INTERNATIONAL
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Design of a Do-It-Yourself Kneeling chair

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SCHOOL OF ECONOMICS, BUSINESS ADMINISTRATION & LEGAL STUDIES

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I hereby declare that the work submitted is mine and that where I have made use of another's work, I have attributed the source(s) according to the Regulations set in the Student's Handbook.

March 2018
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Abstract

This dissertation with topic “Design of a Do-It-Yourself Kneeling chair” was written as part of the MSc in Strategic Product Design at the International Hellenic University.

The aim of this thesis was to investigate the feasibility of a “Do-It Yourself” Kneeling Chair concept by designing and constructing such a chair as well as testing people’s ability to build it themselves with readily available materials and tools, indicated by instructions in adequate form. The ultimate goal was to make this chair reachable to all users, through the DIY process. The main result is not the chair per-se, but the documentation – instruction manual of how to build it along with the empirical demonstration of the concept.

Firstly, it was conducted a market research on DIY furniture and on the kneeling chair itself. Then, it was made historical and morphological analysis of the chair. Product and target specifications were established. There was concept generation through sketches, prototyping and testing through users’ experience. Finally, the evaluation of the last phase led to the final concept proposal, accompanied with the proper documentation.

I would like to thank my supervisor, Dimitris Nathanael, for his excellent guidance and support during this process. He was always available and willing to answer my queries.

To my classmates and friends: I would like to thank you for your cooperation as well. Without your help I would not have been able to complete this project.

Christine Chopteridou

23/03/2018

Contents

Introduction

The introductory part that follows refers to the kneeling chair concept and the DIY trend.

Fundamentals of seating

"The purpose of a seat is to provide stable bodily support in a posture that is:

(i) comfortable over a period of time.

(ii) physiologically satisfactory.

(iii) appropriate to the task or activity in question.

All seats are uncomfortable in the long run, but some seats become uncomfortable more rapidly than others, and in any particular seat, some people will be more uncomfortable than others." (Stephen Pheasant, 1986).

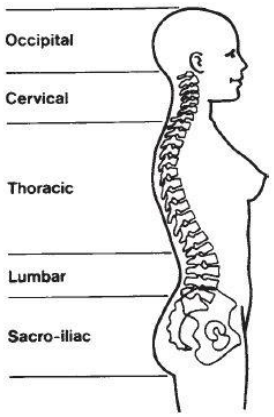


Figure 1

The spine is a flexible structure, the configuration of which is controlled by many muscles and ligaments (Figure 1).

The well-formed human spine presents a sinuous curve when viewed in profile.

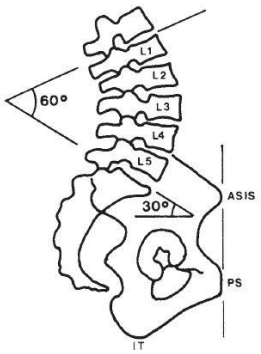


Figure 2

In the upright standing position, the pelvis is more or less vertical, and the first lumbar vertebra and sacrum make angles of about 30° above and below the horizontal respectively (Figure 2).

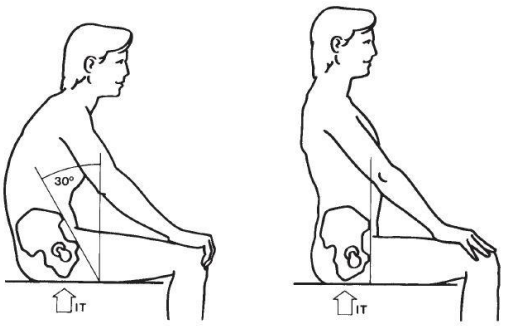


Figure 3

In relaxed sitting (Figure 3, left) the pelvis rotates backwards, and the spine is flexed. This is considered to be a bad thing, since the flexion of the spine causes the deformation of the intervertebral discs. To sit up straight (Figure 3, right) requires muscular exertion to pull the pelvis forward.

In seat designing therefore, the objective is to support the lumbar spine in its neutral position without the need for muscular effort, in order to allow the user to adopt a position that is physiologically, satisfactory and comfortably relaxed. Experimental studies by Andersson (1974) and Grandjean (1988) affirm that a seat that allows the user to adopt a semi-reclined position minimize the mechanical loading on the lumbar spine and maximize the overall levels of reported comfort (both for users who suffer from back trouble and for those who do not), (Stephen Pheasant, 1986).

Forward tilt seating

Recently a radical new approach to seat design has been proposed. Mandal (1976, 1981) claimed that the seat surface should slope forwards, in order to diminish the need for hip flexion (specifically in tasks such as typing and writing) and encouraging lumbar lordosis.

Most of seat designs now incorporate a tilt mechanism (Figure 4).

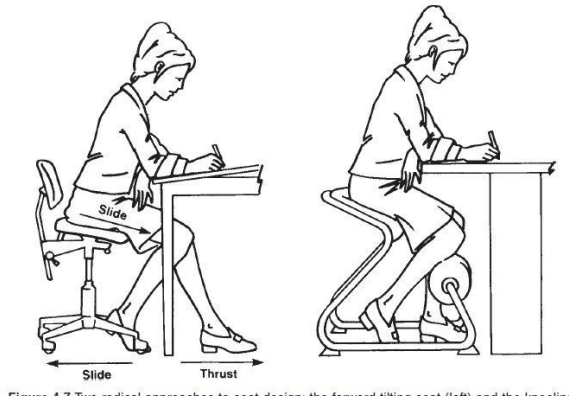


Figure 4

Balancing correctly on the forward slope seat is a skill that needs to be learned. The user must exert a backward thrust with the feet in order to stay in the seat and don't slip out (Figure 4, left). This difficulty is overcomed with the 'kneeling chair' which provides a seat sloping forward at 30° to the horizontal, combined with a padded support for the knees (Figure 4, right).

On one hand, scientific studies on the matter, do not support the theory that the kneeling chair offers any particular advantages, as compared with a well-designed, conventional chair, either with regard to sitting in general, or with regard to office use in particular. On the other hand, however, one must also add that on the basis of clinical experience, it is quite clear that some people who suffer from back trouble find the kneeling chair very helpful. And those back-pain patients who like the kneeling chair, they often like it very much indeed.

What's more, body pains are associated with sitting in the same position for too long. By alternating your sitting routine between the kneeling chair and the standard office

chair, you can expect an important improvement in your body posture (Jon Muller, 2018).

Do-it-yourself (DIY) trend

“DIY is described as the method of building, modifying, or repairing things without the direct aid of experts or professionals. Academic research describes DIY as behaviors where "individuals engage raw and semi-raw materials and component parts to produce, transform, or reconstruct material possessions, including those drawn from the natural environment. DIY behavior can be triggered by various motivations previously categorized as marketplace motivations (economic benefits, lack of product availability, lack of product quality, need for customization), and identity enhancement (craftsmanship, empowerment, community seeking, uniqueness).” (Wikipedia, 2018).

Today, despite the negative facts that the economic crisis has emerged to our society, it has also triggered a trend of creativity and imaginativeness. Most of us have changed our old consumer habits and found alternatives which are more economical, but not lacking in quality and functionality.

Many people today prefer to learn how to make something on their own, either by asking those who know or by researching the internet, rather than buying it from a store. Also, more and more people want to repair or convert their old or damaged items, rather than throw them in the rubbish and get new, as it is common in oversized societies.

This trend also raised since the increase of the environmental awareness and awareness of the ecological problems of our planet. So, there are everywhere available ways and ideas to recycle materials and turn them in useful and beautiful objects instead of throwing them in the rubbish.

DIY Consumer Profile

It's difficult to create an accurate DIY consumer profile because there are buyers from multiple generations, incomes and geographical regions.

Nearly 50% of DIY consumers are female. 52% are 24 - 44 years old and are driven by life changing events such as buying a home, getting married or having a child. DIYers ages 35 – 54 are usually driven by the desire to increase energy efficiency and consumers over 55 deal with projects concerning household repairs.

In general, DIY consumers have a desire for being creative and active and they perceive handicrafts as a form of relaxation and enjoyment. They have a need to personalize, help the environment and save money at the same time. The DIY consumer is here and growing, regarding Zach Williams.

DIY furniture market

Home improvement such as renovating and remodeling one's home is the key segment and also the largest segment in the global DIY furniture market. The global DIY market is growing, and this growth is mainly supported by the media presence, through television or the online presence in the form of video websites or social media. Online platforms such as YouTube, Pinterest, various crafting outlets and blogs are sources of DIY projects, tutorials and how-to videos. Every individual can share his/ her project/ experience with the world, give feedback or receive a review.

The most popular DIY furniture projects are various types of tables (dining, coffee, side tables), shelves, storage cabins, chairs and benches, beds, sofas and desks.

The main materials used in all aforementioned projects are wood and screws/nails. The most essential tools for building them are: tape measure, cordless drill, kreg jig, clamps, miter saw, nailer, orbit sander.

DIY - Kneeling chair project

It is a fact that the keeling chair, considered an ergonomic chair, is overpriced. The lack of its availability in the market in combination with the high cost of the available offerings (50 – 700€) were perceived as an opportunity for developing a kneeling chair DIY project.

Existing products in the market (including DIY projects):






Source: Pinterest images

Kneeling chair Analysis

Historical facts

The Kneeling chair was born from Hans Christian Mengshoel in the late 1970's. For centuries, similar postures have been adopted by the tibetan monks for prayer rituals who used a Seiza bench for meditation and prayer. Although Seiza benches place a lot of pressure on the knees, it was proved to be much more comfortable because the forward sloped seating angle encourages a natural posture and opens up the gap between the torso and thighs. This made meditation pain free and more effective because the curvatures of the spine were correctly aligned.

The studies of a Scandinavian doctor, called Ac Mandal, during the 1960's-70's on the postural changes which occurred on a forward tilted seat compared to regular seating, proved that the curvatures of the spine were better balanced and his patients showed a significant reduction in back pain.

Flexion (the forward bending of the hips) is common when we sit. An everyday example of this is bending over a desk when we write.

If a seat has a slope of about 15 degrees, the pelvis moves forward, and this opens up the angle between the torso and thighs. This causes a reduction of the pressure on the spine and maintains a more evenly balanced posture.

Recent studies have affirmed Mandals work and suggest that the pressure on the spine can be reduced by 35% if an angle of 110 or greater is achieved between the torso and thighs.

