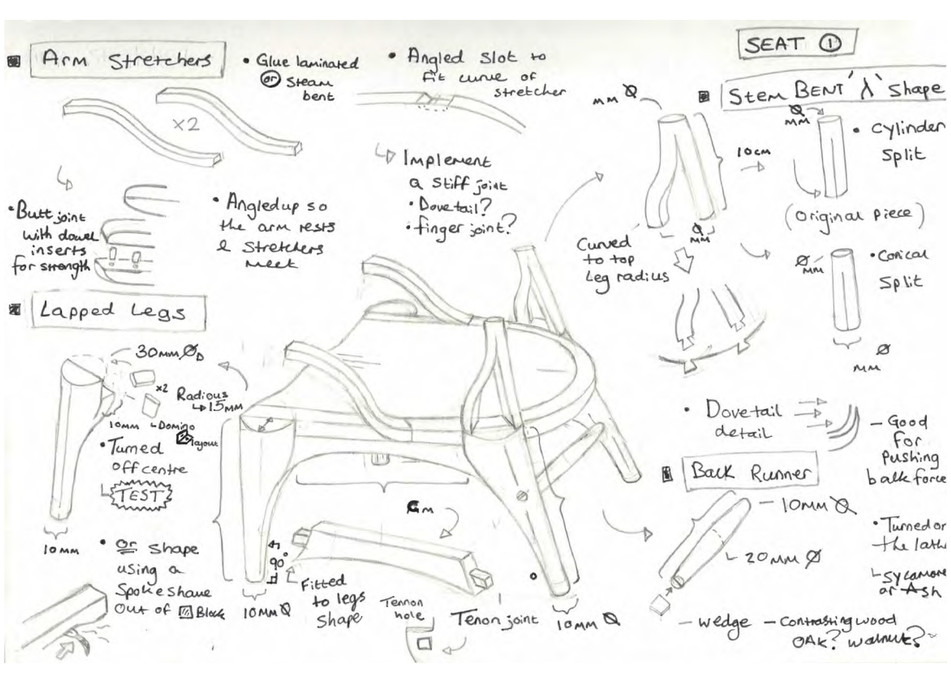
Initial chair CAD B
Photography: Alex Key
Date: Dec '19

Design Development: 1.4 Half-scale drawings

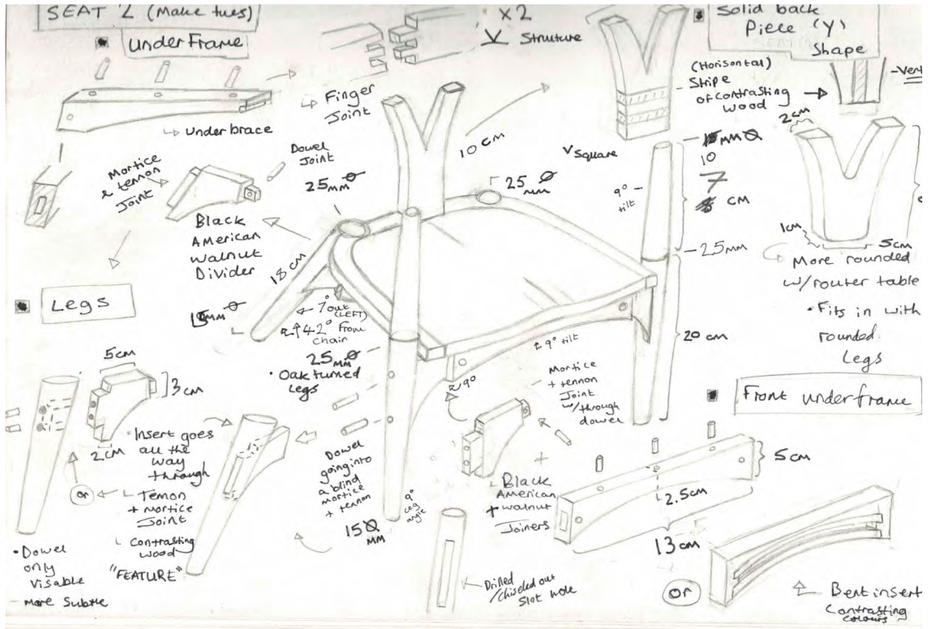
Once I had finished developing my initial models and sketches, I started to refine my design. These refinements came in the form of working at half scale, the initial measurements of which were taken from a full-scale chair (See p91-94).

This was a valuable stage in the development of ideas for me, as I was developing designs based on my workshop findings as well as inital ideas. At this stage I was continuing to explore different styles of chairs from dining to lounge, inspired by my reading into Danish chairs[1]. I was also considering how I could implement other processes into the making of these pieces such as the 3-axis milling machine for the seats or routing and lathe turning for the legs. This was a very interesting area of exploration as it meant that I was dicovering different methods of making leading to different stylistic outcomes of pieces, from design to function.

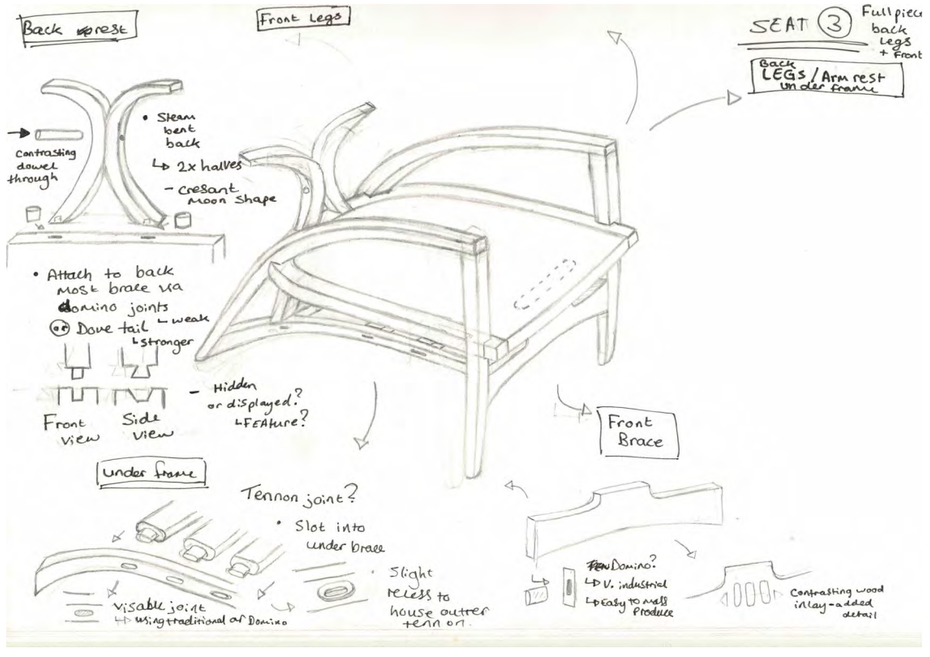
1 Oda, N., 1999. Danish Chairs. San Francisco, Calif.: Chronicle Books.



Half-scale chair design 1
Photography: Alex Key
Date: Jan '20



Half-scale chair design 2
Photography: Alex Key
Date: Jan '20

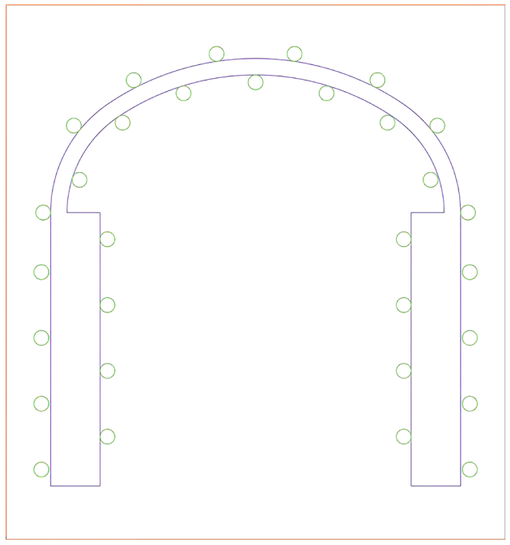


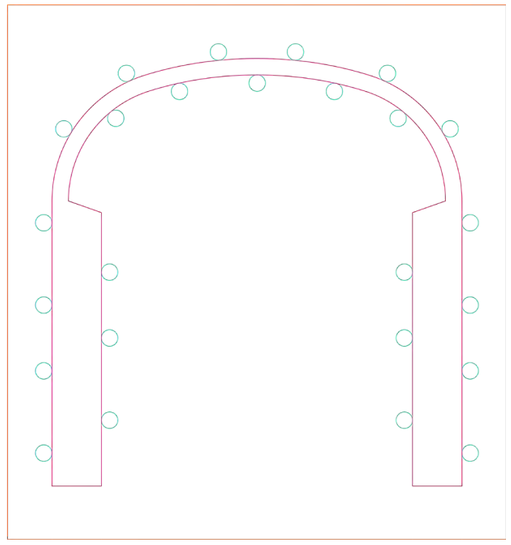
Half-scale chair design 3
Photography: Alex Key
Date: Jan '20

Design Development: 1.5 Half-scale model

Once I had developed some initial designs, I decided to develop them physically in the workshop. I intended not to confine myself to making any of the previous designs but instead to develop the process and create a design as I went along.

Back: The first part of the half scale model which I made was the back. The inital aspect of which was the back for the JIG, which was initially drawn in Rhino as that allowed me to create it accurately. I laid out the holes for the dowel as well as the curved profile I wanted the backs to take. These were in correlation to the shape of the seat which I was also developing alongside them. Overall, the JIG was effective and gave me the results in Sycamore and Walnut that I wanted. However, I'm not sure how effective this JIG would be upscaled, this is because I needed a lot of clamps to get the layers to meet cleanly. This could be fixed by developing the JIG further and implementing some compression blocks which would spead the pressure more evenly.





Back JIGs outlines 1+2
Photography: Alex Key
Date: Jan '20

Back JIG MDF
Photography: Alex Key
Date: Jan '20

Sycamore back glue up 1
Photography: Alex Key
Date: Jan '20

Sycamore back glue up 2
Photography: Alex Key
Date: Jan '20

Sycamore back outcome A
Photography: Alex Key
Date: Feb ‘20

Sycamore back outcome B
Photography: Alex Key
Date: Feb ‘20

Sycamore back outcome C
Photography: Alex Key
Date: Feb ‘20

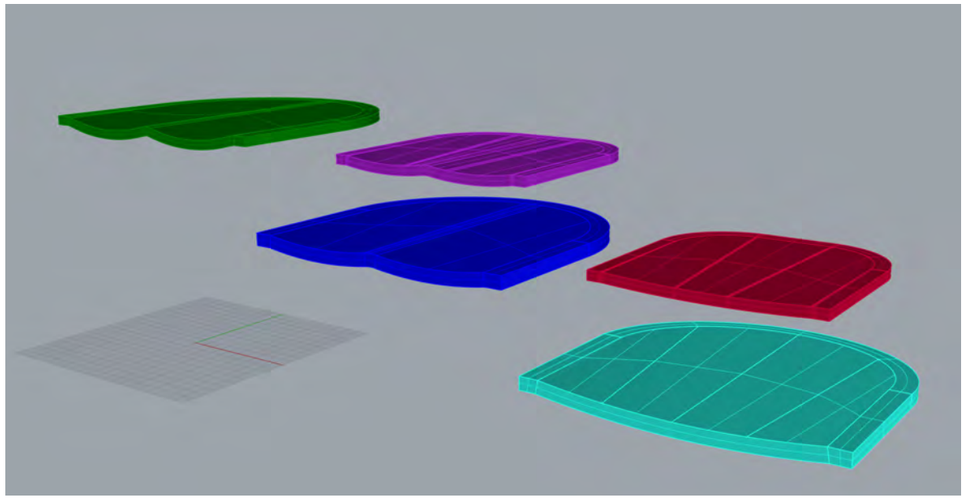
Walnut back outcome A
Photography: Alex Key
Date: Feb ‘20

Walnut back outcome B
Photography: Alex Key
Date: Feb ‘20

Walnut back outcome C
Photography: Alex Key
Date: Feb ‘20

Seats: Alongside the backs I was also developing the profiles for the seats. These were done in Rhino and explored different profiles on the front and back. Ranging from a prominent 'W' shape to a subtle curve. Some of the seats also had a slightly more square back, where as some were more rounded. These subtle differences gave me a variety of results which all gave a unique style to the versions.

All of these itterations were then milled using the 3-axis milling machine in Sycamore with Oak detailing as well as Oak with Walnut detailing. The reason the other wood was added, was to add some flare and detail to the piece, as well as to achieve the width of block for the model. Overall, these tests would be to see whether the process would be viable for the upscaled version, as well as what the outcomes would look like visually.



All seat variations CAD - Rhino 6
Photography: Alex Key
Date: Jan '20

Sycamore & Oak seat glue up
Photography: Alex Key
Date: Jan '20

Sycamore and Oak seats cut up
Photography: Alex Key
Date: Jan '20

Half-scale Sycamore & Oak 3-axis milling outcome 1
Photography: Alex Key
Date: Jan '20

Half-scale Oak & Walnut 3-axis milling outcome 5
Photography: Alex Key
Date: Jan '20

Half-scale Sycamore & Oak outcome 2
Photography: Alex Key
Date: Feb ‘20

Half-scale Sycamore & Oak outcome 3
Photography: Alex Key
Date: Feb ‘20

Half-scale Sycamore & Oak outcome 4
Photography: Alex Key
Date: Feb ‘20

Half-scale Oak and Walnut outcome 5
Photography: Alex Key
Date: Feb ‘20

3-axis milling outcome varieties 2-5
Photography: Alex Key
Date: Feb ‘20

While it was expensive, I feel that the use of the milling machine not only made the process quicker, it also added to the precision of the piece. This ultimately contributed to the project and took me down the digital path further which developed my skills and confidence.

Legs: The next step in the development of my half scale model was the legs. These were turned in Sycamore using the lathe. At this point I made a very specific decision to blend the tenon and the leg together, this was to prevent a prominent difference between the two elements. The legs profile was cone shape, which was directly inspired by my initial model (See p43). This design choice lead to a piece being more unified in image as that profile was in harmony with the spindles.

Once shaped I then attached them to the seat by driving an oak wedge into the top. This was to compliment the oak which ran down the centre of the piece. This little detail really elevated the piece and made it come together. I also explored other leg profiles from thicker cones to thinner, as well as more prominent top joints. These were all good variations but ultimately didn't suit this iteration.

Half-scale sycamore legs on the lathe
Photography: Alex Key
Date: Jan '20

Half-scale sycamore legs outcome
Photography: Alex Key
Date: Jan '20

Half-scale leg wedge joint
Photography: Alex Key
Date: Jan '20

Half-scale leg wedge joint cleaned up
Photography: Alex Key
Date: Jan '20

Half-scale legs - Thin 1
Photography: Alex Key
Date: Feb ‘20

Half-scale legs - Thin 2
Photography: Alex Key
Date: Feb ‘20

Half-scale legs - Thick 1
Photography: Alex Key
Feb: Jan ‘20

Half-scale legs - Thick 2
Photography: Alex Key
Date: Feb ‘20

All half-scale legs 1
Photography: Alex Key
Date: Feb ‘20

All half-scale legs 2
Photography: Alex Key
Date: Feb ‘20

Assembly: Once the legs were attached, I then started to assemble the other pieces onto the model. There was still room for experimentation though, as I had to decide the height of the front and back spindles as well as the orientation of the back. Ultimately, I landed upon the back spindles being 8.5cm tall and the front being 10cm. This was to create an angled back which was intended to make it comfier to use.

These joining spindles were then turned with an hourglass profile in Sycamore, this was to compliment the legs. Once turned I decided on the positioning which was within the holes for the back legs and on top of the front legs. The latter in an attempt to keep that continuous line going through the piece.

Half-scale legs & seat dry assembly
Photography: Alex Key
Date: Jan '20

Half-scale legs legs & seat assembly
Photography: Alex Key
Date: Jan '20

Sycamore back orientation test
Photography: Alex Key
Date: Jan '20

Sycamore back orientation test
Photography: Alex Key
Date: Jan '20

Back angle & spindles test
Photography: Alex Key
Date: Jan '20

Spindles glue up
Photography: Alex Key
Date: Jan '20

Outcome: Once assembled I was happy with the final outcome. I really liked the seat and the back; I feel that they were the best executed aspects of the model. I did like the legs and the spindles; however, I feel they could be improved upon with the profile and the dimensions. The only issue that I have with this piece is that it looks very fragile and potentially could not support a person's weight.

All of these aspects will be developed and improved upon using Rhino and drawing development. Potentially seeing implementation of aspects such as an under frame or steel on the inside of the legs. Each of these possibilities would result in different aesthetic choices. However, this model is a close to final version of one of my outcomes for this project, which conveys the ideas I wanted to explore outlined in my RFD.

Half-scale outcome 1
Photography: Alex Key
Date: Feb '20

Half-scale outcome 2
Photography: Alex Key
Date: Feb '20

Half-scale outcome 3
Photography: Alex Key
Date: Feb '20

Chapter 2 - Integration

Primary Research:

- 1.1 London research trip
- 1.2 Outline drawings
- 1.3 English woodlands timber visit

Secondary Research:

- 2.1 Design inspiration
    - Hans Wegner
    - Ercol Furniture
    - Bern Chandely Furniture
    - Marc Fish
    - Bobby Mills Studio

Ergonomic Research:

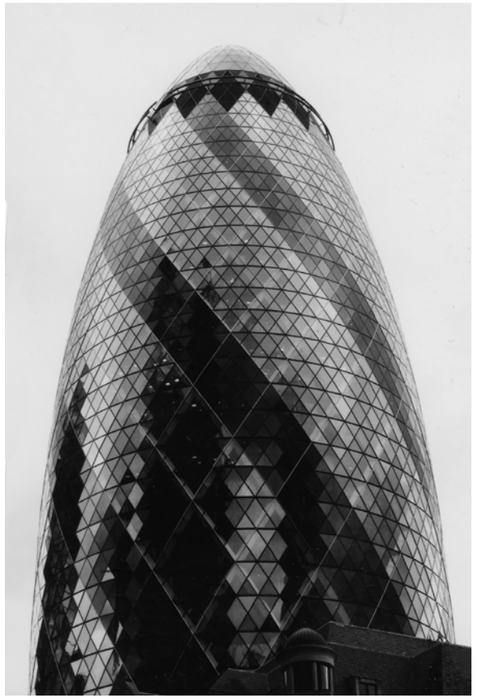
- 3.1 Primary dimensions research
- 3.2 Secondary dimensions research

Primary Research: 1.1 London research trip

In the initial stages of this project I visited London to conduct some primary research. The aim of this trip was to gather inspiration for this project from architectural shapes and patterns. I looked at several buildings such as the Gherkin, London Bridge station, Guys hospital and more. I decided to take these photos in black and white because I really wanted to show off the shapes as well as the textures of the buildings.