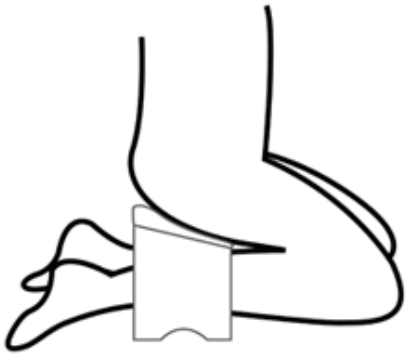
Inspired by Mandals findings, three furniture designers, Oddvin Ryken, Svein Gusrud, Peter Opsvik started working together, on designing and developing chairs. All of these were based around the kneeling posture and were named the now famous "balans". Their innovative designs and ideas have caught the attention of ergonomic specialists worldwide and still sell in great numbers today.

Until 2006, Stokke were the main manufacturer of the Variable balans kneeling chair.

In 2006, they sold their ergonomic division to a company called Varier. This expansion has seen the rebirth of the kneeling chair, new products and a rise in consumer interest.

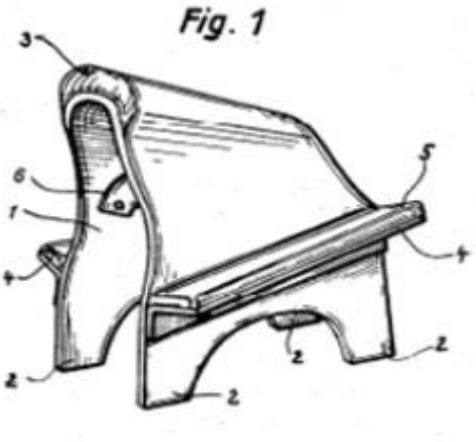
An illustrated timeline

Tibetan Seiza Bench
The kneeling or 'seiza bench' has been used for centures in Tibet.



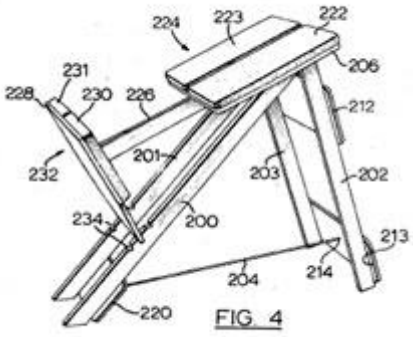
Buzzi 1970

Furniture for sitting, patented in Rome, Italy, on November 17, 1970.



Vowles 1972

J. Harding Vowles, U.S patent no 3669493, June 13, 1972, Canada. This chair was designed to reduce pressure on the posterior during extended periods of sitting by transferring some weight to the knees.



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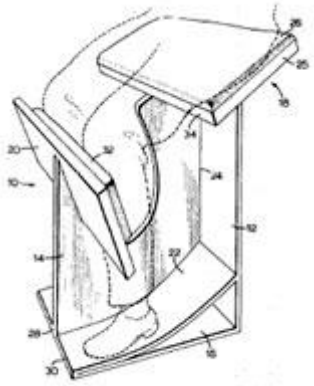
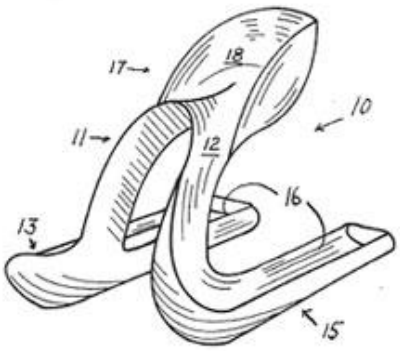
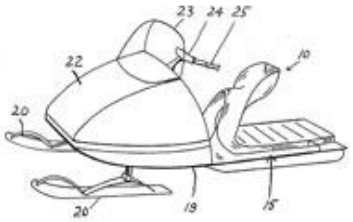


Gilings Jr 1973

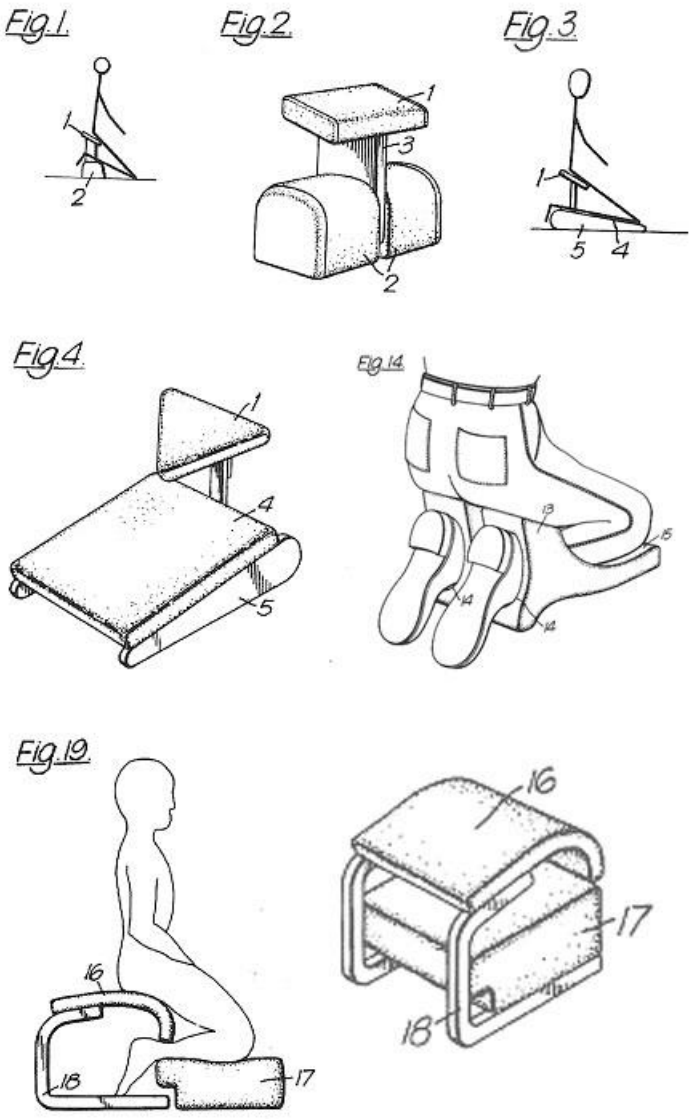
Knee–chair by Peter Gillings Jr. April 17. 1973 US patent no 3863978. Originally designed for a snow mobile.





Mengshoel 1979

Hans C Mengshoel, June 15, 1979, U.S. patent no 4377309.



Opsvik 1979

Balans chairs — Peter Opsvik, Varier — 1979, Norway.

Morphological characteristics

Kneeling chairs are especially designed to maintain a natural curve in the lower back to remove pressure and put the entire back at ease.

They encourage you to find your natural balance line, which runs in a line from your ear, to your shoulder, to your hips and ankle. These are perfectly aligned when seated in kneeling position.

They also encourage the body to form an open posture. When you are seated in a normal chair your body is formed like an “h”, and you are typically sitting in a closed angle of 90° or less. In an ergonomic chair, one sits in an open angled position of about 110°.

There are tons of benefits of sitting in an open angled position. It is in general a much healthier body posture which allows your back (and spine) to form its natural curvature. This relieves spinal compression (which causes an aching back) as well as prevents tensions in your lower back and leg muscles. Adopting the kneeling seating position also allows your diaphragm to move efficiently and promotes better breathing and blood circulation.

By practicing these healthy posture, you will also find yourself gaining more energy and concentration and just feel healthier. This is why Mengshoel and Mandal called this position a “dynamic seating position”.

But don’t kneel all the time though!

You should never be supporting the bulk of your weight with your knees or upper shins. The lower pads should be act as a support for your knees or shins, and will help you maintain a healthy seating angle, but please don’t forget to vary your positions! Once you get used to the seating position of a kneeling chair and the many benefits it offers to you it will become effortless and seem completely natural.

A kneeling chair typically has two major features: a padded seat, which is angled forward at 20 to 30 degrees, and a padded support in front of the seat on which the shins and knees rest. The ergonomic chair must be adjusted and put into optimal position to suit your specific height and weight.

In the following picture (Figure 5) you can see a woman of average height and weight (163cm, 63kg) sitting on a version of a kneeling chair (side view). In the picture are noted important dimensions for the ergonomics of the sitting.

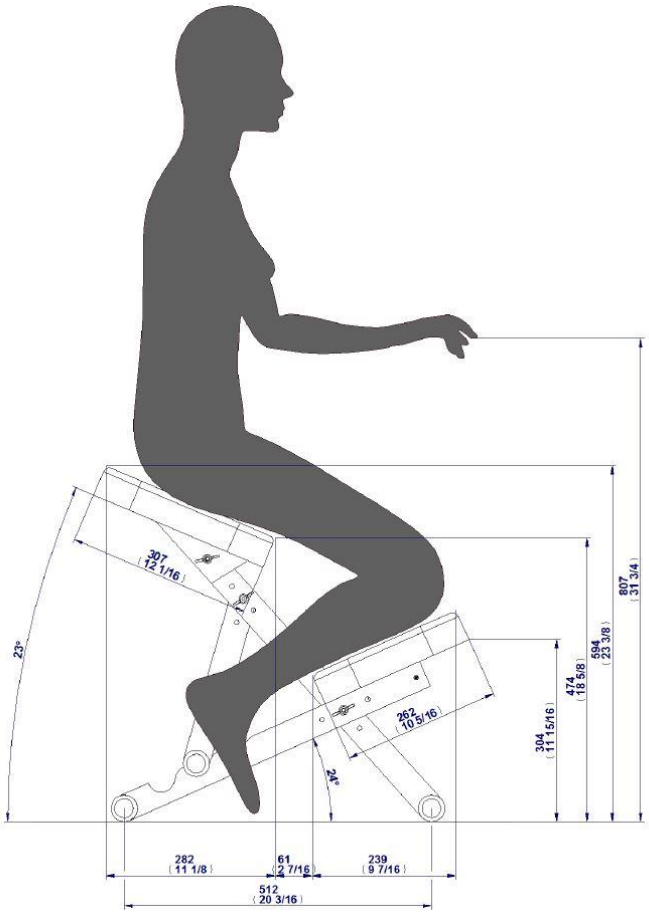


Figure 5

Identification of genotypes

The concept of the keeling chair was first developed in Northern Europe during the 1970's, from ideas on alternative seating positions that originated from Danish surgeon Dr. AC Mandal an Norwegian Hans Christian Mengshoel. They invited a number of chair designers to develop the kneeling chair, based on their principles.

Many kneeling chairs came from this attempt, but the best known is the Variable Balans by Norwegian designer Peter Opsvik. The name Balans is synonymous with one of the main principles of the design of this kneeling chair, the balance.

So, the Variable is the one of the 4 ergonomic types of the kneeling chair. There are also the Multi, the Thatsit and the Wing balans (names given by the designer, Peter Opsvik and the company he works for, Varier).

Variable balans:

The original knelling chair. The body moves in response to the chair's gentle tilting motion. The open angle between the upper and lower body enhances blood circulation and the abdomen and back muscles work to keep the posture.

Multi balans:

Where flexibility meets stability. One can choose the seat angle that's most comfortable for him/her. The abdomen and back muscles work to keep the posture upright. The wider the angle between the upper and lower body, the less pressure on the vertebrae. With less pressure on the back, there's less tension in the neck and shoulders.

Thatsit balans:

Total support – unlimited movement. One can vary his/her position by placing the lower leg on, in front of, between, or beside the kneepads. The body moves in re-

sponse to the chair's tilting motion. The spine is perfectly supported. The open angle between the upper and lower body aids blood circulation.

Wing balans:

A natural upright posture helps strengthen the core. The abdomen and back muscles work to keep the posture upright. One can adjust the height of the seat to suit him/her and roll on the wheels. The open angle between the upper and lower body aids the blood circulation.

The genotype that I based on for the DIY project is the Multi balans. It's most commonly used and can be easily manufactured, comparing to the other types.

Specifications

Target

The kneeling chair DIY project targets a group of people that are young adults, at the age of 24-44. Those people have a constant desire of being active, being strong members of the society that take part in the creation of their environment and have control

over their lives. They mustn't necessarily have special skills or any experience regarding DIY projects. Also, they don't have to own a workshop or any special toolkit.

Product

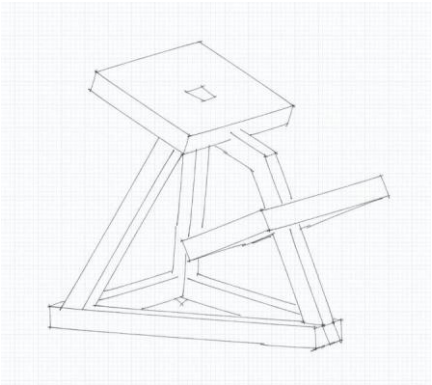
The purpose of this thesis is to design a DIY kneeling chair that can be manufactured in the easiest way, with the less materials and tools possible avd of course with the minimum cost.

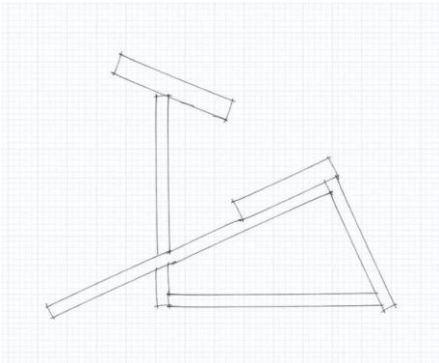
The kneeling chair must be durable, sturdy and comfortable. It must be easily transported and adjustable regarding height. The pad should be thick and smooth.

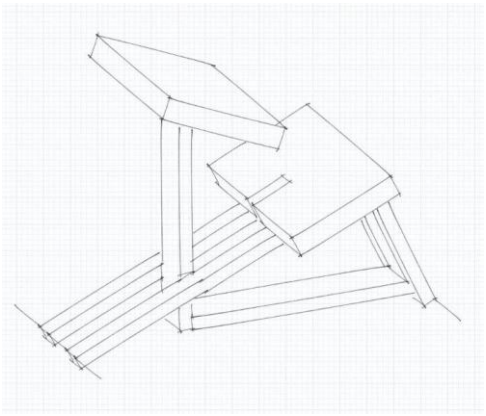
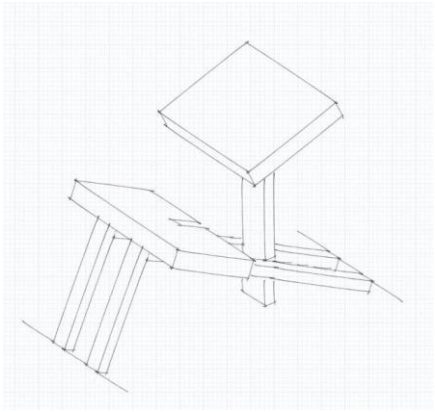
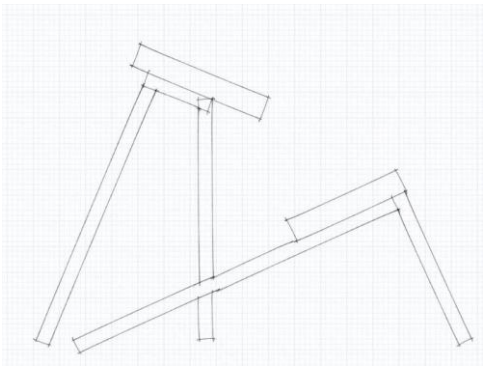
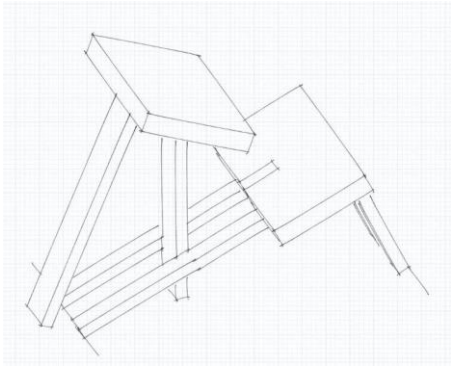
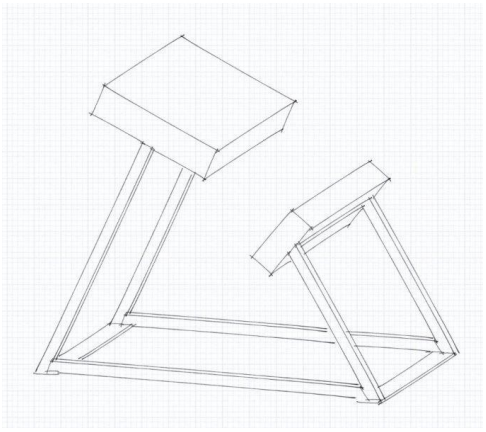
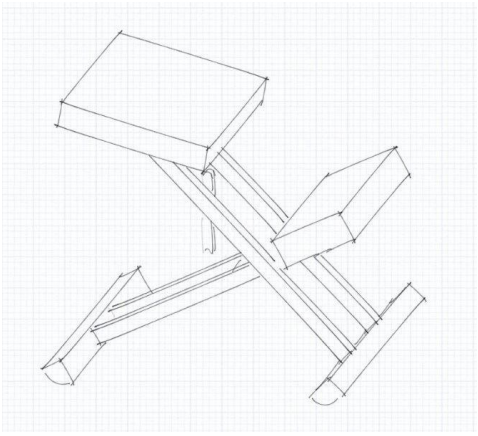
These are the most important needs as noted from kneeling chair users' reviews on the internet.

Concept development

Having in mind the morphological characteristics and the ergonomics of the kneeling chair from the existing bibliography, I tried to experiment with new forms keeping some important values/dimensions steady.





Sketches

I soon realized that it's very difficult to find a new form which could satisfy in an adequate level the kneeling chair users' needs. The stability of the chair and the adjustability of seat's height are the most crucial specifications that restrict the form experimentation.

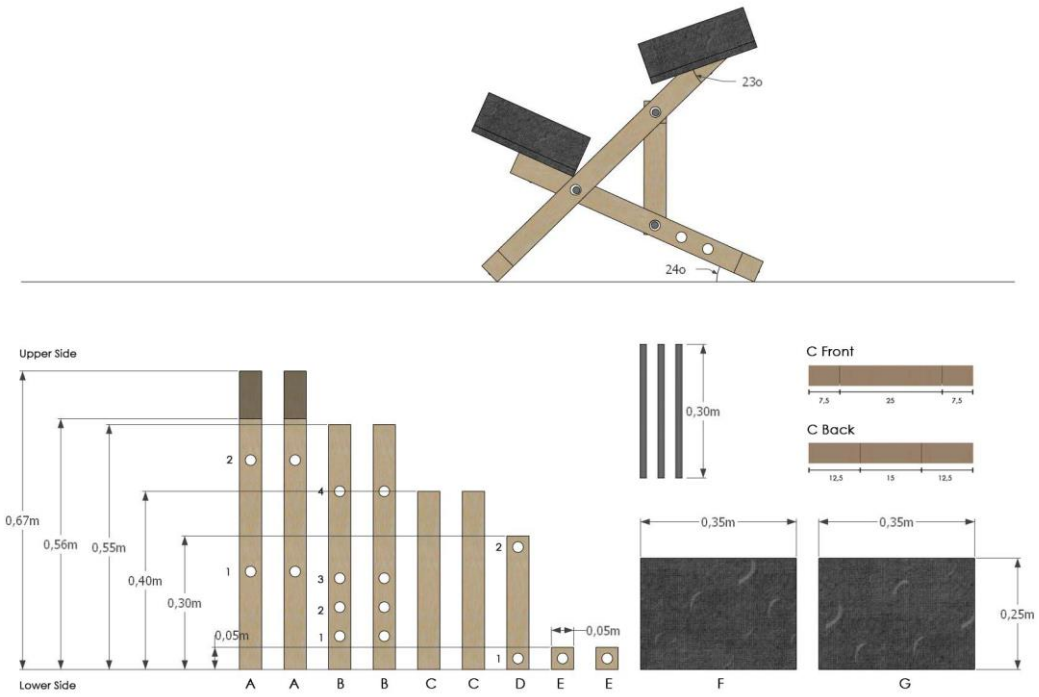
Prototyping/ Concept testing through User's experience/ Evaluation

After experimenting with various forms in concept development, the process of screening/ scoring led to a concept selection which seems to address in a better and more efficient way the user's needs. The only weakness of this concept is that it follows the common form of the kneeling chair that is widespread on the market, although slightly differentiated.

Even though the final concept was obtained through a thorough research, some uncertainties required further development. That' s why the concept was tested through users' experiences. The users not only tested the constructiveness of the selected concept but contributed with their input to the final form of the concept and the configuration of the instruction manual.

Their effort is documented below, step by step.