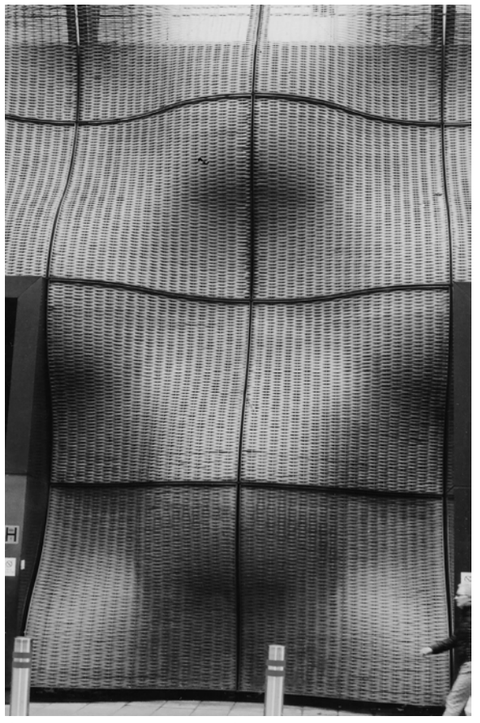
The buildings I found most interesting were Guys Hospital, London Bridge station and the Lloyds building. I specifically liked the fluid shapes as well as the texture of the metal exterior of Guy's hospital and the repetitive cylindrical shapes of the Lloyds building. These are all aspects which will influence my work throughout this project.

Guy's Hospital exterior 1 - T.Hetherwick
Photography: Alex Key
Date: Aug '19

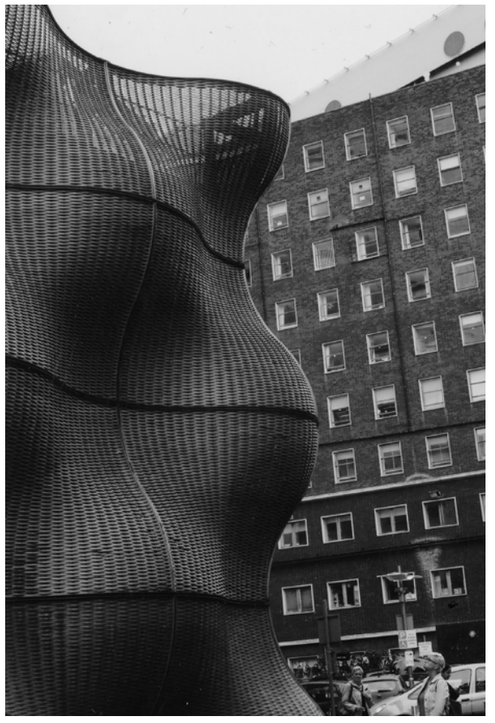


The Gherkin - Foster & Partners
Photography: Alex Key
Date: Aug '19

Office block (Monument Stn) - N/A
Photography: Alex Key
Date: Aug '19



Guy's Hospital exterior 2 - T.Hetherwick
Photography: Alex Key
Date: Aug '19



Guy's Hospital exterior 3 - T.Hetherwick
Photography: Alex Key
Date: Aug '19

White Lattice Steel Structure (Kingscross Stn) - John McAslan & Partners
Photography: Alex Key
Date: Aug '19

London Bridge Station exterior 1 - Mark Middleton
Photography: Alex Key
Date: Aug '19

London Bridge Station exterior 2 - Mark Middleton
Photography: Alex Key
Date: Aug '19

Unnamed bridge (Monument Stn) - N/A
Photography: Alex Key
Date: Aug '19

The Shard - Rogers, Stirk, Habour & Partners
Photography: Alex Key
Date: Aug '19

Walkie Talkie - Rafael Vinoly
Photography: Alex Key
Date: Aug '19

Lloyds Building - Rogers, Stirk, Habour & Partners
Photography: Alex Key
Date: Aug '19

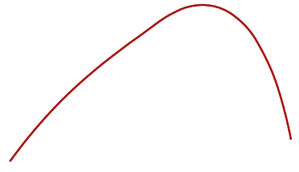
Primary Research: 1.2 Outline drawings

I used the pictures which I had taken on my research trip to London to create some two-part glue laminating JIGs. I did this by tracing over the shapes in the photos with the curved line brush tool in Adobe Illustrator. This gave me full control over the curvature of the line as well as the length, it also allowed me to scale them to various sizes allowing me to experiment with the outcome.

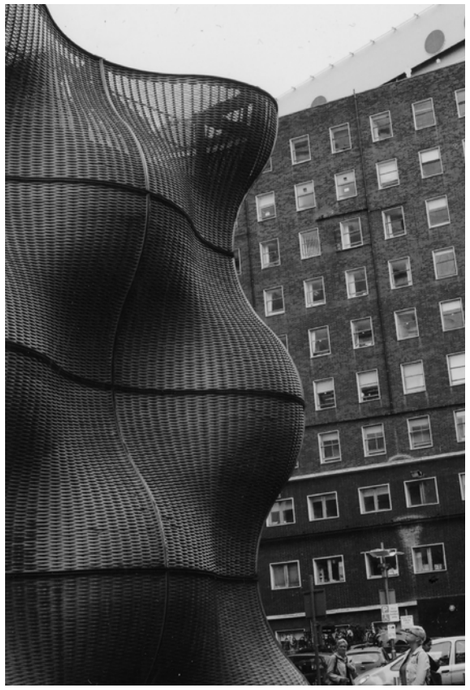
I chose to trace over, Guys Hospital exterior, White steel lattice structure, Walkie Talkie and the Lloyds building. The reason for choosing these was because they had the most unique exteriors as well as dynamic curves, which would result in the most interesting outcomes. I traced over a few more but found that these initial drawings gave the most interesting and consistent outcomes (See p24-29).

Overall, this was a valuable contribution to the project as it pushed my practical experimentation in a new and unique direction. However, I feel I would have benefited from more photos from another trip to a different area, as that would have resulted in more shapes to experiment with.

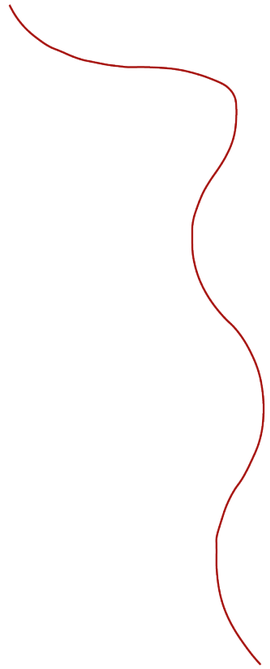
White steel lattice structure - John McAslan & Partners
Photography: Alex Key
Date: Aug '19



White Steel Lattice Structure outline
Source: Alex Key
Date: Oct '19



Guy's Hospital exterior - T.Hetherwick
Photography: Alex Key
Date: Aug '19

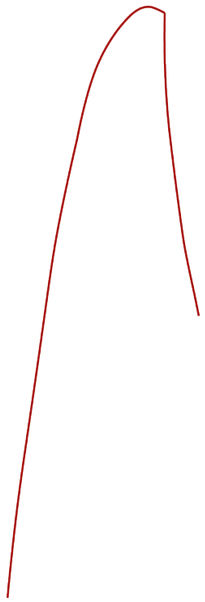


Guy's Hospital exterior outline
Source: Alex Key
Date: Oct '19

Walkie Talkie - Rafael Vinoly
Photography: Alex Key
Date: Aug '19

Walkie Talkie outline
Source: Alex Key
Date: Oct '19

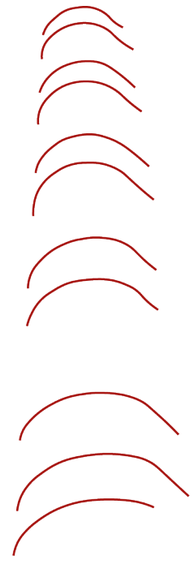
Walkie Talkie - Rafael Vinoly
Photography: Alex Key
Date: Aug '19



Walkie Talkie outline
Source: Alex Key
Date: Oct '19

2-part compression JIG A - Walkie Talkie
Photography: Alex Key
Date: Dec '19

Lloyds Building - Rogers, Stirk, Habour & Partners
Photography: Alex Key
Date: Aug '19



Lloyds Building outline
Source: Alex Key
Date: Oct '19

2-part compression JIG B - Guy's Hospital exterior
Photography: Alex Key
Date: Dec '19

Primary Research: 1.3 English woodlands timber visit

At around the halfway point into this project I decided to visit English Woodlands Timber in Midhurst, West Sussex. This was in direct correlation with my dissertation at the time which was researching the idea of sustainability and whether the Hembury chair succeeded in it. This influenced my own work by making me think about the timber I was using for my own project and how I could make it more sustainable. I had conversations with members of the timber yard asking about the wood as well as making sure it was from an ethical and sustainable source. This knowledge about timber and the timber industry helped me purchase lumber with the aim of reducing my overall impact on the environment as well as giving the project a local connection for me.

Air drying timber log stacks
Photography: Alex Key
Date: Jan '20

Unloading of timber
Photography: Alex Key
Date: Jan '20

Shelves of waney edge timber 1
Photography: Alex Key
Date: Jan '20

Shelves of square edge timber
Photography: Alex Key
Date: Jan ‘20

Forklift unloading waney edge timber
Photography: Alex Key
Date: Jan ‘20

Planned wood rack 1
Photography: Alex Key
Date: Jan ‘20

Planned wood rack 2 - Chesnut, Elm, French Walnut
Photography: Alex Key
Date: Jan ‘20

Ash close up
Photography: Alex Key
Date: Jan ‘20

Pippy Oak close up 1
Photography: Alex Key
Date: Jan ‘20

Pippy Oak close up 2
Photography: Alex Key
Date: Jan ‘20

Chestnut close up
Photography: Alex Key
Date: Jan ‘20

Secondary Research: 2.1 Design inspiration

In the next stage of research for my project I decided to look at other designers. This was not only to find where my work could fit amongst them but also to act as guiding inspiration for where I may progress this project.

Hans Wegner: Is a massive influence on me as a maker, from how he incorporates elegant shapes to the natural beauty of the wood used in his pieces. He is an icon within the Danish and Scandinavian furniture design movement. My favourite piece of his is the 'Wishbone' or 'Y' Chair, because of the soft flowing back as well as the profile of the legs. His pieces all look visually clean and neat, which is no more apparent than in the CH008 coffee table. These are all aspects which inspire me and are characteristics that I would like to emulate in my own work.

Wishbone Chair
Source: Carl Hansen & Son
Date: 12/04/2020

CH008 - Coffee Table
Source: Carl Hansen & Son
Date: 12/04/2020

Chinese Bench
Source: Free3D.com
Date: 20/04/2020

Ercol: Is another great influence on me as a designer not only in aesthetics but also in technique. The turned legs as well as the laminated backs and seats not only influence me, but also the Danish/Scandinavian furniture movement.

Ercol is a traditional English furniture making company dating back to 1920 but saw the combination of CNC and hand techniques in the workshop in the 50s. This is an aspect which I am personally exploring and developing during this project, from learning the software to how I can incorporate the 3-axis CNC mill. I would like to take this aspect further by exploring the relationship between the machine and more traditional making methods throughout this project, by incorporating as well as developing it in my own practice.

Butterfly Chair - Ash
Source: Ercol
Date: 12/04/2020

Love seat - Ash
Source: Ercol
Date: 12/04/2020

Bern Chandley: Specifically makes modern interpretations of Windsor chairs in Melbourne, Australia out of Ash and Oak. One of his most popular pieces is the low back diner, this is a piece which see the turned legs style atop a chunky seat. While I find his pieces interesting structurally, I think that aesthetically they are very simplistic and bland.

Although an aspect which does peak my interest is the ebonised finish, this something that I may return to and explore later in my project. Although, another element of this piece which I find very interesting is the curved part of the underframe. This is a visual element which echos the back rest and really ties the piece together, an aspect I will be attempting to emulate in my own work throughout this project.

Low back diner - Ebonised Ash
Source: Bern Chandley Furniture
Date: 12/04/2020

Low back diner - American White Ash
Source: Bern Chandley Furniture
Date: 12/04/2020

Marc Fish: Is an artist which combines resin as well as wood. The aspects of his pieces which inspire and influence me the most are the curved, flowing shape of the wood as well as the colours. He has a team which creates his pieces by hand which results in them targeting a high financial bracket. The aspect I admire about his work is how the back and the legs form one piece on the Ethereal lounge chair, which he pushes further by making it flow into the seat aswell in the Ethereal chair.

This striking shape is also complimented by the colours in the seat, which are all rich browns and frosted whites from the resin. These colours, quality of work and business model is something I would like to emulate in my own outcomes from this project.

Ethereal Lounge Chair
Source: Marc Fish
Date: 15/04/2020

Ethereal Chair
Source: Marc Fish
Date: 15/04/2020

Bobby Mills studio: Combines the style of traditional English furniture and Danish furniture design to create bespoke handmade commissions. While his pieces may not be the most visually striking, I find his branding the most inspiring. His photography conveys a sense of high quality and passion, this is only heightened in the materials he uses. The contrast between the light and dark in the Walnut and Oak of the stool is really excentuated against the dark backdrop and directional light.

His work is further complimented by the fact that he uses timber from fallen trees, adding to the gravitas and history behind the pieces. The story behind the piece is an element I would like to potentially incorporate into my own practice as a designer/maker, as I feel this will deepen not only my connection but also the consumers to my products.

Three-legged stool - Walnut & Oak
Source: Bobby Mills Studio
Date: 13/04/2020

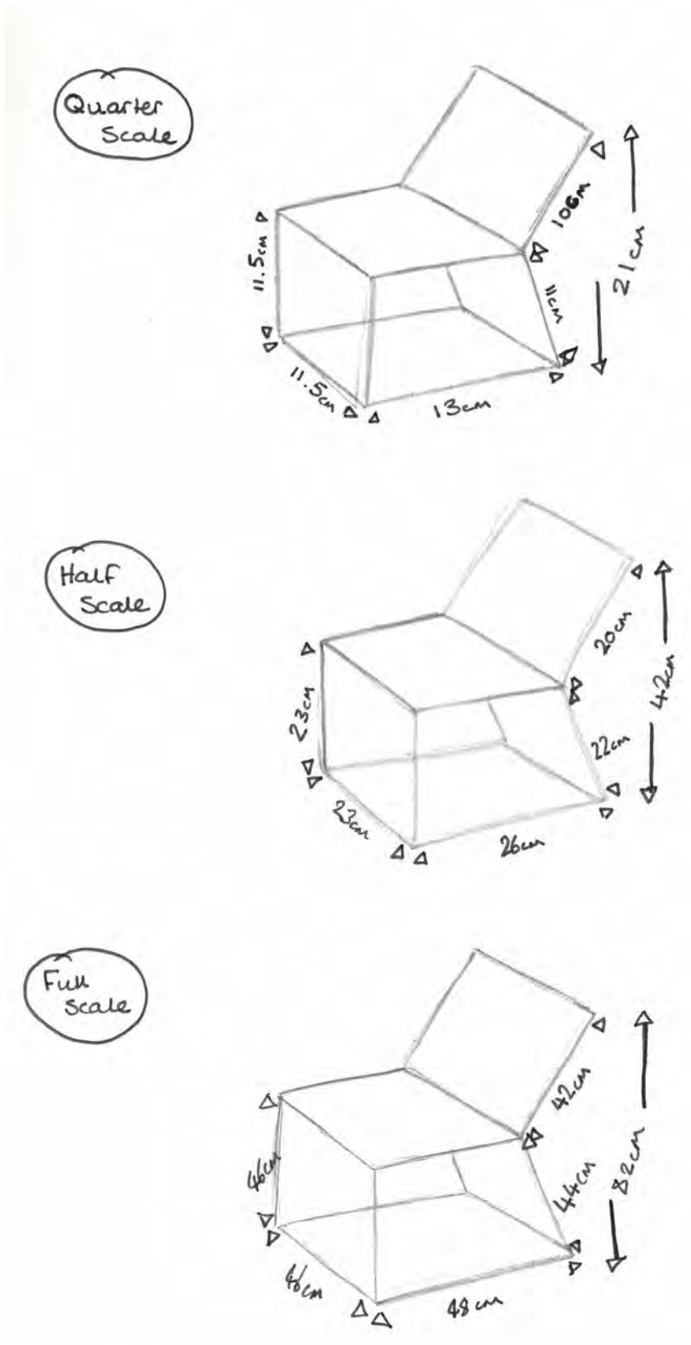
Rocking Chair - Oak & Ash
Source: Bobby Mills Studio
Date: 13/04/2020

Ergonomic Research: 3.1 Primary dimentions research

Continuing on with my research into furniture, I decided to gather some measurements from a full scale chair. This was to act as a guide for my inital models, drawings as well as CAD. I chose a standard chair that is previlent in large spaces such as University, the reason being that this chair is mass produced. This means that the sizes cater to a large portion of the population, which would be good sizes to emulate if I wanted to take my pieces into production.

I started by measuring the back, seat and leg height, the only issue with this chair was there was not arm rest to measure, I didn't think this was an issue at the time, but I do address it later on. From these full-sized measurements I decided upon some half scale and quarter scale measurements by halving as well as dividing the original measurements by four. This was to act as a rough guide for models - physical, CAD, and drawings.

Original chair which I measured for scales
Source: Alex Key

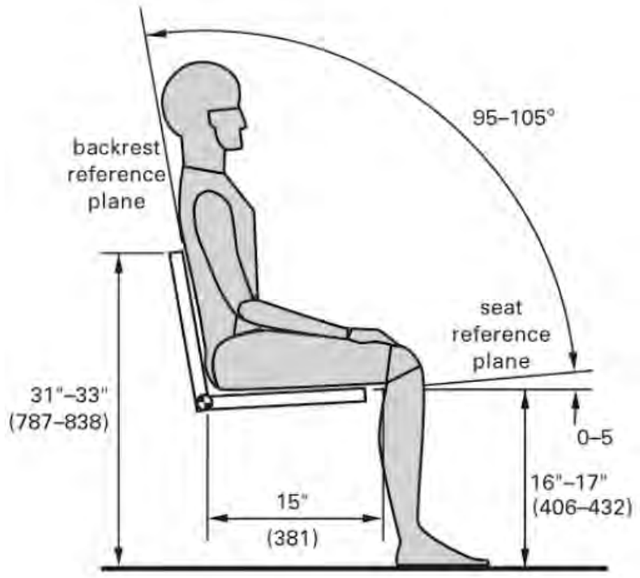


Measurements & scale guide
Source: Alex Key

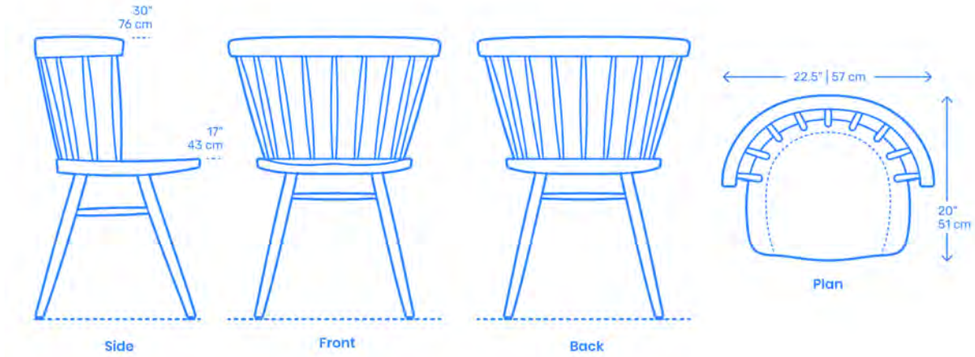
Ergonomic Research: 3.2 Secondary dimentions research

Once I had done some initial primary research into ergonomics and dimensions, I decided to explore it further. This led me to a variety of diagrams which outlined sizes, angles as well as heights for a chair to best suit a person. One of the best ones was from Urbanologydesigns.com which simply outlined all the valuable information for a chair in a simple and clear diagram.