First Attempt – Concpet A



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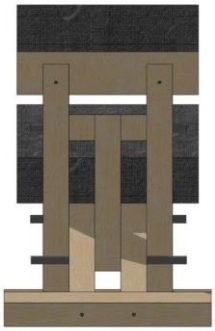
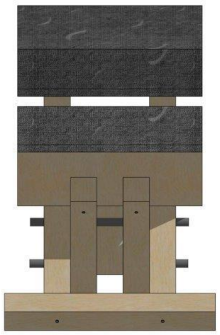
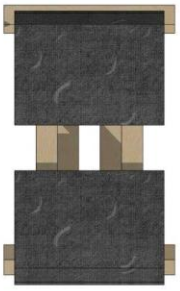
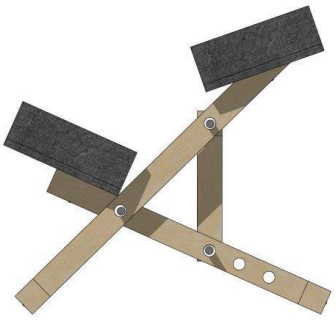
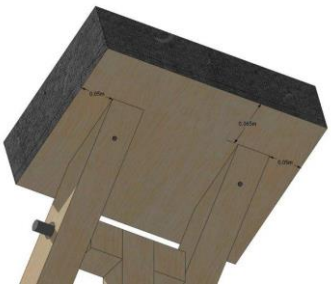
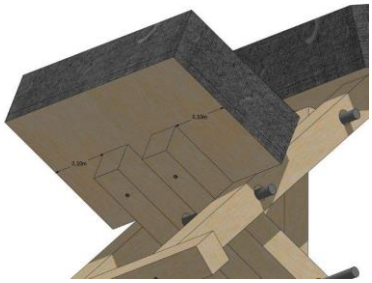





Views of 3D model

At their first attempt, the users had to follow my instructions in order to complete the project. They bought the materials and gathered the tools needed.

Table 1: Table of Materials

Materials	Quantity	Thickness (mm)	Dimensions (mm)	Cost (€)	Comments
Foam	1board	80	1000x1000	9	-
Wood beams	2 pieces	50x50	5600	15	You can use pine, maple, oak, cedar or cherry wood.
Screws (Type A)	4 pcs	Ø4	M100	0,80	-
Screws (Type B)	4 pcs	Ø4	M60	0,80	-
Rod	1 piece	Ø8	M100	2	-
Fabric	$1m^2$	-	1000x1000	5-15	Price is relative to the quality of the fabric you choose.
Plywood boards	2boards	15	350x250	3,75	cut to size
Staples for Staple Gun	1packet	-	Depending the Staple gun you have	2,5	-
Cutting board (Optional)	1	-	Bigger/ equal to the foam board	-	Any hard surface that you can use as a cutting board

Tools needed:

Pen/ Pencil, Cutter, Ruler/ Meter, Scissors, Hand miter saw, Jig saw, Cordless drill, Drill bits, Staple gun

Steps followed:

Preparation of body parts

1. Cut the beams to parts.

Take the wooden beams and with the aid of a pencil and a ruler/ meter draw vertical lines to the following lengths (cm): 5, 5, 30, 40, 40, 55, 55, 67, 67.
The start point of each length is the end point of the previous one.
Use a hand saw and try to cut the parts vertically at the lines you have drawn.

2. Make holes to the cut parts and enumerate them.

Draw centerlines along all parts. Use them as a guide to mark the signs.
Place the same parts next to each other and mark them simultaneously in order to save time.
The signs marked onto the parts will be the centers of the holes you are going to drill in a later phase.

67cm length parts (A): mark a sign to 22cm (hole n.1) from one side (lower) and then to 25cm (hole n.2).
55cm length parts (B): mark a sign to 15cm (hole n.4) from one side (upper), and from the other (lower) mark 3 signs first to 7.5cm (hole n.1), then to 6.5cm (hole n.2) and then again to 6.5cm (hole n.3).
40cm length parts (C): draw vertical lines to length 7.5cm from both sides of the one part (front) and to length 12.5cm from both sides of the other part (back).

30cm length part (D): mark a sign to 2cm (hole n.1) from one side (lower) and 2cm (hole n.2) from the other (upper).
5cm length parts (E): mark a sign to the center of one of its faces.

Make the holes with Ø12mm using the hand drill and try to be as steady as you can so as to drill them vertically. In order to reach this diameter, drill 4 times each hole with 4 different bits (Ø6mm, Ø8mm, Ø10mm, Ø12mm).

3. Make a diagonal cut to A parts (upper side).
Turn the parts clockwise to the face with no holes and draw a vertical line to 57cm length (direction: from lower to upper side).
Join the right down point of the edge of the part with the upper point of the line you just draw and create a triangle. Cut it with the use of a jigsaw. Try to be steady while cutting so as to create a smooth surface.

4. Cut the rod in 3 parts of 30cm length.
Use the meter and the hand saw.

Assembly of the body

5. Take one part of rod and parts A and B. Pass the rod through holes n.1 of parts A and n.4 of parts B. Parts A must be outwards and parts B must be inwards.

6. Take another part of rod and parts E and D. Lift the upper sides of parts A and pass the rod through part A hole n.2, part E, then part D hole n.2, the second part E and finally the second part A hole n.2.

7. Take the last part of rod and pass it through part A (hole n.3 or n.2 or n.1 depending on your height), part D hole n.1 and then from the second part A (same hole as the first part A). A short person should choose n.3, while a tall n.1.

8. Screw parts C to the assembly.

Use screws type A.

Take the front C part and screw it to parts A. The lines you have drawn will help you center it. They indicate the outer edges of parts A.

Do the same with the back C part and parts B.

Preparation of seat and knee board

9. Cut the foam board into pieces.

Place the two plywood boards onto the foam and trace their boarders with a pen/pencil onto the foam. Cut the drawn pieces with the cutter. You can place the foam on a cutting board if you want so as not to scratch the surface underneath.

10. Cut the fabric into pieces.

Draw onto the fabric with a pen/ pencil two rectangular shapes 50x40cm. Use the ruler to draw them and the scissors to cut them.

11. Assembly the seat and knee board.

Place the foam boards in the middle of each of the fabric pieces. Then place the plywood boards on top of them. Cover the boards with the fabric (wrap them) and stabilize it with the aid of the staple gun. Use around 15 staples for each board.

Final assembly

12. Placement of the seat board.

Screw the one board on the inclined surfaces of A parts.

In order to place it centrally, make sure that the edges of the widthwise faces of the board are at a distance of 5cm from the outer edges of the A parts and the edges of the lengthwise faces are at a distance of 6,5cm.

Use screws type B.

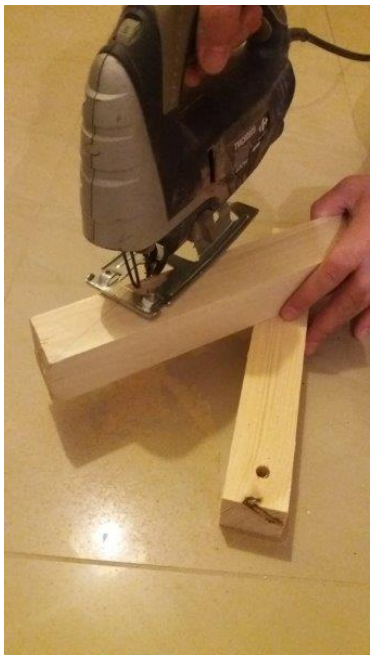
13. Placement of the knee board.

Screw the other board on the upper side of B parts.

The inner board’s lengthwise face should touch the A parts. Make sure you have placed it centrally. The edges of the widthwise faces of the board should be at a distance of 10cm from the outer edges of the B parts.

Use screws type B.

Photos form User’s experience:



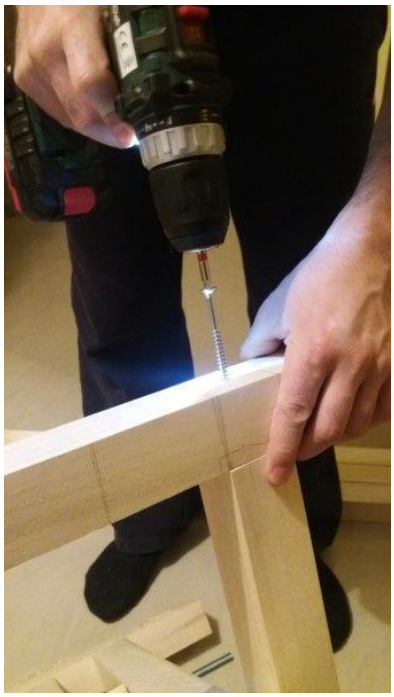






Table 2: Table of Steps.

Steps	Materials	Tools	Time (min)	Difficulty (1-3)	Points of Attention	User's input (data from videotaping)	Follow-up comments
1	Wood beams	Pencil, Ruler, Hand saw	30	3	Verticality of cutting.	The cutting of the wooden beams requires physical strength and it's time consuming. The verticality cannot be sufficiently achieved even with a hand miter saw.	It's better for the users to buy the wooden parts cut to size. DIY stores like Leroy Merlin offers the service of cutting for free.
2	Wood parts	Pencil, Ruler, Cordless drill	30	2	Verticality of drilling. The users must ensure the verticality of the drilling so as not to find difficulty in executing steps 5,6,7.	The users tested different ways of drilling so as to achieve verticality. The fact that they had to drill 4 times each hole made it more difficult to achieve it.	The users firstly must reassure the stability of the wood part they are going to drill. It's preferable if someone is holding it steady and someone else is drilling it. They should elevate it, maybe place it on top of another wood part that is not needed and the person who is drilling must hold the drill with both hands.

Steps	Materials	Tools	Time (min)	Difficulty (1-3)	Points of Attention	User's input (data from videotaping)	Follow-up comments
3	Wood parts	Pencil, Ruler, Jig saw	10	3	Straight/smooth diagonal cut	The users tested 2 different directions of cutting with the jig saw. Both were inefficient. The surfaces created were uneven which meant that step 12 couldn't be performed efficiently.	The use of Jig saw doesn't secure a straight cut, so another option is to use the hand miter saw.
4	Rod	Meter, Hand saw	5	1	-	There was an awkward moment until they found a way to hold the rod in order to cut it.	Place the rod onto a workbench or even a wood part. Leave the part that is going to be cut free hanging. This way the cutting is facilitated.
5	Wood parts, Rod	-	5	1	Pay attention to the arrangement of the parts considering the numbering of the holes.	Step easily executed.	-
6	Wood parts, Rod	-	5	2	Pay attention to the arrangement of the parts considering the numbering of the holes.	Users found difficulty in passing the rod through the holes of the parts.	Use the hammer to push the rod through the parts.
7	Wood parts, Rod	-	2	1	-	Step easily executed.	-

Steps	Materials	Tools	Time (min)	Difficulty (1-3)	Points of Attention	User's input (data from videotaping)	Follow-up comments
8	Wood parts, Screws type A	Cordless drill	5	2	The screw must penetrate vertically the parts.	The step was executed successfully by one person, although C parts were kind of unsteady during the screwing.	For reassuring the correctness of the construction it is preferable this step to be executed by two people. One must hold steady the C parts and the other do the screwing with a steady direction.
9	Foam, Plywood boards, (Cutting board)	Pen, Cutter	10	2	Verticality of cutting.	The foam pieces were cut relatively easily but their faces were uneven. The users had to repeat many cuts in order to cut through foam's thickness.	Buy the foam pieces cut to size.
10	Fabric	Pen, Ruler, Scissors	10	1	-	Step easily executed.	-
11	Fabric, Plywood boards, Foam, Staples	Staple gun	15	1	-	Step easily executed.	-

Steps	Materials	Tools	Time (min)	Difficulty (1-3)	Points of Attention	User's input (data from videotaping)	Follow-up comments
12	Seat Board, Screws type B	Meter, Cordless drill	5	3	Centrally placement of the board onto the parts.	The step was executed successfully by one person, although the board was kind of unsteady during the screwing.	This step needs to be executed by two people. One must hold steady the board centrally and the other should screw steadily the screws into the parts.
13	Knee Board, Screws type B	Meter, Cordless drill	5	3	Same as step 12	Same as step 12	Same as step 12

Total Cost: 40-55€

Duration of construction: 137'

Additional comments:

At step 3: With the use of the hand miter saw the users managed to cut diagonal smooth surfaces, but since the tool can cut max. at 45o, the surfaces and by extension the seat was parallel to the ground and not inclined as it should be.

As a result, I had to explore another solution for achieving the inclination of the seat and that led me to Concept B.

Second Attempt – Concept B

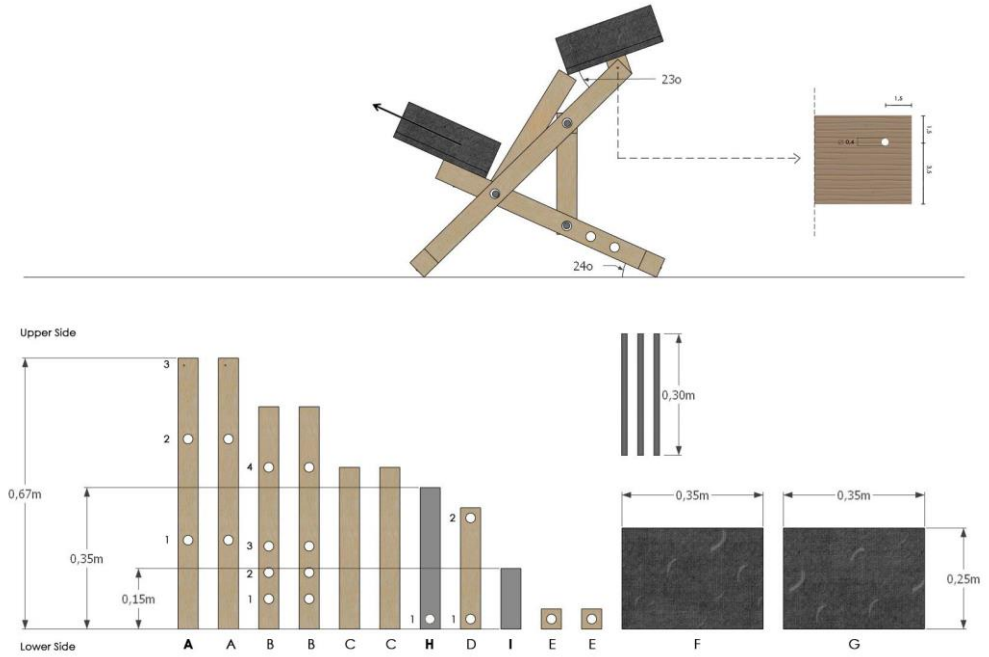
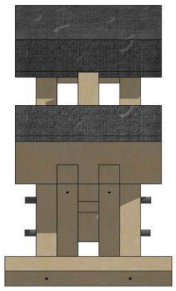


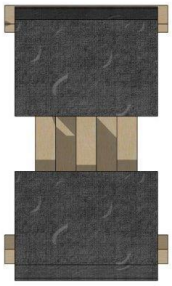
Figure 7

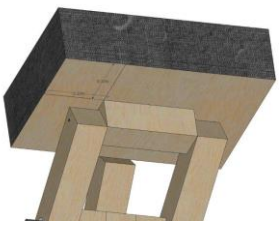
The information I received by observing the users trying to build the chair of Concept A following my instructions, helped me improve the design of the chair and the construction process as well. The main problem of performing Concept A was that one of the main requirements of the kneeling chair (the inclination of the seat in 23o) couldn't be satisfied so I came up with a solution which changed the chair design and a big part of the DIY process.

The solution required the addition of two new parts H and I and the replacement of A parts (Figure 7). The seat in this case is being screwed in a base (part I) and then to the body parts (parts A), which means it's not stabilized until it touched the new part added (part H) and lock its position. The part H has the proper length in order the seat to be stabilized in the requested inclination.

Below are documented in detail the changes in design, materials, tools needed and steps being followed.




Views of 3D model

Table 3: Table of Materials

Materials	Quantity	Thickness (mm)	Dimensions (mm)	Cost (€)	Comments
Foam	2 boards	80	350x250	3	Cut to size
Wood parts	2 pieces	50x50	670	15	Cut to size You can use pine, maple, oak, cedar or cherry wood.
	2 pieces		550		
	2 pieces		400		
	1 piece		350		
	1 piece		300		
	1 piece		150		
	2 pieces		50		
Screws (Type A)	6 pcs	Ø4	M100	0,80	-
Screws (Type B)	2 pcs	Ø4	M60	0,80	-
Rod	1 piece	Ø8	M100	2	-
Fabric	$1m^2$	-	1000x1000	5-15	Price is relative to the quality of the fabric you choose.
Plywood boards	2 boards	15	350x250	3,75	cut to size
Staples for Staple Gun	1 packet	-	Depending the Staple gun you have	2.5	-
Cutting board (Optional)	1	-	Bigger/ equal to the foam board	-	Any hard surface that you can use as a cutting board
Glue (Atlacoll)	100gr	-	-	1	-

Tools needed:

Pen/ Pencil, Cutter, Ruler/ Meter, Scissors, Cordless drill, Drill bits, Staple gun, Hammer.

Steps followed:

Preparation of body parts

First of all buy the wooden parts cut to size. DIY stores like Leroy Merlin offers the service of cutting for free.

1. Make holes to the cut parts and enumerate them.
The procedure is the same as in Concept A.
A parts have the same length 67cm, with no diagonal cut, but an additional hole n.3 on the upper side of each of the parts. The hole has Ø 4mm and it must be drilled at a distance of 1,5cm from both edges (top – left), (Figure 7).
In the additional H part with 35cm length, mark a sign to 2cm (hole n.1) from its lower side. This, as well as the rest of the holes have Ø12mm.
Additionally, in order to reassure the stability of the wood parts you are going to drill, it's preferable if someone else is holding them steady and you are drilling, holding the drill steady with both hands. You could also elevate the parts, maybe place them on top of other wood parts that are not needed. This will facilitate the procedure.

2. Cut the rod in 3 parts of 30cm length.
Same as step 4 in Concept A.
Additionally, place the rod onto a workbench or even a wood part. Leave the part that is going to be cut free hanging. This way the cutting is facilitated.

Assembly of the body

3. Take one part of rod and parts A, B and H. Pass the rod through holes n.1 of parts A, n.4 of parts B and n.1 of part H. Parts A must be outwards and parts B must be inwards. Part H must be in the middle of all parts.

4, 5, 6. Same as steps 6, 7, 8 in Concept A.
In case you find difficulty in passing the rod through the wood parts, use the hammer to facilitate the procedure.
Additionally, for step 6:
For reassuring the correctness of the construction it is preferable this step to be executed by two people. One must hold steady the C parts and the other do the screwing holding the drill with a steady direction.

Preparation of seat and knee board

7. Cut the fabric into pieces.
Same as step 10 in Concept A.

8. Assembly the seat and knee board.
Same as step 11 in Concept A.
Additionally, screw the I part centrally on one of the boards. This will be the seat board. The I part must be placed at a distance of 10cm from all 4 edges of the board, (pictures below).

Final assembly

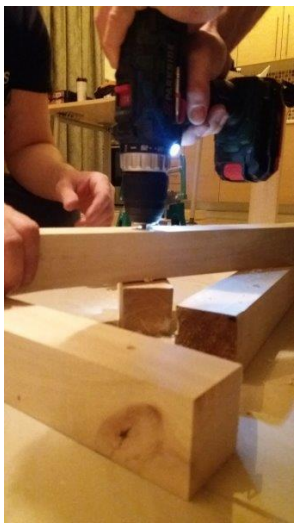
9. Placement of the knee board.
Lift the H part upwards and screw the knee board on the upper side of B parts. Same procedure as in Concept A, only that in this case the inner board's lengthwise face should be at a distance of 2cm from the A parts.

10. Placement of the seat board.

Place the I part between the A parts and let the seat lean on the top of the H part. Screw the seat to this position. As you can see from the following pictures the edges of I and A parts are not aligned. Try to pull the screw through the hole n.3 of the A parts and the middle of the side face of the I part.

Use screws type A.

Photos form User's experience:




DOCKERS
KHAKIS

Table 4: Table of Steps.