Although an issue I found with various diagrams was that they did not have a reference for the arms rest. This was an issue for me as I wanted to implement this into my designs. Although I did have a rough idea of positioning and sizes, it was through workshop experimentation which lead me to a conclusive answer. (See p61-62)



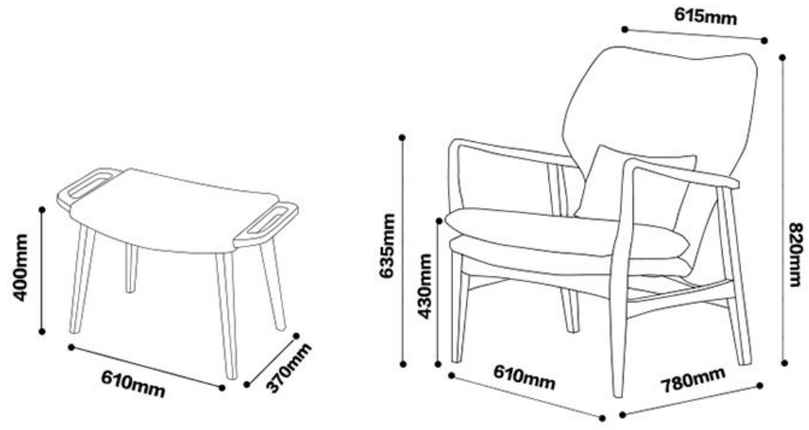
Measurements & angle guide
Source: Urbanologydesigns.com



Nakashima straight-back chair
Source: Dimensions.guide

As I continued to research into chair dimensions, I came across the Nakashima straight-back chair which outlined the sizes in a clear orthographic drawing. This was useful as this chair was visually in line with what I was exploring in the initial stages of this project.

Through further research though I came across the dimensions for a chaise lounge chair, this was exceptionally useful as it gave me the height and length of the arms. Combining these measurements with the angles in the first diagram gave me the knowledge of what sizes and angles worked best for a chair in this style, which I applied to my own designs throughout this project.



Chaise lounge dimensions
Source: Chaiseloungedimensions.net

Chapter 3 - Organisation

Planning:

- 1.1 Year plans
- 1.2 Weekly plans

Design Drawings:

- 2.1 Final CAD
- 2.2 Orthographic renders
- 2.3 Technical drawings
- 2.4 Exploded diagram

Making Plans:

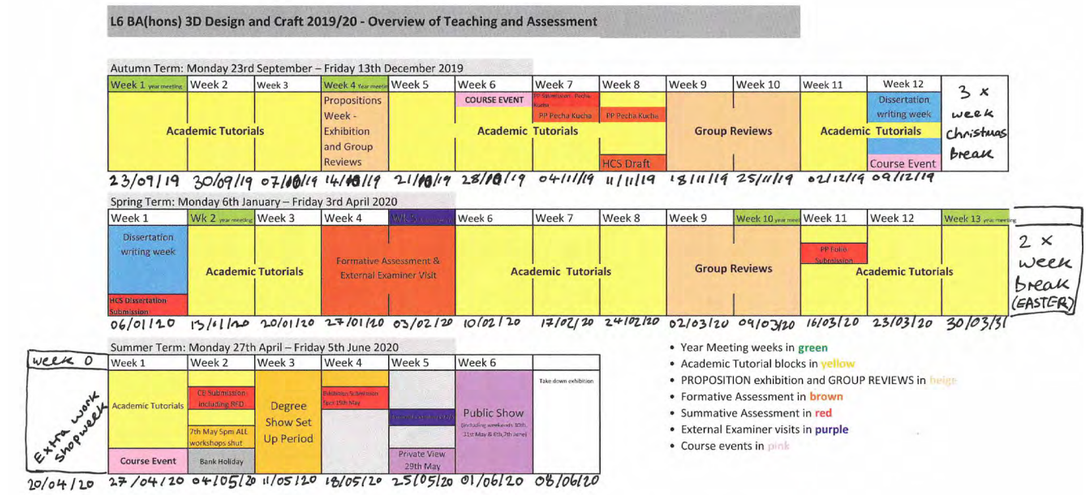
- 3.1 Part & process list
- 3.2 Weekly making plan

Planning: 1.1 Year Plans

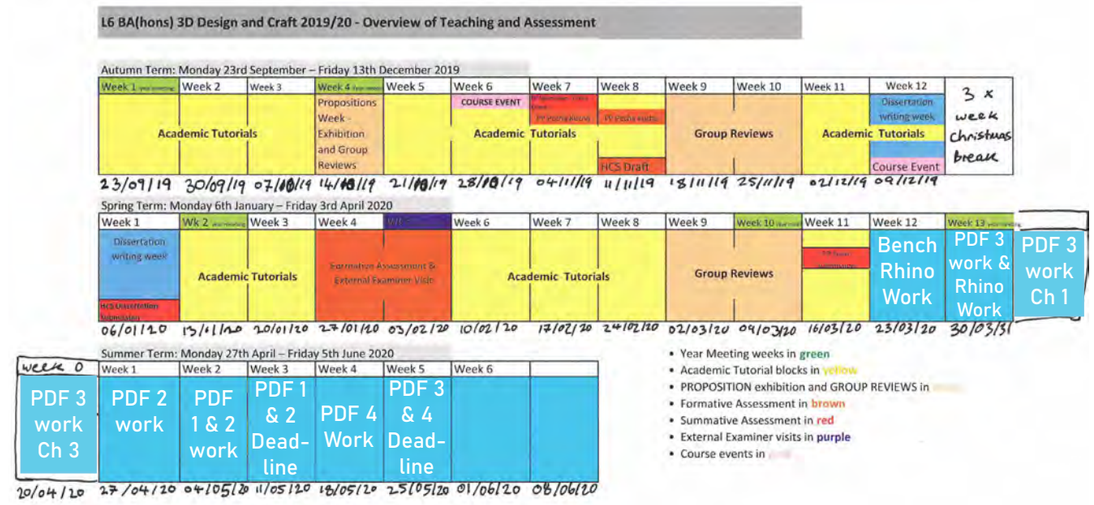
This overview of the year was very beneficial in helping me to structure my time in and out of the workshop. I found in the first term though I was still struggling to find a balance between all the modules. This was not helped by the fact that I was exploring long processes practically culminating in me having to wait for results to progress further.

However, I did improve my time management in the second term, because I had finished the Historical and Contextual studies module but also because I started to plan my time better. This was done by breaking the term down into weeks as well as the individual days into three chunks.

This process was going well until the year drastically changed due to the Covid-19 outbreak. This resulted in the University closing and me having to transition to working from home with digital submissions. The second timetable outlines this updated time frame by highlighting the altered aspects in blue. This was unfortunate as it resulted in me not being able to finish the second and third furniture pieces that I wanted to make. This also change my submission format from a practial and digital to just a digital submission. Although, I did have one chair finished, The Crest chair, it would have been nice if I could have finished the others.



Original year plan/overview
Source: Avril Wilson
Edited: Alex Key

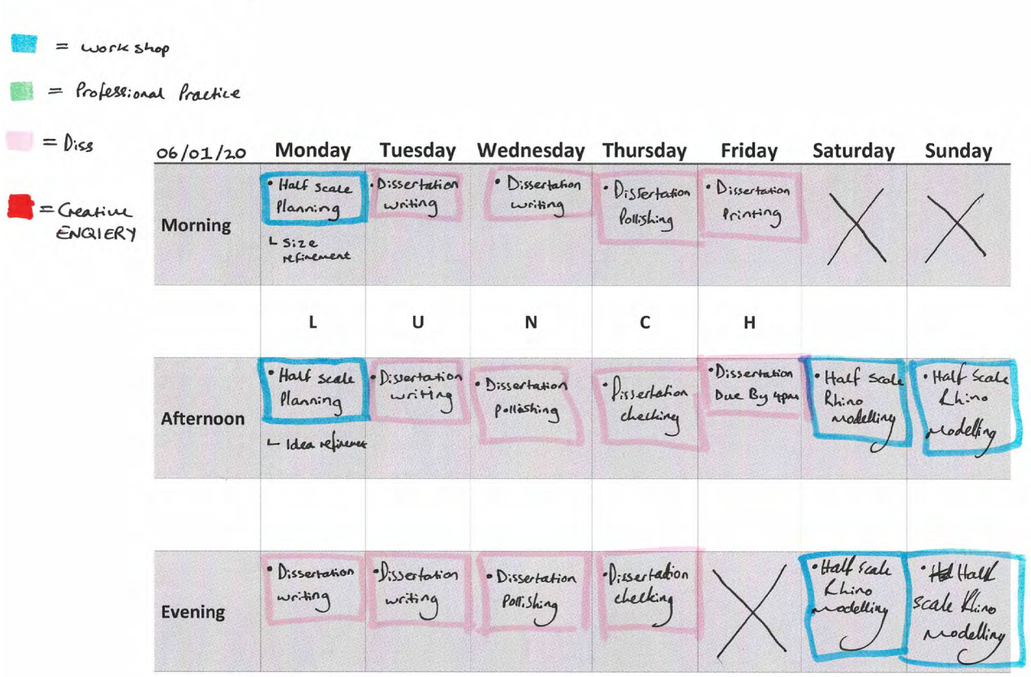


Updated year plan/overview (Post COVID-19)
Source: Avril Wilson
Edited: Alex Key

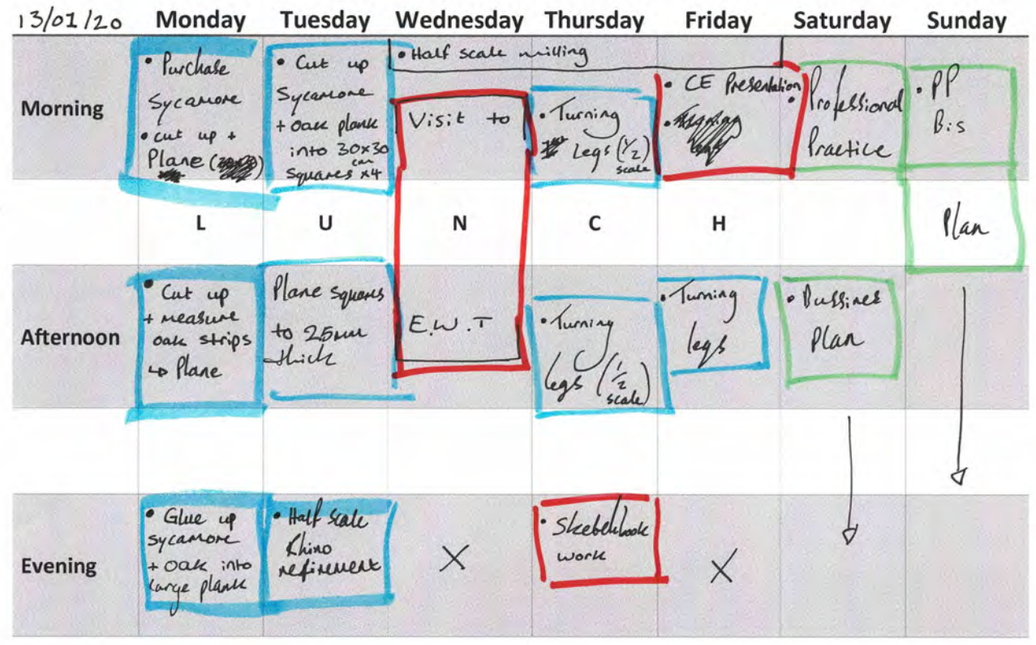
Planning: 1.2 Weekly Plans

I broke down my week day by day after Christmas, this was because I wanted to use my time a lot more efficiently. The breakdown consisted of three parts, morning, afternoon and evening - helping me contain my tasks better as well as keep track of my workflow. I also colour organised my tasks into, workshop, professional practice, dissertation and creative enquiry, this visual aid was a quick way of letting me know which task was for which module.

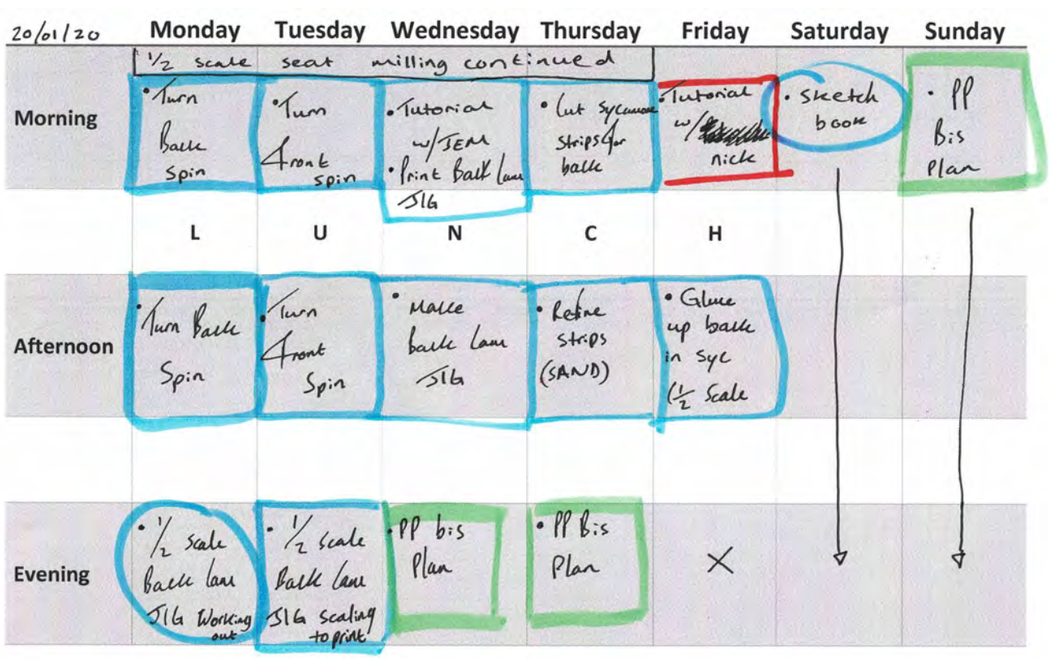
Overall, this was a wise decision for me as it helped me structure my time better, as well as made me more efficient. It was especially helpful in the final stages of my dissertation as well as when I was developing my half-scale model.



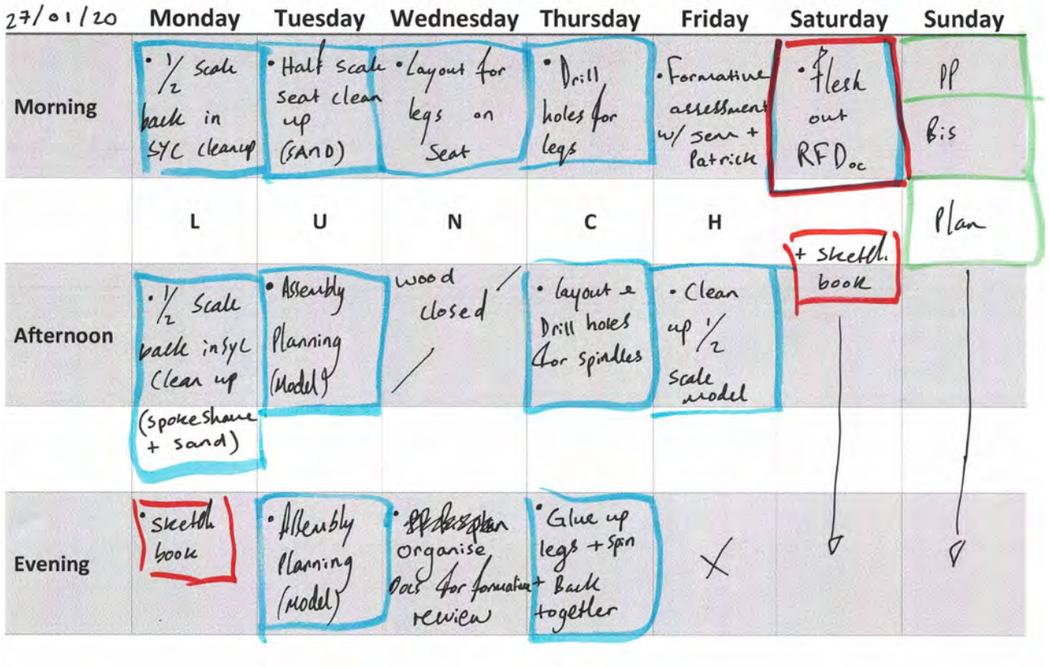
Weekly plan - 06/01/2020
Source: Alex Key



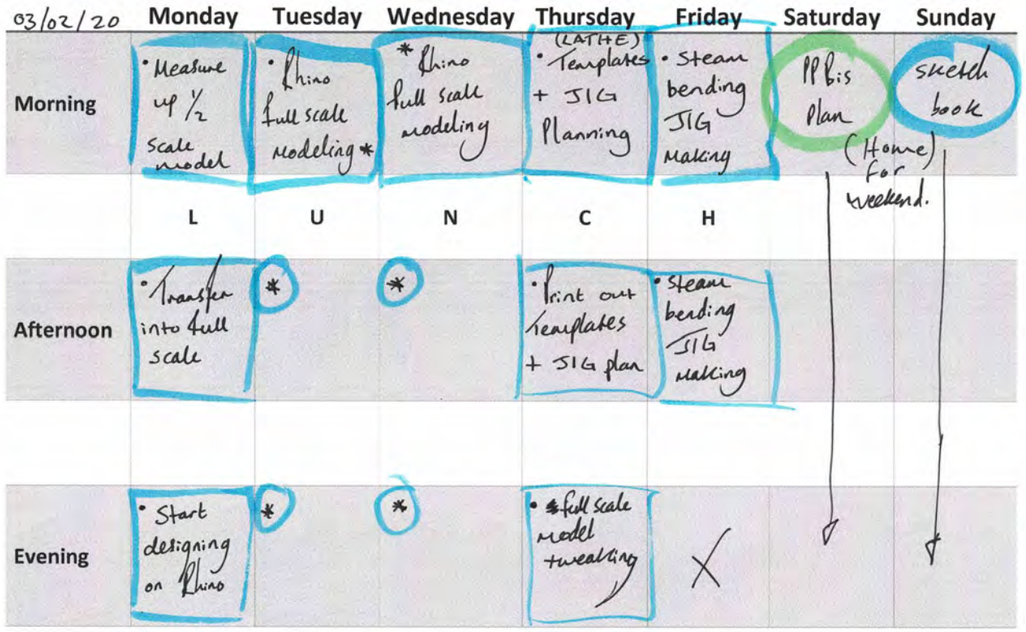
Weekly plan - 13/01/2020 (Half scale model development started)
Source: Alex Key