Steps	Materials	Tools	Time (min)	Difficulty (1-3)	Points of Attention	User's input (data from videotaping)	Follow-up comments
1	Wood beams	Pencil, Ruler, Cordless drill	30	3	Verticality of drilling.	Step was easily executed by two people.	The drilling was far more successful.
2	Rod	Meter, Hand saw	5	1	-	Step was easily executed by one person.	-
3	Wood parts, Rod	-	5	1	Pay attention to the arrangement of the parts considering the numbering of the holes.	Step easily executed by one person.	-
4	Wood parts, Rod	-	5	2	Pay attention to the arrangement of the parts considering the numbering of the holes.	The fact that parts E are not fixed in their position puzzled the users.	Use glue in order to fix parts E in their position. Apply glue on the faces of parts E and A that are in touch.
5	Wood parts, Rod	-	2	1	-	Step easily executed by one person.	-
6	Wood parts, Screws type A	Cordless drill	5	2	The screw must pene-trate vertically the parts.	Step was easily executed by two people.	-
7	Fabric	Pen, Ruler, Scis-sors	10	1	-	Step easily executed by one person.	-
8	Fabric, Ply-wood boards,	Staple gun	15	1	-	Step easily executed by one person.	-

	Foam, Staples. Screws type B						
9	Knee Board, Screws type B	Meter, Cordless drill	5	3	Right placement of the board onto the parts.	Step was executed by two people.	-
10	Seat Board, Screws type A	Meter, Cordless drill	5	3	Right placement of the board between parts A.	Step was executed by two people.	-

Total Cost: 35-50€

Duration of construction: 87’

Additional comments:

Considering the advice of a professional furniture manufacturer, in both concepts the seat and knee boards should be attached to the chair body in a different way. For the correctness of the construction, the plywood boards should be screwed onto the wood parts and not the other way around.

The right procedure is the following:

Firstly, you screw the plywood boards onto the wood parts. Then you place the foam boards on top of them and then you cover them with the fabric, which is stabilized on the construction with the aid of the staple gun.

In general, Concept B seemed to satisfy the requirements of a kneeling chair quite enough for the first two positions of the chair, but not so much for the third one. The additional part looked clumsy and strange in the general view of the chair as it was roughly placed there. So, I searched for an alternative way of maintaining the seat in the requested inclination without any additional parts.

I realized that if the central part of the chair body (part D in both concepts) was lengthened in a certain height, then it would support the seat to the requested inclination without any additional help. In this way I ended up with Concept C, the final concept, which was tested and proved to be satisfactory in all 3 positions.

Additional changes that needed to be done after users' testing:

The knee board was broadened by 15cm as it was too narrow even for a man of a medium stature. It was also remoted a few cm from the chair body so as to facilitate and improve the sitting. It was added one I part 15cm length in order to connect the knee board with the chair body.

The seat board was also broadened so as to be more comfortable and lengthened by 5cm so as to cover the central wood part in all 3 positions of chair height.

The E parts were also lengthened to 15cm so as to have the same length with I parts. Just for the simplification of the construction, as the length of the E parts doesn't affect any factor of the construction.

Final Concept Proposal/ Documentation

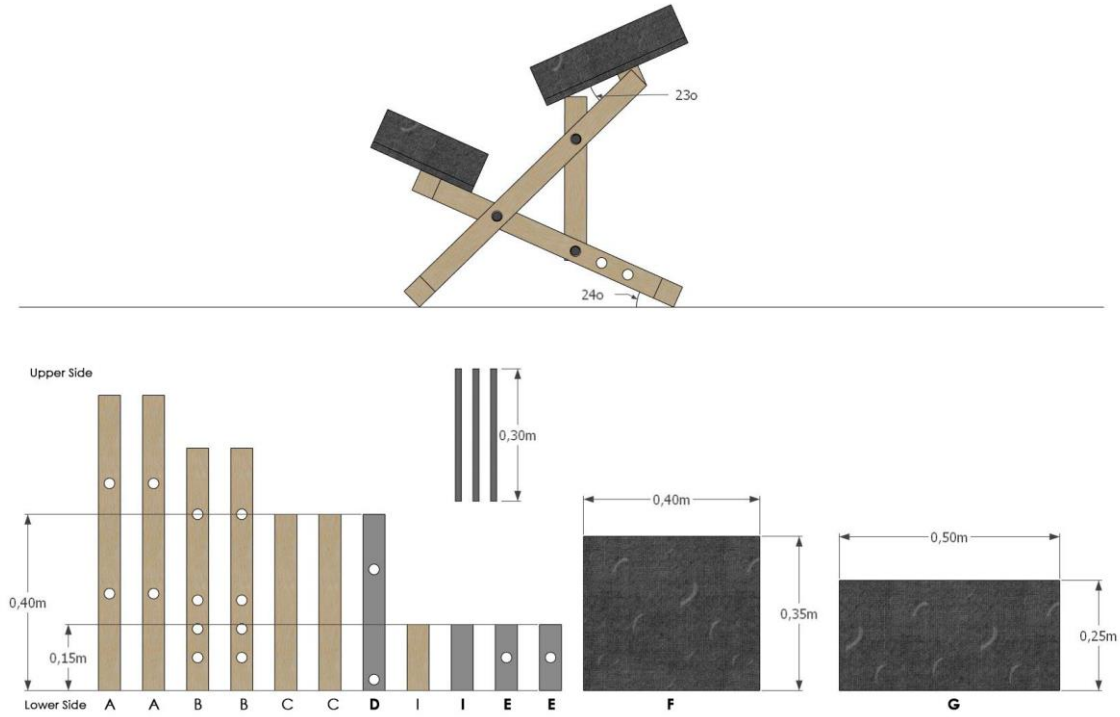


Figure 8

Views of 3D model

Table 5: Table of Materials

Materials	Quantity	Thickness (mm)	Dimensions (mm)	Cost (€)	Comments
Foam	2 boards	80	350x250	3	Cut to size
Wood parts	2 pieces	50x50	670	15	Cut to size You can use pine, maple, oak, cedar or cherry wood.
	2 pieces		550		
	2 pieces		400		
	1 piece		350		
	1 piece		300		
	1 piece		150		
	2 pieces		50		
Screws (Type A)	8 pcs	Ø4	M100	0,80	-
Screws (Type B)	4 pcs	Ø4	M60	0,80	-
Rod	1 piece	Ø8	M100	2	-
Fabric	1m^2	-	1000x1000	5-15	Price is relative to the quality of the fabric you choose.
Plywood boards	2 boards	15	350x250	3,75	cut to size
Staples for Staple Gun	1 packet	-	Depending the Staple gun you have	2.5	-
Cutting board (Optional)	1	-	Bigger/ equal to the foam board	-	Any hard surface that you can use as a cutting board
Glue (Atlacoll)	100gr	-	-	1	-

Instruction Manual of DIY process

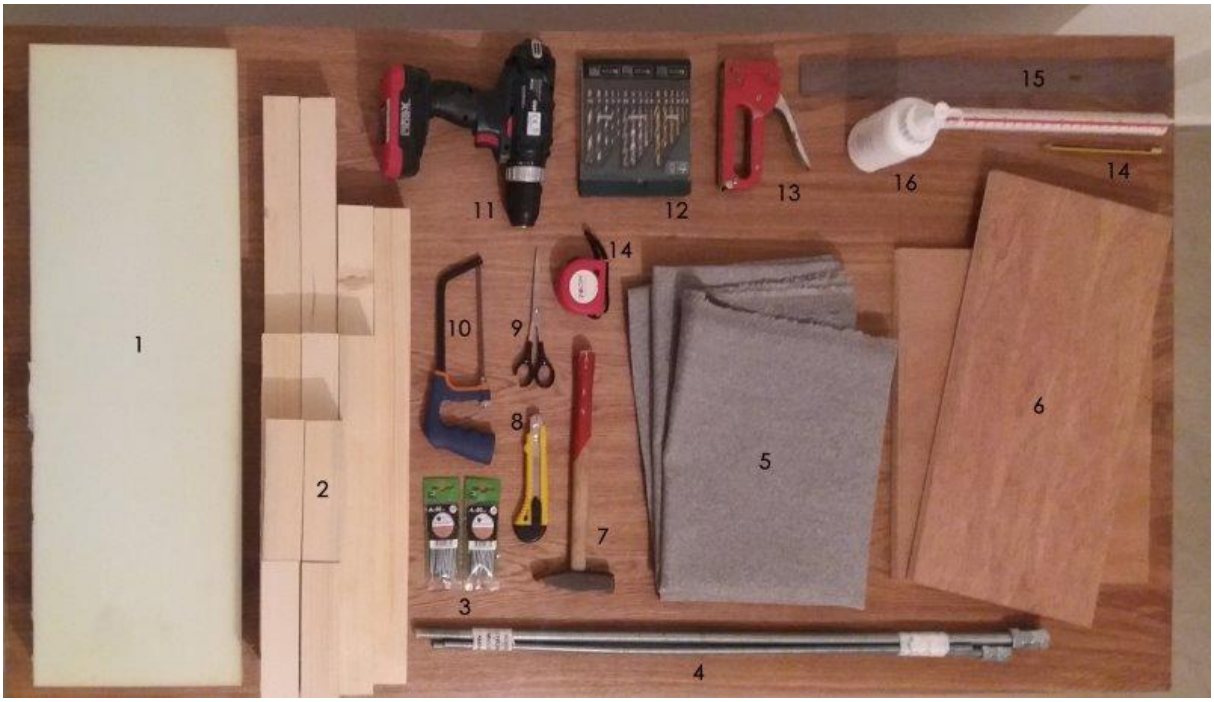


Figure 9

1. Foam, 2. Wood planks, 3. Screws, 4. Rod, 5. Fabric, 6. Plywood boards, 7. Hammer, 8. Cutter, 9. Scissors, 10. Mini saw, 11. Cordless drill, 12. Drill bits 13. Staple gun (loaded with staples), 14. Pen/ Pencil, 15. Ruler/ Meter, 16. Wood glue, e.g Atlacoll.

Total Cost of DIY project: 35-50€ (depending on the fabric you choose).

Duration of process: 92-97’

In the following pages you will find the steps that you have to follow in order to complete the DIY construction.

For each step it is noted a level of difficulty (scale from 1*-3*).

*= Easy, **= Normal, ***= Hard

Also in brackets, it is noted the duration of its step individually.