Weekly plan - 20/01/2020
Source: Alex Key



Weekly plan - 27/01/2020 (Half scale model development finished)
Source: Alex Key

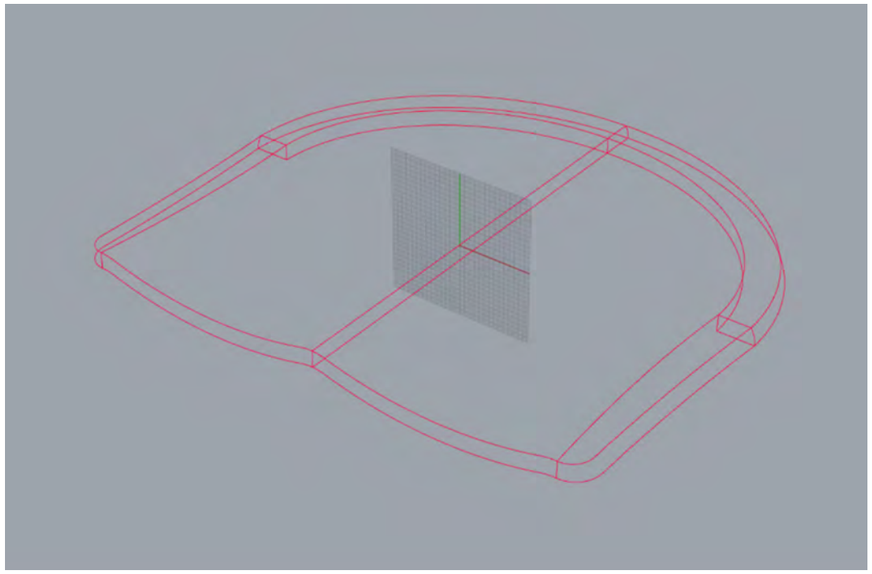


Weekly plan - 03/02/2020
Source: Alex Key

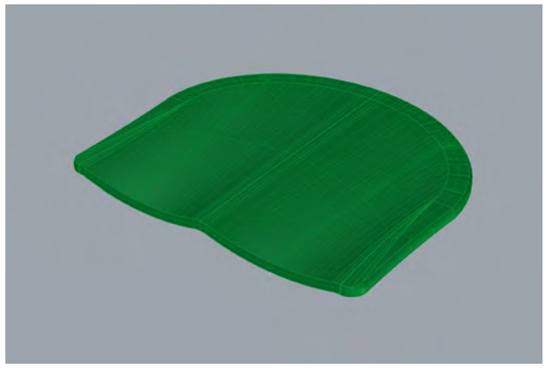
Design drawings: 2.1 Final CAD

Once I had developed my half-scale model in the workshop (See p63-64), I then transferred it to Rhino to develop a full-scale version. This was to aid the making of the piece as well as to finalise any technical and visual details, with the aid of the angles and dimentions research I had done previously (See p91-94). Developing my design in Rhino this way allowed me to tweak a variety of aspects, such as the angle of the legs, the proportions of parts like the spindles as well as creating the addition of an underframe.

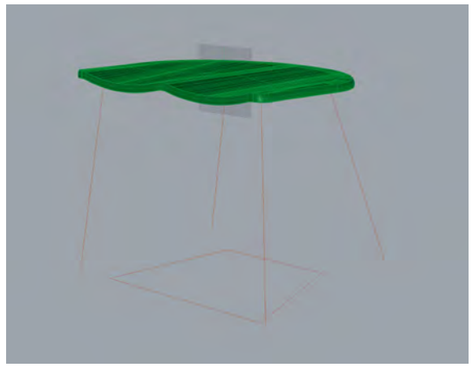
Making a 3D model also helped me to convey a better visualisation of what the final piece would look like as well as creating technical drawings which would contribute to the making. In conclusion the move to digital model making allowed me to finesse and develop aspects of my chair refining details such as angles, sizes and adding additional elements.



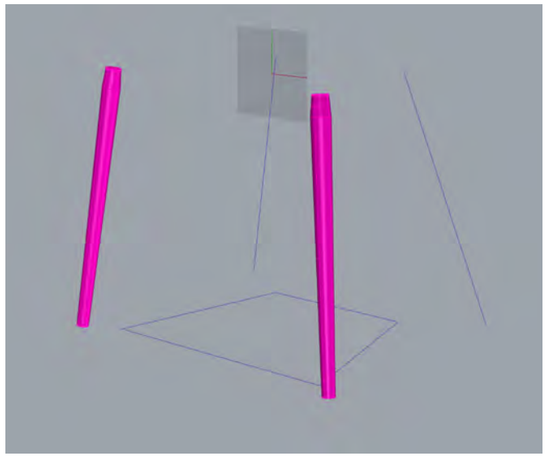
Seat wireframe - Up-scaled from the half-scale file version
Source: Alex Key



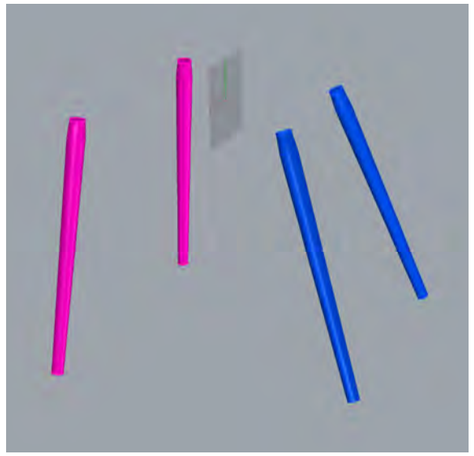
2. Seat surface assembled
Source: Alex Key



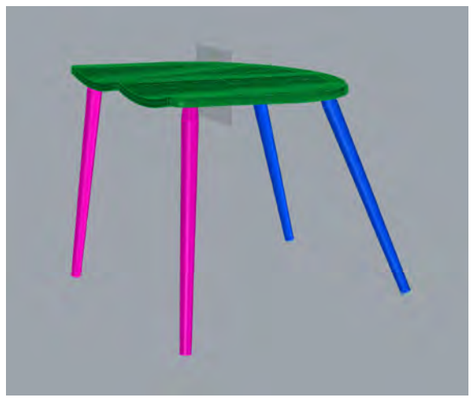
3. Leg angle line guide - 68 & 82 degree angles
Source: Alex Key



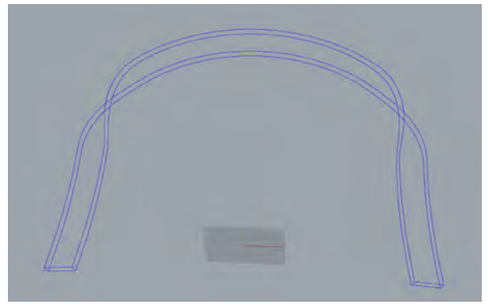
4. Front legs - 2 Truncated cones boolean union together
Source: Alex Key



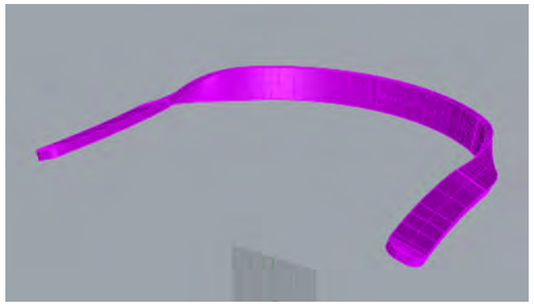
5. Back legs assembled
Source: Alex Key



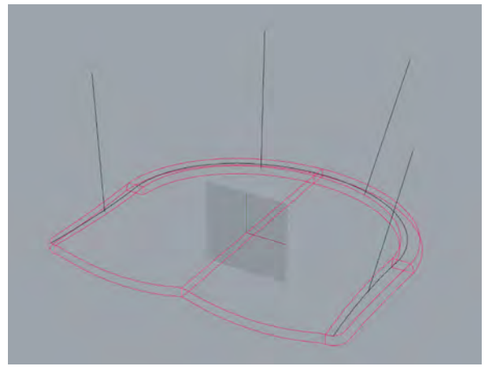
6. Seat & leg assembly
Source: Alex Key



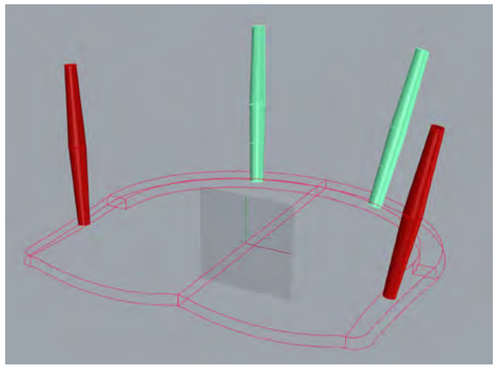
7. Back framework wire drawing
Source: Alex Key



8. Surface applied to back wire frame via creating a surface from 2,3,4 edge curves
Source: Alex Key

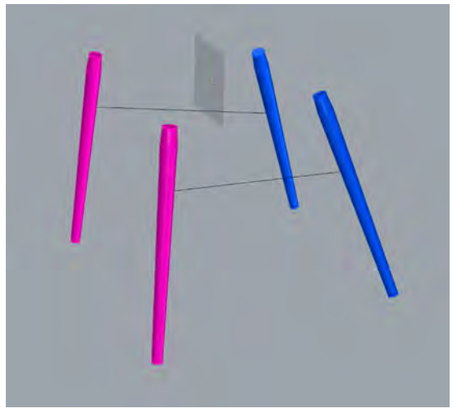


9. Front & back spindle centre line at 72 & 78 degrees
Source: Alex Key

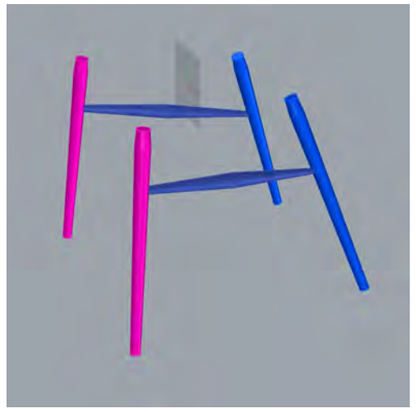


9. Front & back spindle assembled created by two mirrored truncated cones
Source: Alex Key

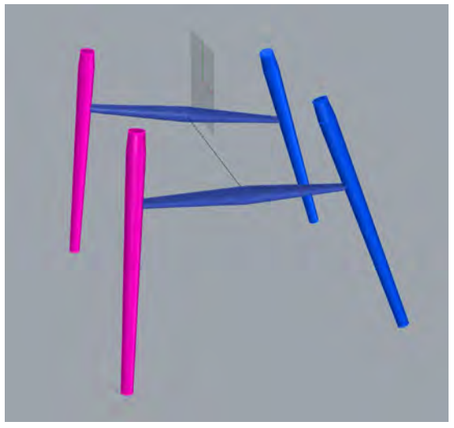
10. Legs, seat, spindles & back assembled
Source: Alex Key



11. Side spindles centre line
Source: Alex Key

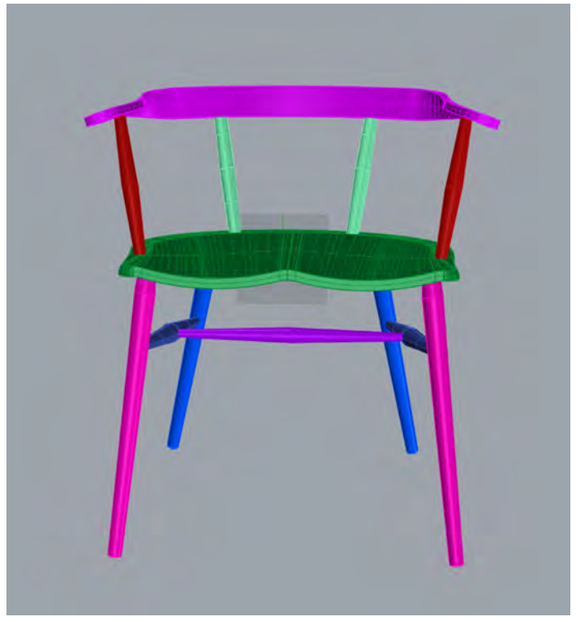


12. Side spindle assembled
Source: Alex Key

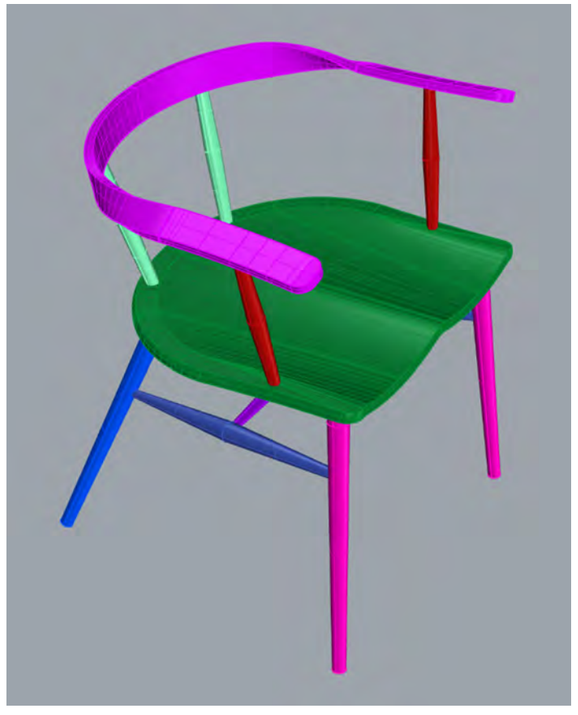


13. Centre spindle centre line
Source: Alex Key

14. Centre spindle assembled & full model
Source: Alex Key



Full model in Rhino 6
Source: Alex Key



Full model in Rhino 6 (2)
Source: Alex Key

Design drawings: 2.2 Orthographic renders

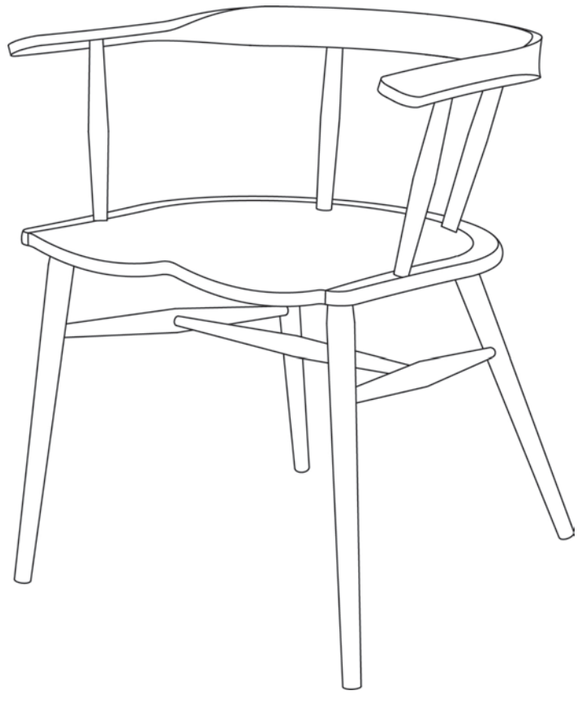
Once I had developed a full-scale model of my chair in Rhino, I then used it to create some visual aids for the making process. The first being an orthographic render, this shows the chair from multiple angles which will aid me in the making. These renders also gave me a good idea as to what the resolved outcome of the piece will look like, from finish to material colour. This will aid me in the making, as the planning of my piece allows me to visualise the piece as I am going along. This is also a very effective method of exploring the design and seeing if there are any last-minute issues which I can fix before I waste material or time.

Crest chair - Silhouette render
Source: Alex Key

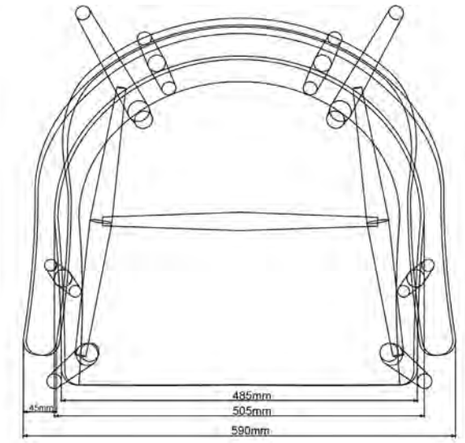
Othographic Render - Crest chair
Source: Alex Key

Design drawings: 2.3 Technical drawings

I also decided to make a technical drawing of my chair, this was to act as a reference sheet for technical aspects such as angles, sizes and dimensions. This was a very helpful list as it acted as a record of the details which I could use in the later stages of making. This also helped me spot any issues or problems which could have potentially surfaced during the making process thus wasting less material and time. Overall, this was a very beneficial diagram which I made as it allowed me to get a better understanding of the intricacies of my design as well as the more complex tasks which I would have to do.

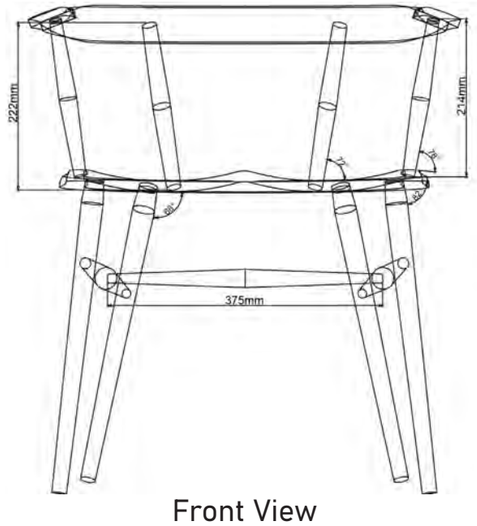


Line drawing - Crest chair
Source: Alex Key

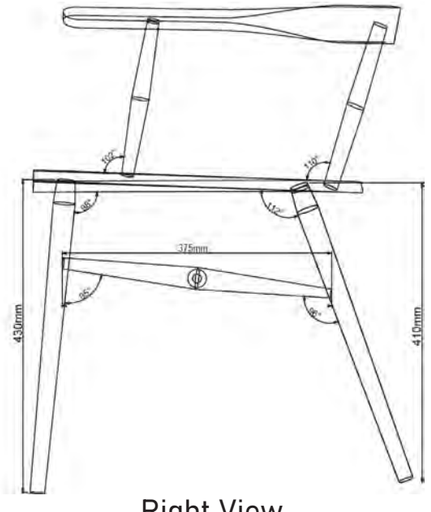


Top View

Perspective View



Front View



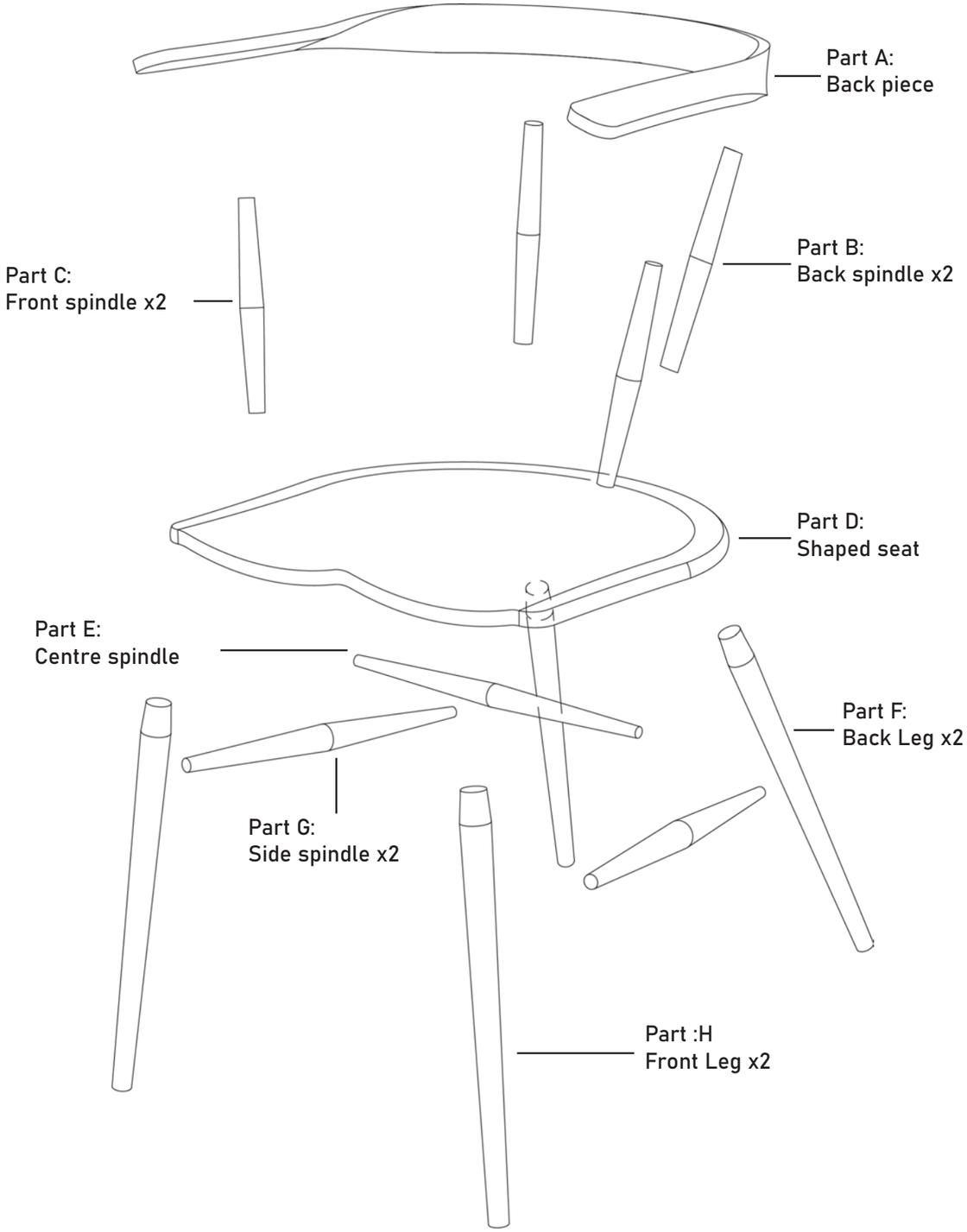
Right View

Orthographic technical drawing - Crest chair
Source: Alex Key

Design drawings: 2.4 Exploded diagram

The final design drawing I did was an exploded diagram; this was to help identify the individual parts of the chair for the parts and processes list. This not only helped me break down the piece into manageable segments, but it also assisted me in visualing how I was going to assemble the design. This was done via pulling the Rhino model apart and exporting it as an Illustrator drawing.

All these design drawings are beneficial to me as they help me to look at the piece in more detail, but they would also help me in a more professional context. They would be benificial if I was to approach a design company to put the Crest Chair into production or outsource the making. All these drawings would help a design firm (E.g. Benchmark) understand the chair visually and technically - something I would like to potentially explore beyond this project and University.



Exploded diagram - Crest chair
Source: Alex Key

Making plan: 3.1 Parts & processes list

The next step for me in the planning stage was to create a parts and processes list using the parts labelled in the exploded diagram. This not only helped me to break down the Crest Chair into manageable segments, but it also helped me plan how I was going to make the piece. I broke the piece down into 7 columns: material, quantity, part drawing, process, size and time. This was to get a better understanding of how long it would take so I could plan my time efficiently.

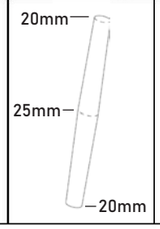
This was a very helpful aspect of the project as it aided me in working efficiently and to a tight time frame. However, I feel that the times of the processes could change if I was to make this piece multiple times as I would get quicker and more efficient, resulting in a price fluctuation.

Part A: Back Piece

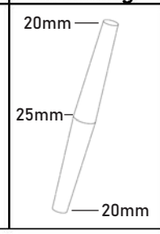
Material	Quantity	Part drawing	Process	Size (mm)	Time (Hours)
Ash (Strips)	X6		1. Planner/Thicknesser 2. Table saw 3. Steam bending 4. Glue lamination 5. Shaping/clean up – (Spokeshave & sandpaper) 6. Pillar drill	1500 x 60 x 2	1. 0.45 2. 0.30 3. 2.00 4. 1.00 5. 4.00 6. 0.20 --- Total: 8.35

Part A - Processes & parts list
Source: Alex Key

Part B: Back Spindle

Material	Quantity	Part drawing	Process	Size (mm)	Time (Hours)
Ash	X2		1. Band saw 2. Lathe 3. Sand 4. Wedge slot cutting	222 x 25 x 25	1. 0.10 2. 1.00 3. 1.00 4. 1.00 --- Total: 3.10

Part C: Front Spindle

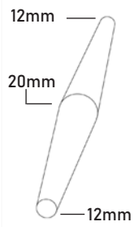
Material	Quantity	Part drawing	Process	Size (mm)	Time (Hours)
Ash	X2		1. Band saw 2. Lathe 3. Sand 4. Wedge slot cut	214 x 25 x 25	1. 0.10 2. 1.00 3. 1.00 4. 1.00 --- Total: 3.10

Part D: Shaped Seat

Material	Quantity	Part drawing	Process	Size (mm)	Time (Hours)
Ash Oak	X3 X2		1. Band saw 2. Thickness/planner 3. Glue up 4. Band saw – (Split into 2x halves) 5. Thickness/planner 6. 3-Axis mill x2 7. Biscuit joint & glue up 2x halves 8. Drill holes – 25mm x4 (Legs) 20mm x4 (Spindles) 9. Clean up (Sand)	305 x 500 x 30 (X2) 1: 200 x 500 x 30 2: 20 x 500 x 30 3: 83 x 500 x 30	1. 0.30 2. 1.00 3. 1.00 4. 0.20 5. 0.30 6. 5.12 x2 7. 1.00 8. 2.00 9. 3.00 --- Total: 19.45

Part B, C, D - Parts & Processes list
Source: Alex Key

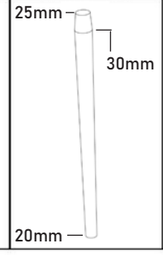
Part E: Centre Spindle

Material	Quantity	Part drawing	Process	Size (mm)	Time (Hours)
Ash	X1		1. Band saw 2. Lathe 3. Sand 4. Wedge cut 5. Drill hole for side spin 15mm	410 x35 x 35	1. 0.30 2. 1.00 3. 1.30 4. 1.00 5. 0.30 --- Total: 4.30

Part G: Side Spindle

Material	Quantity	Part drawing	Process	Size (mm)	Time (Hours)
Ash	X2		1. Band saw 2. Lathe 3. Sand 4. Drill holes for centre spindle 10mm	375 x 35 x 35	1. 0.30 2. 1.00 3. 2.00 4. 0.30 --- Total: 4.00

Part H: Front Legs

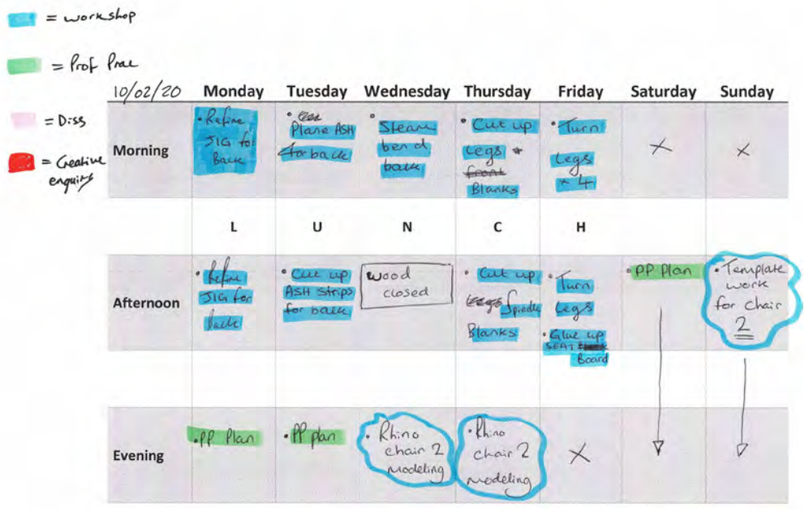
Material	Quantity	Part drawing	Process	Size (mm)	Time (Hours)
Ash	X2		1. Band saw 2. Lathe 3. Sand 4. Wedge slot cut 5. Drill hole for side spindles 15mm	430 x 35 x 35	1. 0.30 2. 2.00 3. 1.30 4. 1.00 5. 0.30 --- Total: 5.30

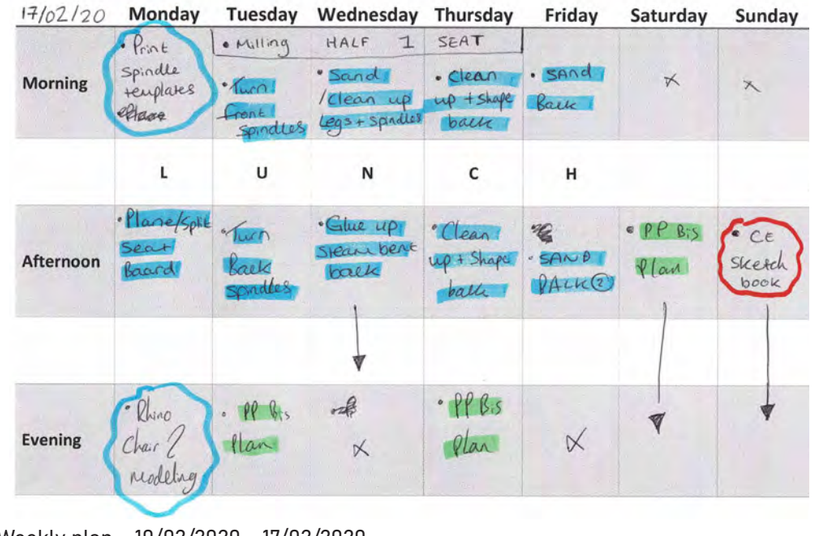
Part E, G, H - Parts & Processes list
Source: Alex Key

Making plan: 3.2 Weekly plan

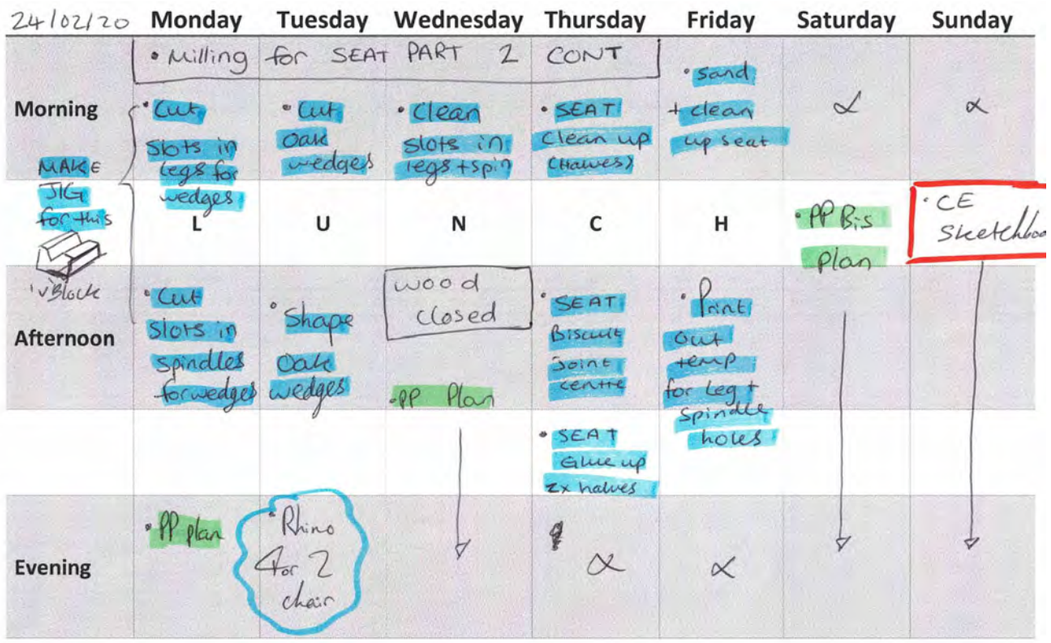
Using the parts and processes list outlined, I then used it to plan out how I was going to make the chair. This was exceptionally useful for me as it allowed me to be methodical and focused with the pieces I was making. This timetable meant I was more efficient and could see where this project was going. This was supported by the technical, orthographic and exploded diagrams as they all acted as visual aids.

This was a very beneficial process for me as it not only helped me keep track of how long this piece took to create but also how efficient I was being.

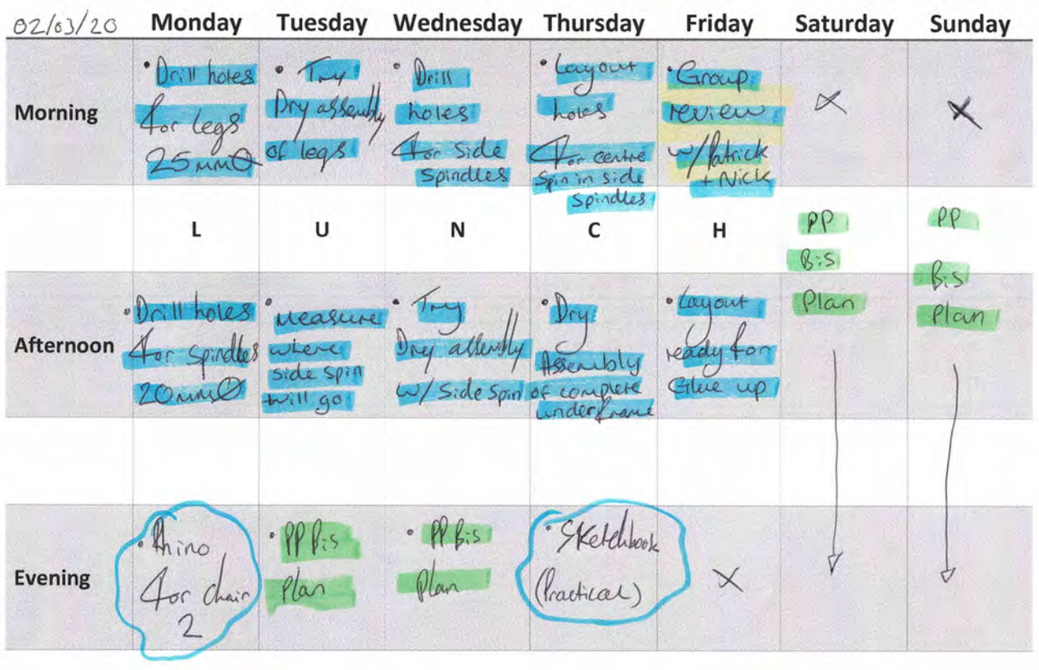




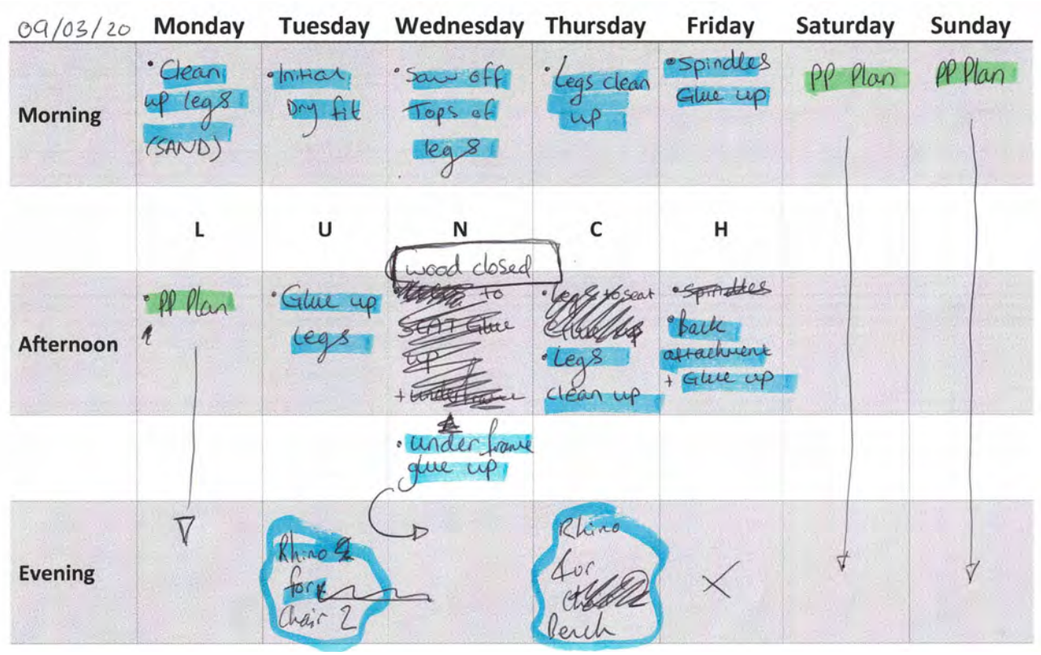
Weekly plan - 10/02/2020 - 17/02/2020
Source: Alex Key