STEP 1 *** (30')

Hole Drilling/ Marking

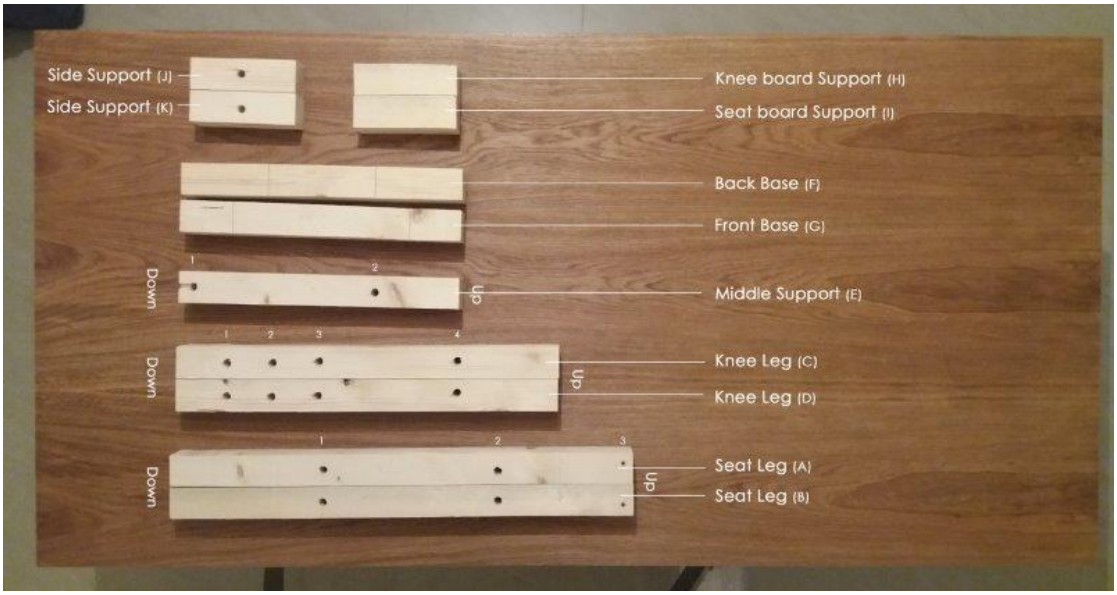


Figure 10

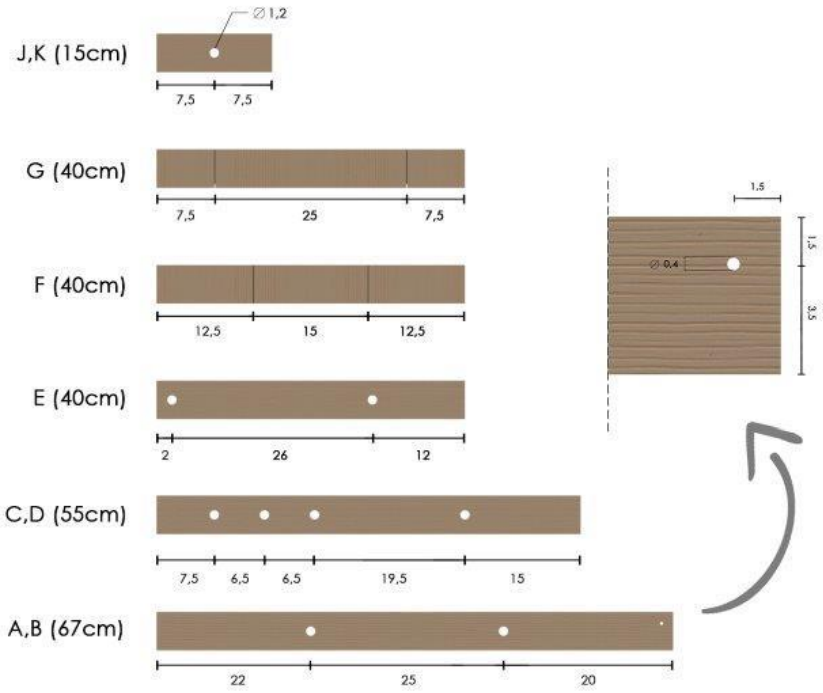


Figure 11

At parts J, K, E, C, D, A, B make holes with Ø12mm.

In order to reach this diameter, drill 4 times each hole with 4 different bits (Ø6mm, Ø8mm, Ø10mm, Ø12mm).

At parts G and F don't make holes, mark signs, vertical lines (guidelines) that will help you later in the assembly process.

Parts H and I are 15cm long, just like J and K. No need of holes or signs.

STEP 2 * (5')

Figure 12

Cut the rod with the mini saw in 3 pieces. Length= 30cm each.

STEP 3 ** (5')

Core assembly

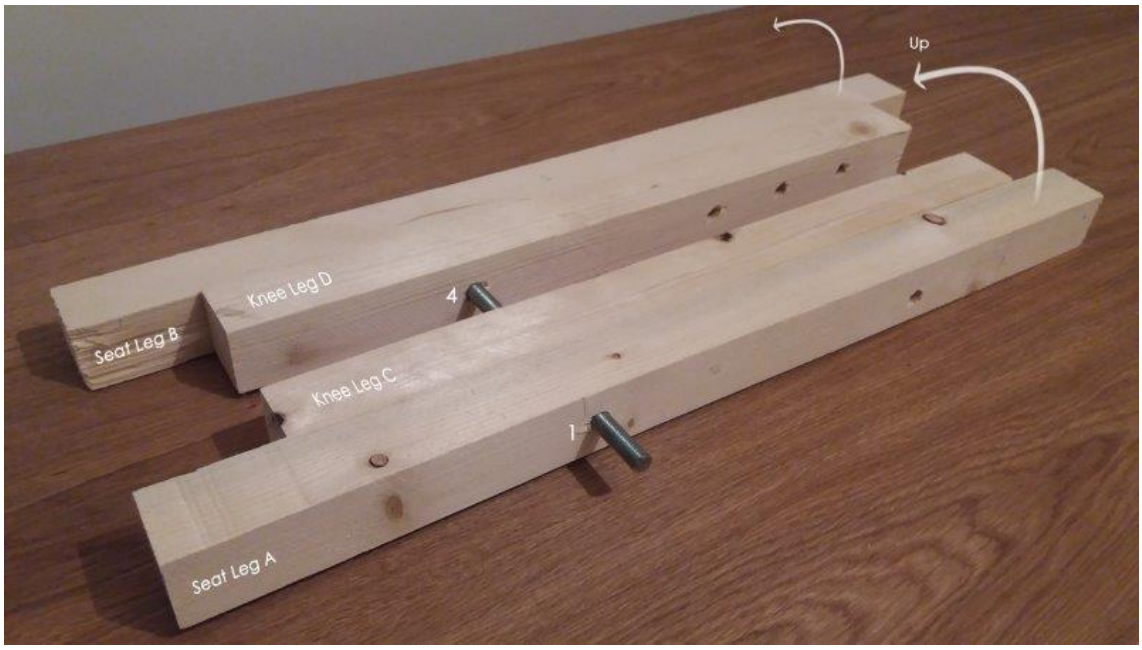


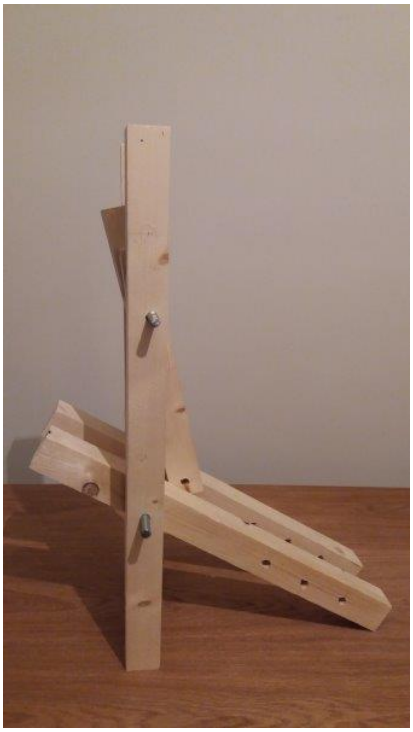
Figure 13

Take one piece of rod and parts A, B, C and D.

Pass the rod trough the holes of the parts. A, B should be outwards and C, D inwards.

The rod should pass through hole n.1 of parts A, B and n.4 of C, D.

STEP 4 ** (5')



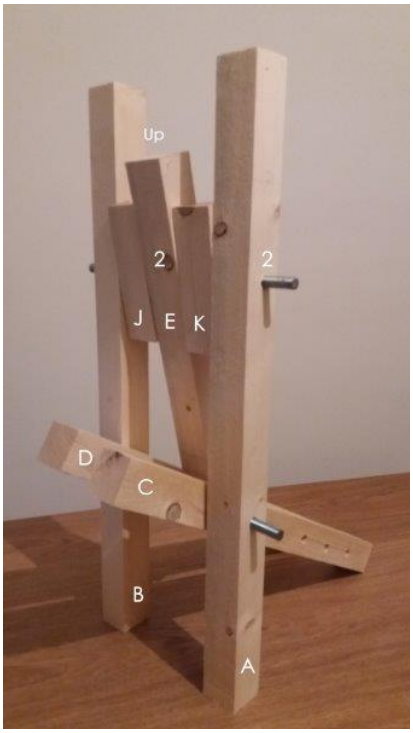


Figure 14/15

Lift up the upper sides of parts A and B and connect them with parts E, J and K with another piece of rod. The rod should pass through hole n.2 of parts A, B and n.2 of E.

Optional step (5’):

Before you pass the rod through parts K and J, you can apply glue on their faces, the ones that mate with parts A and B in order to stabilize them.

This step doesn’t affect the stability of the general construction.

Tip: In case you find difficulty in passing the rod through the wooden parts use the hammer to facilitate the procedure.

STEP 5 * (2’)

Take the last piece of rod and connect parts C, E and D. Pass the rod through hole n.3 of parts C, D and hole n.1 of part E. The position of the lower side of part E is adjustable and affects the height of the seat. You can either choose n.2 or n.1 of parts C, D depending on your height. A short person should choose n.3, while a tall n.1.