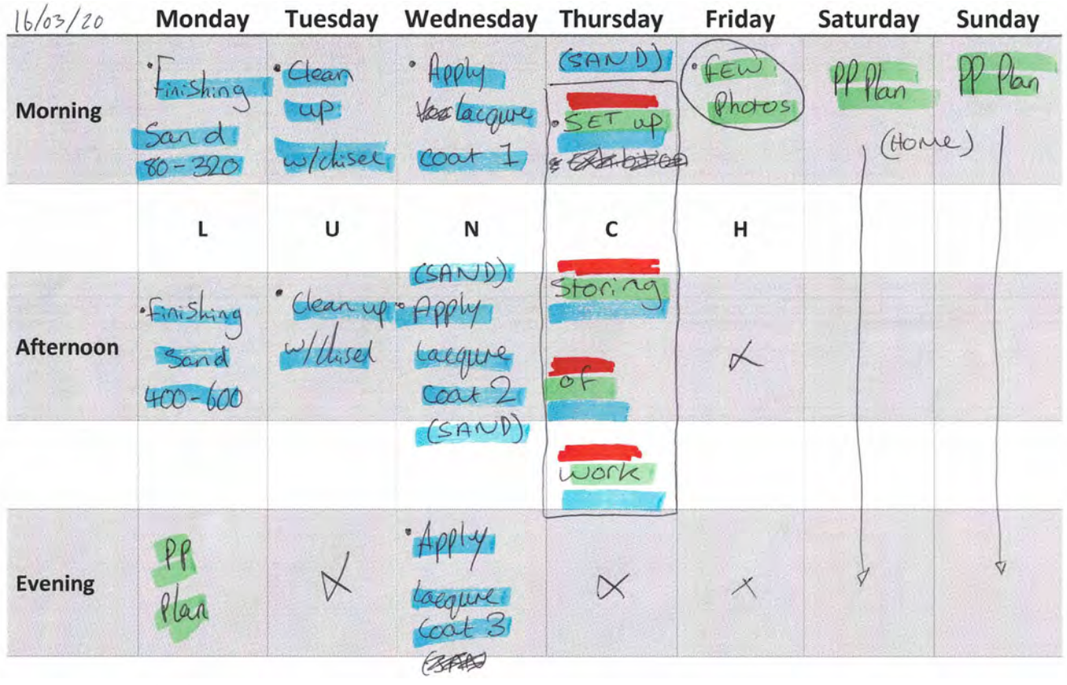
Weekly plan - 24/02/2020
Source: Alex Key



Weekly plan - 02/03/2020
Source: Alex Key



Weekly plan - 09/03/2020
Source: Alex Key



Weekly plan - 16/03/2020
Source: Alex Key

Chapter 4 – Resolution

JIGs & Templates:

- 1.1 Making the back steam bending
- 1.2 Turning templates

Mock-up:

- 2.1 Full-scale mock-up

Making:

- 3.1 Back
  - Steam bending the back
  - Glue laminating the back
- 3.2 Seat
  - Block glue up
  - 3-Axis CNC milling
  - Gluing together the two halves
- 3.3 Legs & spindles
  - Turning
  - Wedge slot cutting
  - Waste triming
  - Drilling holes
- 3.4 Assembly
  - Dry assembly
  - Shaping the arms
  - Attaching the back
  - Attaching the side spindles
  - Glue up
  - Sanding & Finishing

Final Photos:

- 4.1 Crest chair - Final photos
- 4.2 Alternate finishes
- 4.3 Proposed contexts

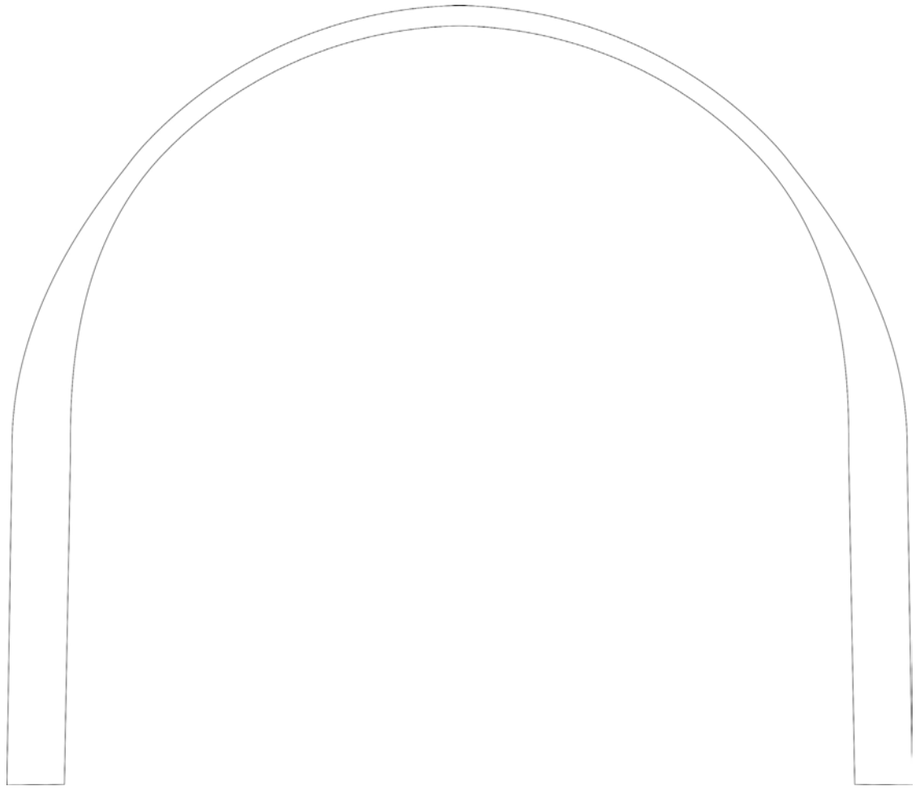
Further Designs

- 5.1 Crescent chair
  - Proposed design
  - Alternate designs
- 5.2 Crescendo bench
  - Proposed design
  - Alterntate designs

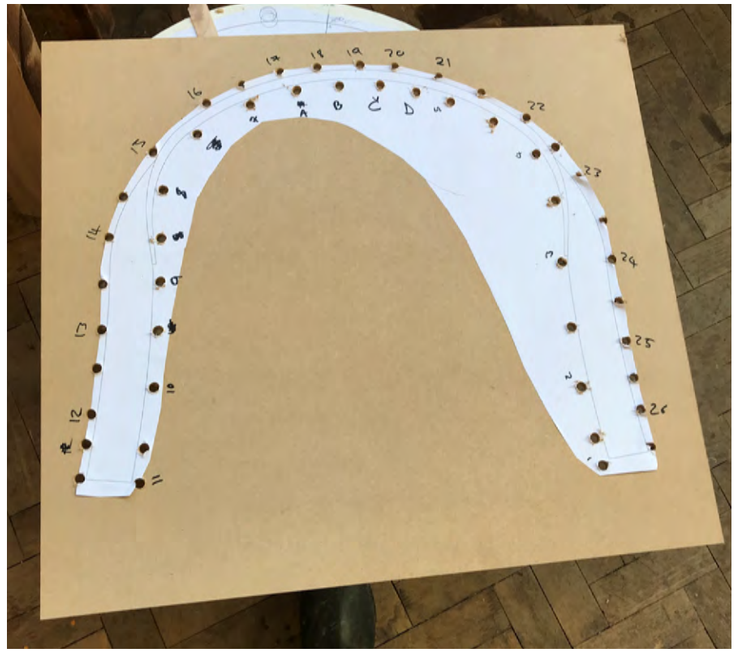
JIGs & Templates: 1.1 Making the back steam bending JIG

The first step to creating the Crest chair was to develop a former JIG to bend the back once it was steamed. The outline template was created from a 2D projection of the top view of the modeled back in Rhino 6 (See p102-106). This was to create an accurate and scaled template which I then built the holding blocks around.

One of the more complex blocks was the two part back compression one, this was cut at an angle (5 degrees) along the curve to create a more ergonomic back, an aspect I had researched earlier. (See p91-94)



Back steam bending JIG outline template from Rhino
Source: Alex Key



Back steam bending JIG - rough
Photography: Alex Key

Back block for steam bending JIG
Photography: Alex Key

Back steam bending JIG finished version
Photography: Alex Key

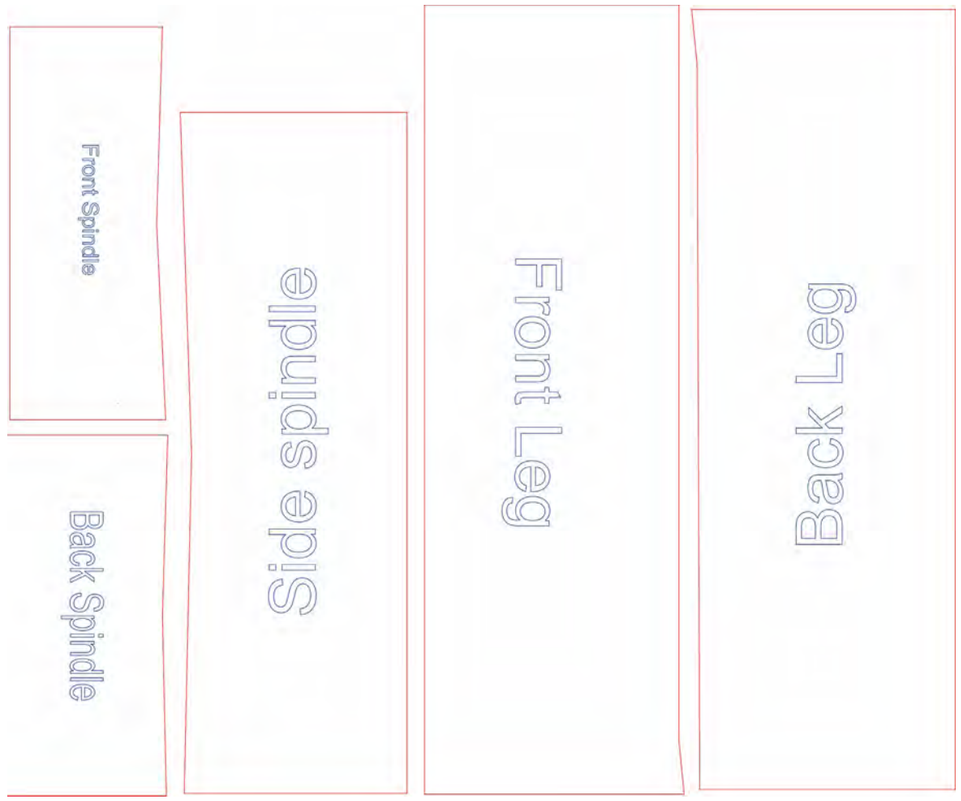
The benefit of this JIG was that it could be used in the steam bending process as well as the glue lamination later. This was beneficial as it meant that I did not have to create two separate JIGs for these processes.

However, if I had more time, I would have refined elements such as the side blocks as well as adding parts so it was easier for one person to use. I would also create another JIG for glue laminating which would have made the process more efficient, especially if I was making multiple. Alternatively, I could have made a custom vacuum bag which would have made glue laminating the back a lot easier as well as the layers tighter.

JIGs & Templates: 1.2 Turning templates for legs & spindles

Once the back JIG was complete, I created some shaping guide templates for the legs and spindles. These were to act as angle guides for when I was turning the parts on the lathe. I printed theses out and labelled the diameters at either end and centres, these measurements corresponded to the technical drawing (See p110). These templates were again created from 2D projections of the parts in a front facing view, making them accurate.

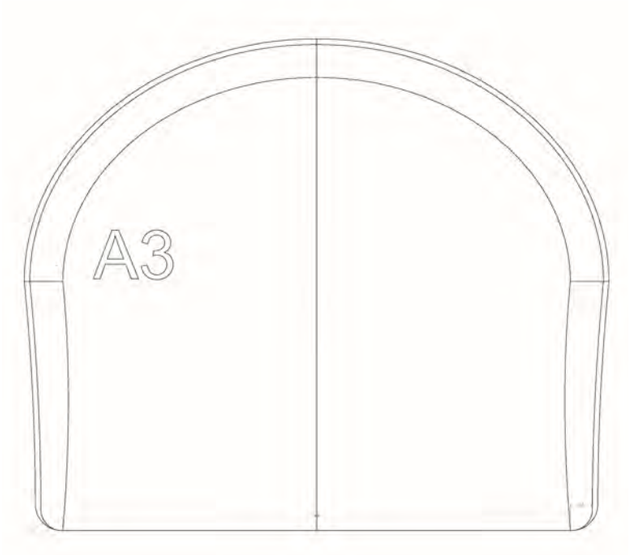
Overall, these guides were beneficial but could be improved upon, by adding some extra length to the templates to act as a guide for how much waste to add. This would allow my turning to be more accurate as well as quicker as I wouldn't have to keep guessing the length of waste to add.



Turning templates outlines
Source: Alex Key

Mock-up: 2.1 Full-scale mock-up

As I progressed with the making of this project, I decided to construct a full scale mock-up to quickly check that the dimensions such as height and seat depth as well as width were correct. This was using a 2D sketch I had made from the top view in Rhino, as well as an initial full-scale back test and some rough leg height blocks.



Full scale seat outline - rough mock up
Source: Alex Key

Full scale seat rough cut out
Photography: Alex Key

Leg height test
Photography: Alex Key

Rough full-scale mock-up
Photography: Alex Key

The result was an admittedly rough model, but it did benefit me by aiding me with the structure, height and angles. I decided that my initial dimensions were correct however I could add a little height to the spindles so that the back rest hugged your body more ergonomically. This was an easy alteration which I amended in the Rhino model as well as my technical drawing/parts list (See p102-115).

Making: 3.1 Back – Steam bending the back

The first part I made for the chair was the back, this was because it was the piece which would take the longest. To achieve the twist from the back to the arm rests I was using six 2mm strips of ash, which I had cut on the table saw. These were steamed then bent in the forming JIG and clamped in place. I was using thin strips because they were easier to bend and required less steaming time to become flexible - around 30mins at full temperature. This was all based on findings from my earlier research into steam bending and glue lamination.

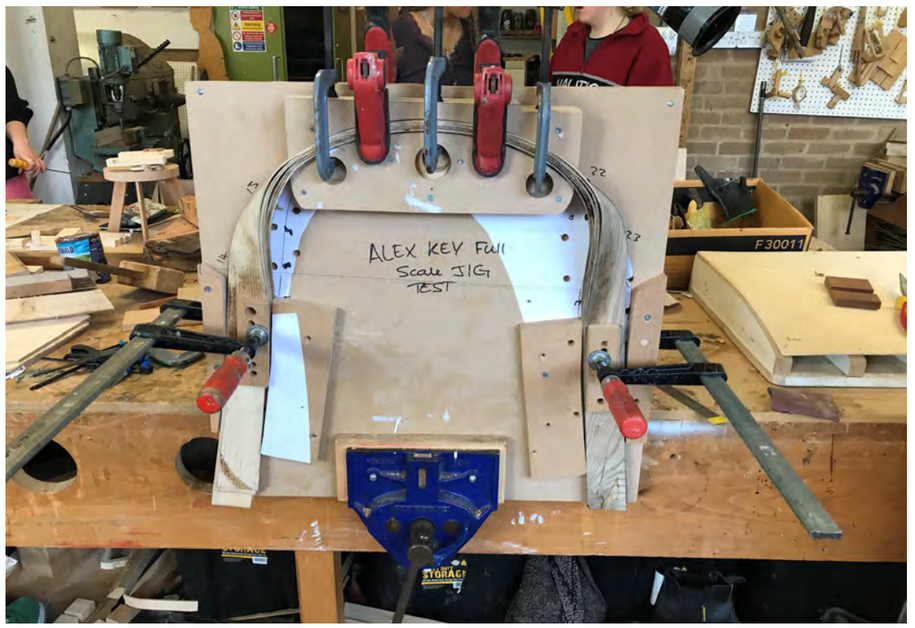
But the main reason I was using steam bending to shape the back was to achieve the very tight curve that I wanted where the back bends into the arm rest. Steam bending is a very traditional process in wood working which has seen a popular resurgence due to designers such as Tom Raffield.

Steam bender set up
Photography: Alex Key

Ash strips in steam bender
Photography: Alex Key

Ash strips in bending JIG 1
Photography: Alex Key

Ash strips in bending JIG 2
Photography: Alex Key



Ash strips in bending JIG 3
Photography: Alex Key

Making: 3.1 Back – Glue laminating the back

Once steamed and bent in the former I left the back to air for several days, this was for the wood to dry so it could accept the new shape. Once dried I then glue laminated the strips together using cascamite glue, this was because it gave me more working time (20mins) when compared to PVA (5mins). I then re-inserted the strips into the JIG and clamped them together and left it to cure/dry overnight - resulting in a rigid structure. I then cleaned it up using a spokeshave and sandpaper to get a clean curve.

Overall, I was happy with the outcome, however I think that I could find a better way of laminating the back together. This could be by putting the strips into a vacuum bag and using a vacuum pump to suck out all of the air compressing the layers together. This would reduce the clamps needed and would result in a tighter bond between the layers. I would explore this idea if I had more time and resources as I would have to develop the bag, as well as alter the JIG slightly.

Ash back glue lamination clamp up
Photography: Alex Key


Ash back glue lamination outcome 1
Source: Alex Key


Ash back glue lamination outcome 2
Photography: Alex Key


Ash back glue lamination clean up with a spokeshave
Source: Alex Key

Making: 3.2 Seat - Assembly & glue up

The next part I made was the seat, this was done by cutting up rough Ash into blocks with Oak dividing strips on the table saw. I used the measurements which I had outlined in my parts list to aid in getting them accurate. Once I had cut them to size, I then glued them together using cascamite as it has a stronger bond than PVA. Once the whole block was glued up, I then split it on the band saw to get two pieces for each half of the seat. This was due to the constrictions of the milling machine bed as it was only 400x500 wide, meaning I had to mill each half individually.

Rough timber being cut up into seat blocks using the table saw
Photography: Alex Key

Seat blocks being planned
Photography: Alex Key

Seat blocks planned
Photography: Alex Key

Seat blocks with oak inserts in place
Photography: Alex Key

Seat blocks glued up in sash clamps 1
Photography: Alex Key

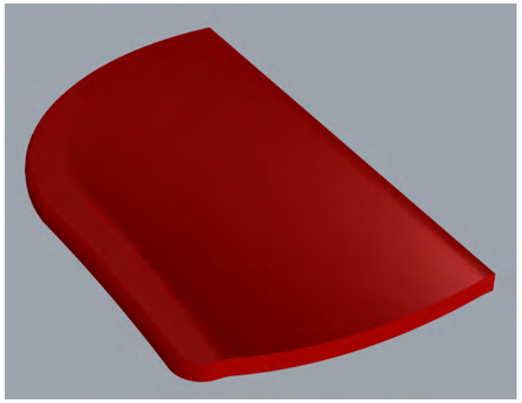
Seat blocks glued up in sash clamps 2
Photography: Alex Key

Seat full block being split on the band saw
Photography: Alex Key

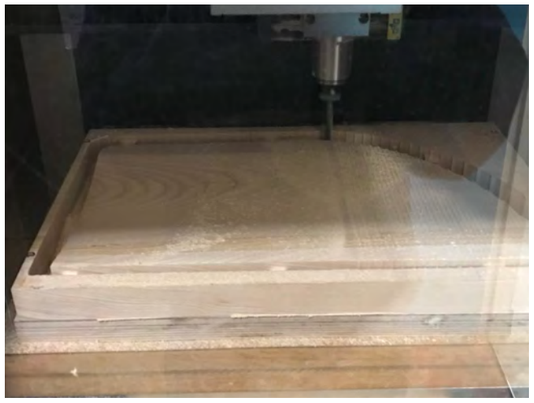
Making: 3.2 Seat - 3-Axis CNC milling

Once I had the two blocks, I then took them over to the CNC milling machine this took 5 hours per half. The reason it took this long was because of the fillet on the chair edge in the Rhino file, this meant it had to do more complicated passes resulting in a wait.

The reason I chose to use CNC milling for the seat portion of the Crest chair was because it is a process that I wanted experience with, but also because it allowed me to combine the digital and hand-making aspects of my technical skills. This resulted in a thinner seat than would have been possible by hand, as well as making the process more efficient in the long run.



Seat half in Rhino
Source: Alex Ke

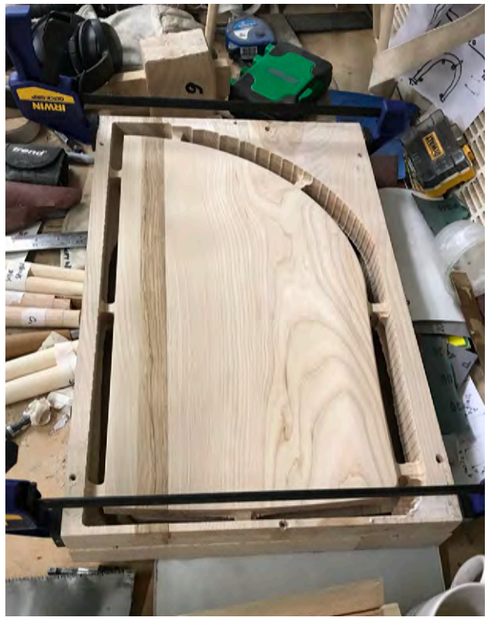


Seat top 3-axis milling
Photography: Alex Key

Seat bottom 3-axis milling
Photography: Alex Key

Seat bottom milling finishing
Photography: Alex Key

Milled seat half 1
Photography: Alex Key



Milled seat half 2
Photography: Alex Key

Milled seat halves 1 & 2
Photography: Alex Key

Overall, I was happy with the outcome of the milling, although if I was to produce this chair in production or again, I would aim to get it completed as a whole block. This would eliminate the join line and would make the piece overall more visually appealing. I would also explore using a 5-axis mill so that it could also do the holes for the legs and spindles, reducing inaccuracy.

Making: 3.2 Seat – Gluing the halves together

Once both halves had been milled, I had to glue them up, this was tricky because the halves were so thin. I decided to join them using biscuit joints, the reason for this was because the profile is thinner when compared to other joining methods such as dominos. The fact that they are thinner does not affect their strength as they expand during glue up. This expansion gave my seat the strength it needed to withstand a person's body weight. The glue I used was again cascamite for its strength, alternatively I could have used Titebond, which is a little weaker, but may have given me a cleaner join.

In future if I was to manufacture these chairs myself, I would seek out a milling machine which had a big enough bed to mill the seat as a whole piece. This would increase strength as well as make the piece more visually appealing as it wouldn't have to glue up two halves.

Biscuit cutter markings on joining edge
Photography: Alex Key

Biscuit cutter set up ready for the first cut
Photography: Alex Key

All the biscuit holes cut
Photography: Alex Key

Milled seat glued together
Photography: Alex Key

Making: 3.3 Legs & spindles - Turning

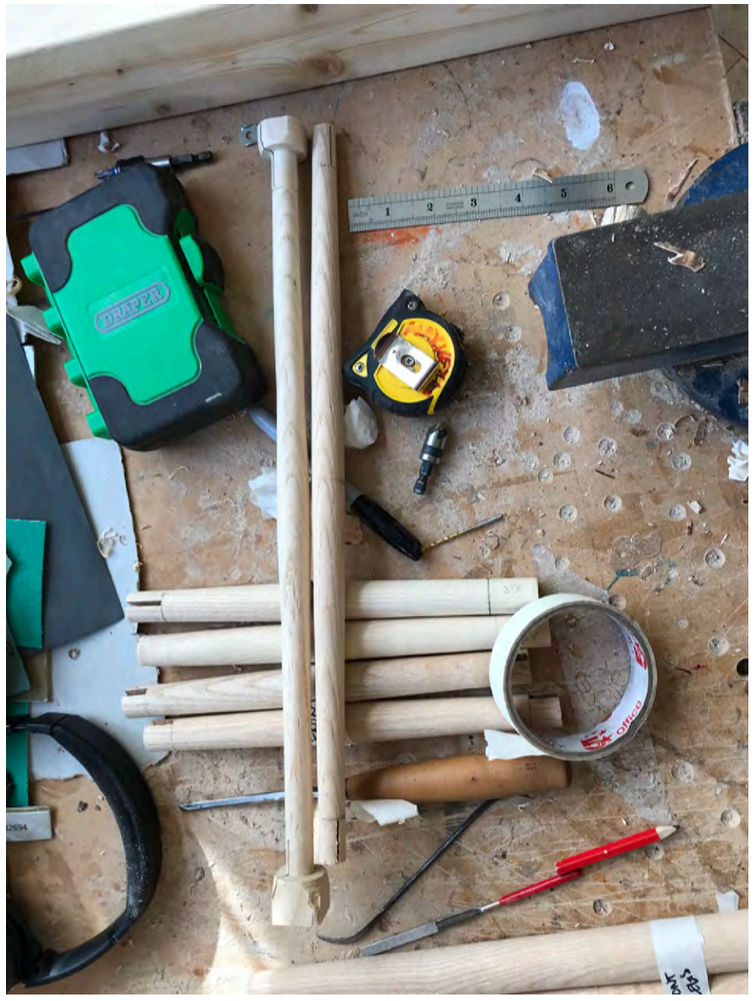
While the seat halves were milling, I turned the legs and the spindles on the lathe. I cut out the blanks for these using the band saw from the sizes which I had decided upon on in the parts list. Once cut out I marked the centres on both ends and started turning.

I turned in two phases, the first being rounding the blanks with the moving cutter through multiple passes. Once, I had rounded the blank I then used the templates (See p124) and tools such as the diamond-headed parting tool in combination with the digital callipers to turn the ends to specific diameters. I then used a skew chisel to turn the angled legs and spindles to the desired shape. Once shaped I then rough sanded using 80 grit sandpaper to clean up the overall shape and remove any rough shavings.

Rounding leg blanks on the lathe
Photography: Alex Key

Leg shaping on the lathe using a skew chisel & parting tool
Photography: Alex Key

Spindle shaping on the lathe using a skew chisel & parting tool
Photography: Alex Key

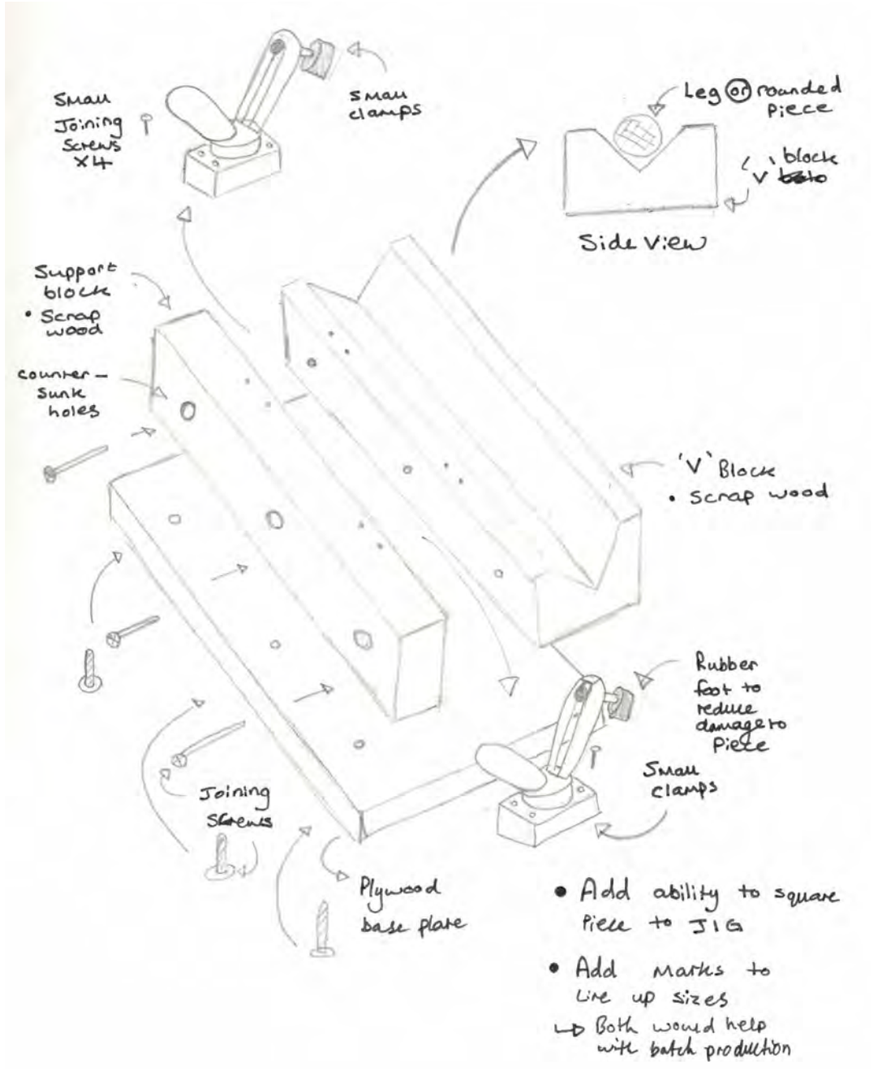


Back & side spindle outcomes
Photography: Alex Key

Leg, side & back spindle tests
Photography: Alex Key

Making: 3.3 Legs & spindles – Wedge slot

When I had finished turning all the legs and spindles I needed, I then cut out the slots for the wedges on the band saw. This was using a 'V' block JIG which I made, with the addition of small clamps to reduce the movement of the pieces. This was made using the angled blade on the table saw, which cut a 40 degree slot which the rounded piece sat in. Using this JIG I cut the wedge slot through a series of passes on the bandsaw, resulting in a 3mm slot.



Leg, side & back spindle tests
Photography: Alex Key

Wedge slot cutting on the bandsaw 1
Photography: Alex Key

Wedge slot cutting on the bandsaw 2
Photography: Alex Key

Making: 3.3 Legs & spindles - Waste trimming

Once I had cut the wedge slot holes in both the legs & the spindles, I then cut the off the waste at either end using the table saw. The reason I did this was to get a clean edge on the ends which would improve the aesthetics of the design as well as making all the pieces the correct lengths.

Leg waste removal on table saw
Phtotography: Alex Key

Spindle waste removal on table saw
Photography: Alex Key

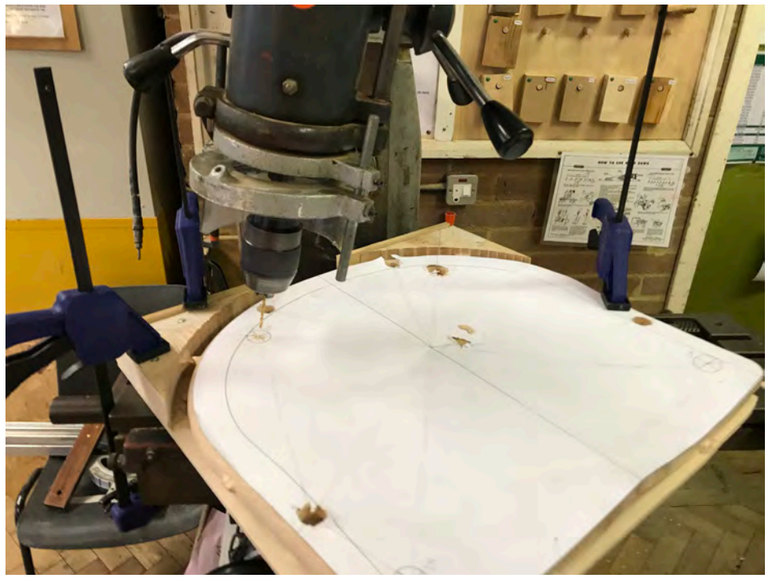
Making: 3.3 Legs & spindles - Hole drilling

Once the two halves of the seat were dried, I then drilled the holes for the legs and the spindles. The leg holes were 25mm and the spindle holes were 20mm, each having a pilot hole drilled at 3mm. I referred back to my parts list (See p113-115) which instructed the angles I had to tilt the drill head to in order to achieve the correct lean.

This was a difficult process which required not only lining up the drill with the centre but also rotating the seat to the correct angle on the bed. I clamped it to the bed for security, however if I was to do it again, I would develop a JIG to hold the seat at the right angle on the bed and in relation to the drill. This would result in the ability to consistently drill the hole correctly in multiple seats as well as being a sturdier clamping surface.

Front leg pilot hole (3mm) being drilled
Photography: Alex Key

Back leg pilot hole (3mm) being drilled
Photography: Alex Key



Back leg pilot hole drilling set up
Photography: Alex Key

Front leg hole drilling (25mm)
Photography: Alex Key

Front spindle hole drilling (20mm)
Photography: Alex Key

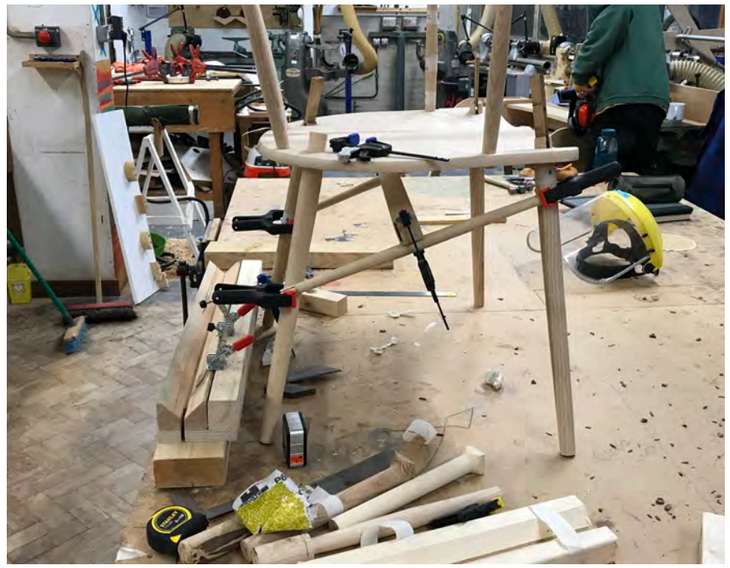
Making: 3.4 Assembly - Dry assembly

I did a dry assembly throughout the drilling process, to assess how it was visually looking as well as to reduce errors. This was also a confidence check for me as it allowed me to see that I was accurately making the spindles the same distance from the centre as well as the correct angle.

Laminated back dry test attachment to spindles
Photography: Alex Key

Full body dry assembly 2
Photography: Alex Key

I then carried onto asses the angle of the side spindles for my piece, I roughly placed them where I thought they would look good and be structurally strong. This was a good test as it allowed me to quickly alter the angle if I needed to. What I did discover from this was that I had turned the side spindles too thin, this was me miss reading the technical drawing. Once re-turned I offered them up again and marked the area to drill resulting in a stronger structure.



Side spindle angle test
Photography: Alex Key

Full body dry assembly 3
Photography: Alex Key

Making: 3.4 Assembly - Attaching the back to the spindles

To attach the back to the spindles I had to hand drill a hole in the spindles and shape them to the angle of the back. The diameter was 8mm as that kept strength, but also didn't visually disrupt the piece. I then cut them to the desired depth and shaped them to fit the angle of the back. Once they fitted together, I then used the first hole as a guide to drill through into the back. Once drilled I cut an Oak dowel oversized to fit through the holes. Overall, this joining method was perfect as it met my desired criteria of being aesthetically pleasing as well as structurally sound.

Back joining holes (8mm) in back spindles
Photography: Alex Key

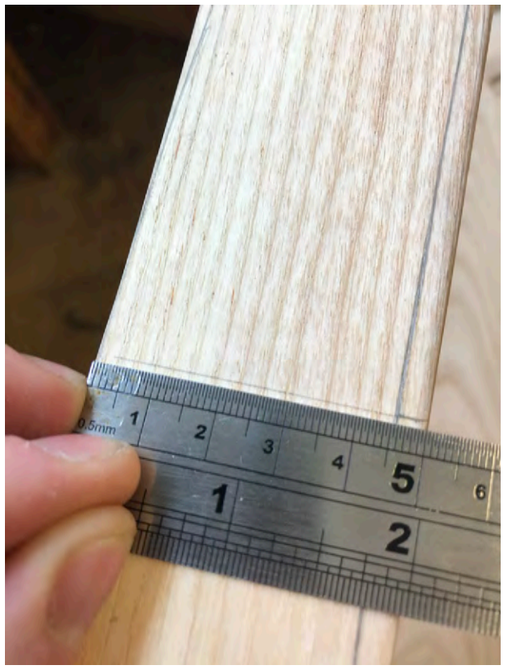
Back spindles dry assembly
Photography: Alex Key

Back joining holes marking
Photography: Alex Key

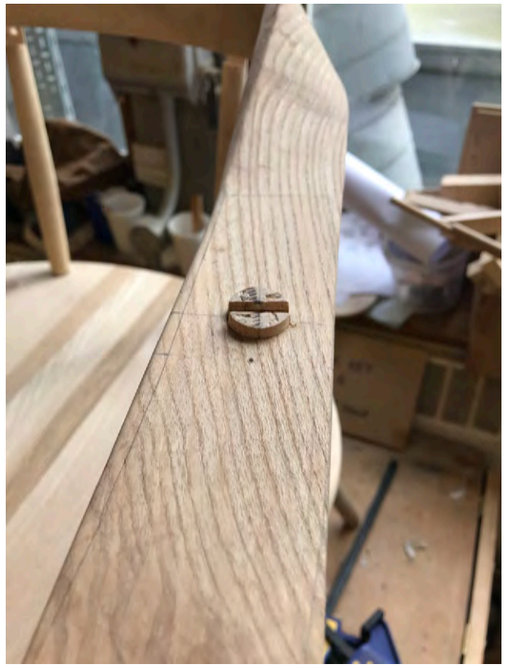
Back joining hole drilled (8mm)
Photography: Alex Key

Making: 3.4 Assembly - Attaching the front to the spindles

In order to attach the back to the front spindles I used the arm shaping template to mark out where the spindles would attach to. I then measured the width of the arm and marked the centre. Once marked I drilled 20mm hole for the spindle using the pillar drill. This was a quick and easy process which lead to a joint which was visually in line with the piece as well as structurally sound which was beneficial.



Arm joining hole measure & marking
Photography: Alex Key



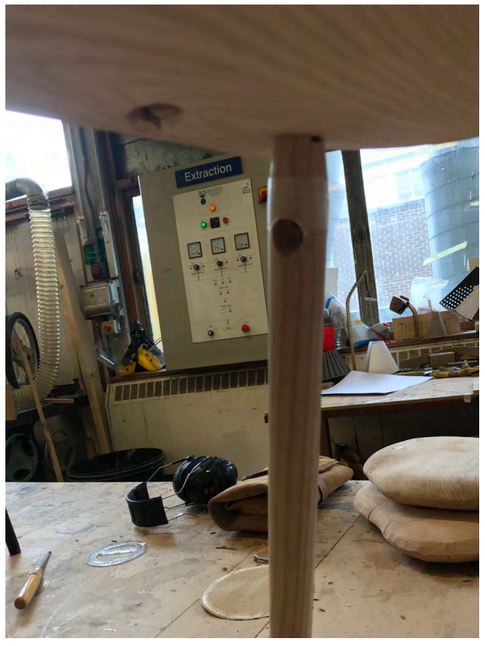
Front spindle wedge joint
Photography: Alex Key

Making: 3.4 Assembly - Adding the side & centre spindles

I next moved on to attaching the side spindle onto the inside of the legs, this was following the marks I made earlier. These were done by free hand using a power drill due to the sharp angle. I started by drilling a hole in the front legs of 15mm then drilling a 10mm hole in the back. The trick here was to make the side spindle just big enough to hold it in place via the legs compressing against it, but not too big that it splits them.

This was a series of trial and error to fit it between the two legs which took time and care. Once done I then drilled another 10mm hole in the centre of the side spindles which would house the centre spindle. The same trial and error applied here in order to not push the legs out too far.

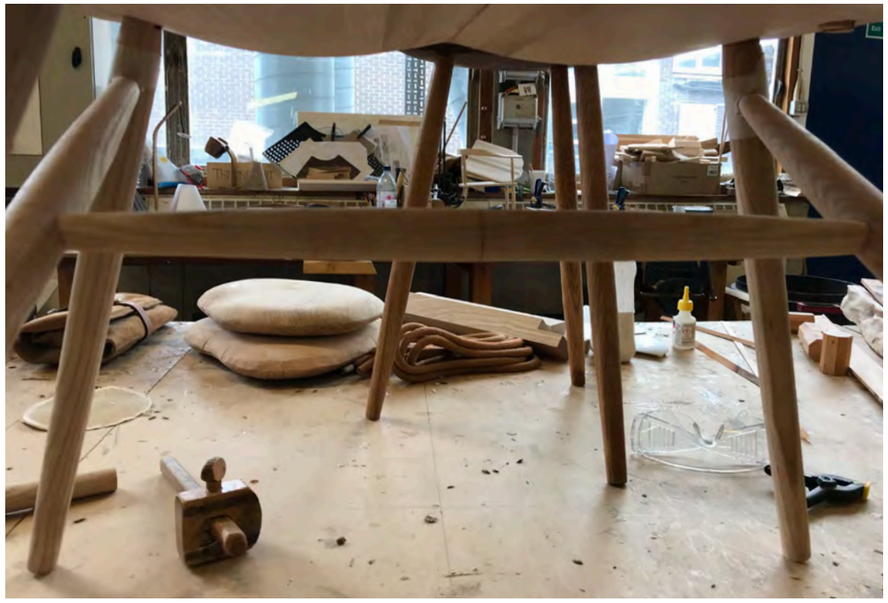
Leg marking up ready for drilling
Photography: Alex Key



Side spindle top hole drilled (15mm)
Photography: Alex Key

Side spindle lower hole drilled (8mm)
Photography: Alex Key

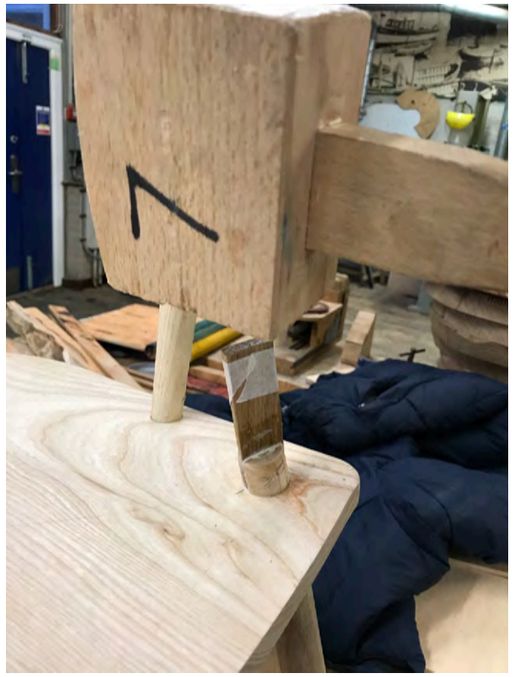
Side spindle dry assembly
Photography: Alex Key



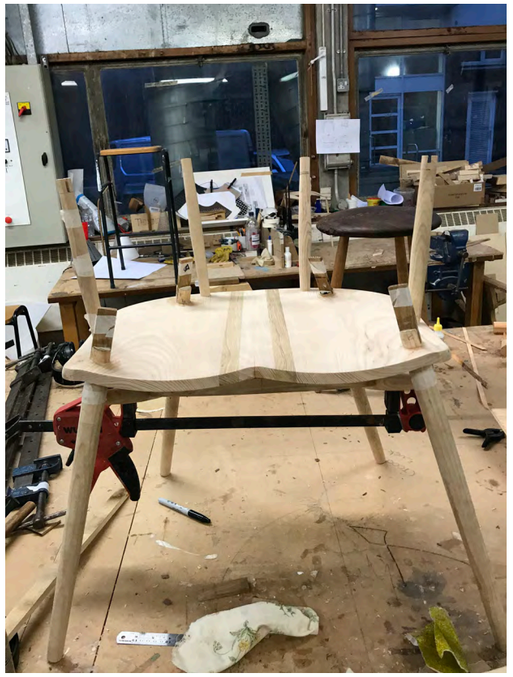
Centre spindle holes drilled & dry assembly
Photography: Alex Key

Making: 3.4 Assembly - Gluing up the chair

Once I had completed all of the various holes which I had to drill so that all of the individual parts of the chair could be assembled, I then turned my attention to gluing it all together. I started with the legs which were joined to the seat using glue and hammering in a wedge joint, which is a very traditional joining method in chairs. The reason I decided to use it was because it is very structurally strong, meaning that it will be able to support the weight of a human. I also decided to make the wedges out of Oak so that it complimented the Oak stripes in the centre, this was a conscious design decision which I feel elevated the piece visually.



Oak wedge being hammered in
Photography: Alex Key



Oak wedge joints glued and hammered in
Photography: Alex Key

3/4 leg tops sawn off
Photography: Alex Key

All leg tops sawn off
Photography: Alex Key

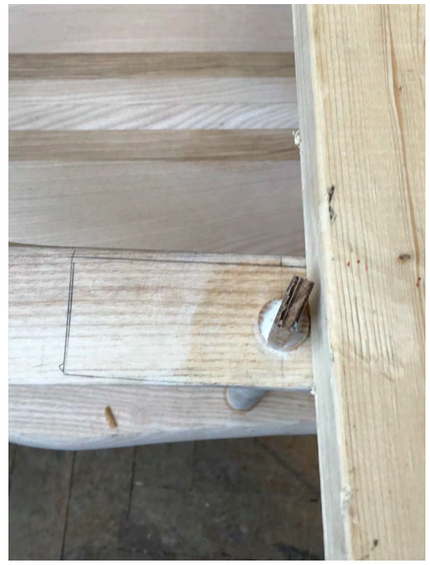
After the wedge joints were dry I then cut off the waste on the tops, this was to make them flush with the seat in order for it to be ergonomically comfy and visually in line with the rest of the piece. This was done using a flush saw in conjunction with a chisel and sandpaper to reduce the damage of a power tool such as an orbital sander.

Centre spindle glue up
Photography: Alex Key

I then continued to glue the side and centre spindles on the underside of the chair. The joining method between these pieces was just a tight fit between the end and the hole with the addition of glue. These joints were held in by tension and compression, which was an aspect I had initially explored at the start of this project.

Once the underside of the chair was complete, I turned my focus towards the front and back spindles. These were attached to the seat and arm rest using wedge joints again, this was because they gave more strength to the structure as well as continued the complimentary aspect of using Oak wood. When dried I then cut the waste off and cleaned them up with a chisel.

Spindles wedge jointed & glued
Photography: Alex Key



Back attached to front spindles wedged & glued
Photography: Alex Key

Front spindle tops sawed off
Photography: Alex Key

On attaching the back and front spindles to the seat as well as the arms portion of the back I then joined the back spindles to the back piece. This was done using Oak through dowels, which was again a decision to keep it aesthetically in line with the rest of the piece but also to add some strength to the connection as the lap joint alone would not have held it tight.

Back to back spindles glue up
Photography: Alex Key

Oak through dowel - Finished
Photography: Alex Key

Straightening block for back glue up
Photography: Alex Key

Making: 3.4 Assembly - Sanding & applying finish

After the glue up was complete, I then started to clean up the piece ready for a finish to be applied. I started sanding down the piece using 80 grit sandpaper, this was to remove any deep scratches and imperfections. I then continued all the way up to 320 to get a consistent, smooth and clean finish. This took quite a long time as there was a lot of tight spaces and difficult angles, however it was worth it as it visually improved the piece.

Sanding down - 80 to 320 grit
Photography: Alex Key

Finishes sample board - Clear coat lacquer, danish oil & wax
Photography: Alex Key

Once having gone up to 320 grit I then compared a variety of finishes, from water-based lacquer to Danish oil. I want to see what these finishes looked like visually when applied to ash wood. This sample board helped me decide on a water-based lacquer as a finish for the whole chair. Which I then applied and when dried sanded over again at 320 grit, then applied another layer, repeating 2 hours later. The reason I chose clear coat lacquer was because it is a durable finish which will not rub off after constant use, but it also brings out the grain and shows off the natural colours of the Ash wood which helps in showing off the limits to which I have pushed Ash to in this project.

Applying clear coat lacqure (Coat 1)
Photography: Alex Key

Applying clear coat lacqure (Coat 2)
Photography: Alex Key

If I was to take this to market, I would have spray applied the finish, this would have given a more consistent finish overall and would have reduced sanding times. I would have also finished the original wood to a higher grit as that would have removed more hairline scratches and marks finishing it to a higher standard overall.

Final outcome: 4.1 Crest chair photos

This is the final outcome for the Crest chair, which achieves at pushing Ash as a material to its limits, by using digital and hand-crafted methods of making.

The digital aspect of this project is evident throughout, in aspects such as the design development, to the CNC 3-Axis milling of the seat for the piece. It helped me develop accurate JIGs, such as the back steam bending JIG being made from a 2D template of the back, and templates which increased my efficiency and execution of the chair.

The other side of this project was the hand-crafted skills which were complimented by the digital in the making of this chair. They required planning as well as knowledge which was complimented by the development using the computer and 3D modelling software. Overall showing that it doesn't have to be one or the other, instead there can be a harmony between the digital and hand-crafted methods of making.

Crest chair final photo 1
Photography: Alex Key

Crest chair final photo 4
Photography: Lauren Hurley

Crest chair final photo 5
Photography: Alex Key

Crest chair final photo 3
Photography: Alex Key

Me in the Crest chair
Photography: Alex Key

Overall, I was pleased with the outcome of this piece, I think it visually looks great as well as is structurally sound. The seat and arm rest are also shaped nicely making them ergonomic and comfy to use. Although there are some aspects, I would refine such as the JIGs used in the making as well as the finish, which would be improved if I was to take it to market.

This chair could easily belong in a commercial setting, or in a client's home, although aspects like making time and price would have to be refined to achieve true commercial viability.

Final outcome: 4.2 Crest chair alternate finishes

This project was specifically about pushing Ash to its limits, however if I potentially took the Crest chair to a maker/distributor - E.g. Benchmark, then I could explore other material or finishing options. This was easy and quick to experiment with in Rhino as you can apply different materials to the model, I tried Walnut, Oak as well as coloured parts combined with Ash.

Crest chair Walnut edition
Source: Alex Key

Crest chair Oak edition
Source: Alex Key

Crest chair Ash & green edition
Source: Alex Key

Crest chair Ash & blue edition
Source: Alex Key

These variations were all very interesting, I especially liked the Walnut edition as the piece looked visually impacting in a darker wood. However, I was not so keen on the Coloured editions as they made the piece look a little more childish, although this playful use of colour did make them very eye catching. Overall, this is an interesting line of enquiry which I will continue to pursue and explore if I am to take this piece and the others to market.

Final outcome: 4.3 Proposed contexts

Due to unforeseen circumstances I could not get any photos of the Crest Chair in a contextual setting. However, I did mock-up two potential contexts for the Crest chair, using some room models sourced from the Sketchup free models library. These contexts were a modern living room and kitchen, which saw multiple Crest Chairs laid out in situ.

Crest chairs set in the living room
Source: SketchUp model library

Crest chairs in Walnut set in the kitchen
Source: SketchUp model library

I chose these contexts because this is where I could see the chairs being most practical. The style of the design could easily fit in a modern lounge as well as the kitchen, fitting nicely under a dining table. However, the only issue I could see with these designs being used in these contexts would be comfort during prolonged use. To counter this, I would add a small leather cushion to the seat and back of the design, which could be in a contrasting colour such as black or a more complimentary tan.

Further designs: 5.1 Crescent chair - Finalised design

The second chair that I wanted to make after the Crest chair was the Crescent chair, this was a three-legged chair which also had the arm rest shape inversed. The idea being that the new back rest would be a more welcoming and open shape. These differences were subtle but still kept the piece feeling with in the same visual family as the previous Crest chair.

The aspect which I thought was the most visually strong in this piece was the wish-bone shaped back leg. This took direct visual inspiration from the wishbone chair by Hans Wegner as well as the Danish & Scandinavian furniture design movements (See p83-85). These are strong influences on the design, but I have added some of my own flare as a designer-maker.

Another strong aspect of this design is the fact that it would reuse the back JIG from the Crest chair but alter it slightly, as well as the same seat shape for the CNC milling. Although I would add a different accent wood such as Walnut or Cherry, which would differentiate the pieces as well as create different visual details.

Crescent chair - Silhouette render
Source: Alex Key

Top View

Perspective View

Front View

Right View

Crescent chair - Orthographic render
Source: Alex Key

Further designs: 5.2 Crescent chair – Alternate designs

Before I landed on my final design I also tried some other variations with some slight alternate details. The first being a render of the chair in Cherry and the back leg being a single turned one. The reason I didn't take this design forward was because the back leg would not have been stable enough, resulting in it falling over. Although, I did like the design of the under frame as it was structurally strong but also kept in line aesthetically with the piece.

I then continued to explore this design by changing the back into a more double crescent shape. While I did like this aspect, it didn't really fit in with the Scandinavian and Danish style design of the piece, it also to me didn't look very structurally sound which would have been a problem for the functionality of the piece.

Crescent chair alternate design 1 - Cherry render
Source: Alex Key

Crescent chair alternate back design 2- Ash render
Source: Alex Key

Crescent chair alternate arm/back rest 3 - Ash render
Source: Alex Key

As I neared closer to the final design I also experimented with maintaining the same back to arm rest design that I had in the Crest chair. While it fits with the design visually, it doesn't differentiate the designs enough. While this could be a good variation in the future, I think the inversed back makes the piece look more visually appealing and is in fiting with the rest of the design.

I also experimented with the final design in Walnut to see if a material change would change the piece in any way. While I like the piece in Walnut, it would be too expensive for me to make at this current stage in my career. This edition would be better as a bespoke commission as if I was to sell it through a shop they would mark up my already high material/making cost making the price unappealing.

Crescent chair final design Walnut
Source: Alex Key

Futher designs: 5.3 Crescendo bench - Finalised design

The second of my finalised designs was the Crescendo bench, this was a design which would seek to push the limits of Ash on a bigger scale. For this bench I opted for a few of the back spindles to go through the seat this was to add strength to the structure as well as to act as a slight visual alternative to the other designs.

These extended spindles would fit into a curved underframe, which would further strengthen the design. The curved underframe reflects the arm to back curve on the top, this visual continuity is something which ties this piece together. The reason for the positioning of the underframe is so that it joins into the thickest part of the leg increasing strength. It's also held in place with a smaller spindle which connects it to the back leg, adding stability but also visually connecting the piece.

Overall, this design continues the ideas of the project by pushing Ash as a material, just on a larger scale. This also would continue the line of enquiry of exploring the combination and relationship between digital and hand-crafted techniques, by exploring larger CNC machining as well as turned elements.

Crescendo bench - Silhouette render
Source: Alex Key

Top View

Perspective View

Front View

Right View

Crescendo bench - Orthographic render
Source: Alex Key

Futher designs: 5.4 Crescendo bench - Alternate designs

I also experimented with a different style of bench before landing on my chosen design, that style was more 'S' shaped. This saw the back being one long bent piece which curved around the backs of the seats. This curved profile was reflected in the under frame, being one long piece also, which weaved between the centre two legs.

This design also had back spindles which went through the seat to the underframe, this was to increase rigidity and strength. The reason I didn't take this design forward was because it felt like two chairs and not a bench. It was aslo the potential fragility of the centre joining 'wishbone' component that also resulted in me not taking this design forward.

Crescendo bench alternate design 1 - Rendered in Ash
Source: Alex Key

Crescendo bench alternate design 2 - Rendered in Ash
Source: Alex Key

I continued to explore the idea of a bench but decided to shift my ideas to a long double seat design, seeing the peak move to the centre of the design. However, I kept the extended back spindles in the design for strength, but also implemented side spindles similar to the initial Crest chair, which was a more simplistic alternative to the initial design.

I also experiment with this design in a different material, Walnut. This gave the piece a more distiguished and classical style complimented by the traditional english profile of aspects such as the legs, which were inspired by Ercol (See p85). However, while looking nice this variation ultimately fit the brief I had outlined for myself.

Crescendo bench finalised design in Walnut
Source: Alex Key