Figure 16

STEP 6 ** (5’)

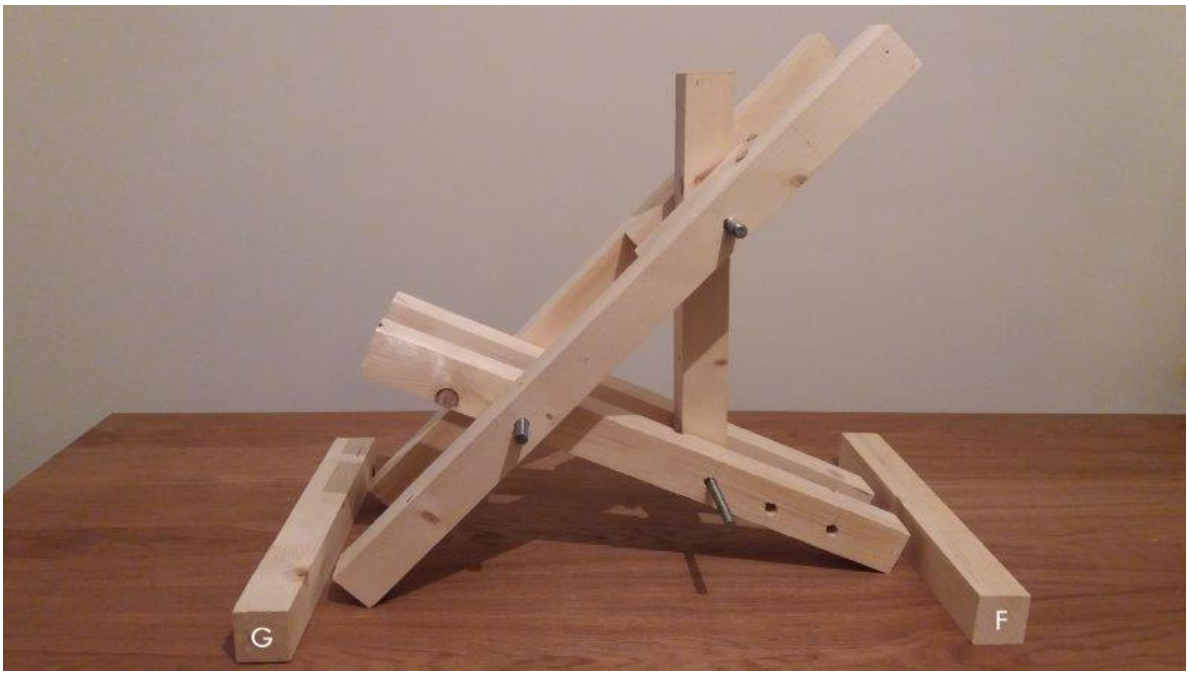


Figure 17

Figure 18

Screw the bases to the legs. Use screws Ø4xM100mm.

Part G is screwed to parts A, B, while F is screwed to C, D.

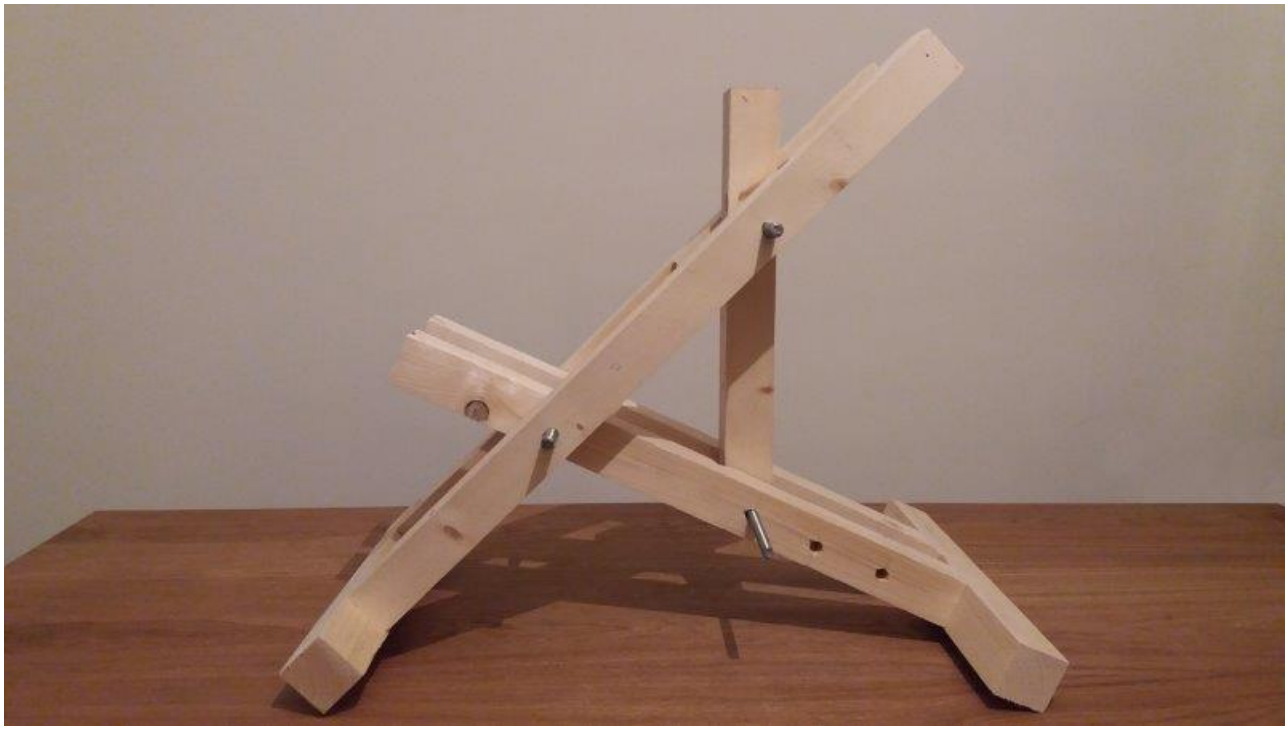


Figure 19

The signs will help you center the bases. They actually indicate the outer edges of the parts.

STEP 7 * (10')

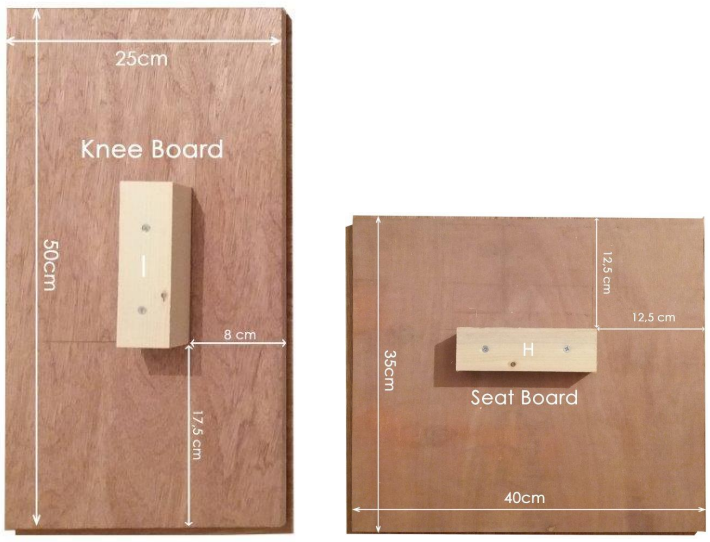


Figure 20/21

Screw the plywood boards to parts H, I. Use screws type B: Ø4xM60mm. You can firstly screw or glue the parts onto the plywood boards. You can also draw the patterns of H, I parts on the other side of the boards in order to have a guide for screwing.

The Knee board is 50x25cm and the Seat board is 40x35cm.

Directions for the right placement of the parts are shown in Figures 20/21.

STEP 8 * (15')

Figure 22/23

Place the foam boards on the fabric and cut it around them with an offset of approx. 15cm.

Now place the plywood boards on top of the foam boards and cover them with the fabric. Stabilize the fabric onto the plywood boards with the staple gun. You will need approx. 15 staples for each board. The seat and knee boards are ready.

STEP 9 ** (5')

Figure 24

Adjust and screw the knee board to the knee legs and the seat board to the seat legs. Directions for the right placement are shown to figure 24.

For the placement of the knee board, turn the construction downwards in order to facilitate the screwing.

Use screws type A: Ø4xM100mm.

Figure 25

Figure 26

STEP 10 *** (10')

Figure 27

Placement of the seat board.

Place the part H between the seat legs and let the seat lean on the top of the E part, the middle support. Screw the seat to this position. As you can see from the figures 27 and 28,

the edges of part H and seat legs are not aligned. Try to pull the screw through the hole n.3 of parts A and B and the middle of the side face of part H. Use screws type A: Ø4xM100mm.

Figure 28

Figure 29

Figure 30/ 31

Figure 32/ 33

Conclusions

The objective of this thesis was the design of a low-cost DIY kneeling chair and the empirically validation of it by unexperienced users.

The final design of the DIY kneeling chair concept can't be characterized as original, but it's notably differentiated from the existing DIY kneeling chair designs. The main point of difference is observed at the seat's height adjustment.

The chair is comfortable and robust. Nevertheless, aesthetics could be further developed.

Also, the addition of 4 wheels on the bases (2 to each one) could be an idea for testing.

The rolling base could satisfy better the need for easily transportation of the chair, but it would raise the total cost of the construction.

So, in general the overall design is quite satisfying for a low-cost concept.

Regarding the DIY process, it was proven to be valid by the general public, unexperienced DIYers, who with a few tools and some widely available materials (found in most DIY stores) completed easily the project.

The duration of the process is approx. 100' and the cost of the materials needed is 35-50€ (depending the quality of the fabric someone will choose).

A basic requirement for the successful completion of the project that couldn't be foreseen before the users' attempts, is the collaboration of 2 people taking part in the construction process, but just only for the execution of certain steps of the process.

The most crucial part of the construction process is the hole drilling. The achievement of the verticality of the drilling is very important for the correctness of the assembly and the general stability of the chair. If the users execute the drilling focused, with steady hands the result can be quite satisfying. Nevertheless, in case they can use a stable drill the outcome will be secured, and they will save valuable time, as well.

The users admitted that the DIY project was enjoyable, regardless of any disappointment or unexpected problems they might faced during the process. Enjoyment was arising when every step was being completed and a big sense of satisfaction overwhelmed them when they finally finished the project.

They also made evaluation of the chair concepts themselves. The experience of sitting in each of the chair prototypes was different to them. They could understand the improvements being made in each step forming the final product.

They actually found themselves enjoying sitting in the final chair concept. They admitted they would gladly start using it in their everyday sitting life.

Designing for a DIY project – methodology

From the experience I got from this small project, I realized that designing a DIY concept, is a totally different process than the usual. You might have a concept in your mind, but you have to prove its validity by having users test it. You have to be very analytic for each of every step of the process. You must firstly understand the way most users think and adapt your design to it. Users tests will help you improve and develop your concept, which will be based on true facts and not on raw ideas.

Observation of the users during the construction process is very crucial for the development of the DIY design. The input the users give either by their saying or the way they react, behave or perform each action must be studied and translated/ integrated somehow into the design. In the current project, the difficulties the users faced helped me improve not only the chair design but the DIY process itself.

In general, observation of the users during the use of a product is a fruitful designing tool that should be used from every product/service designer. The human factor should never be absent from the designing process.

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Appendix

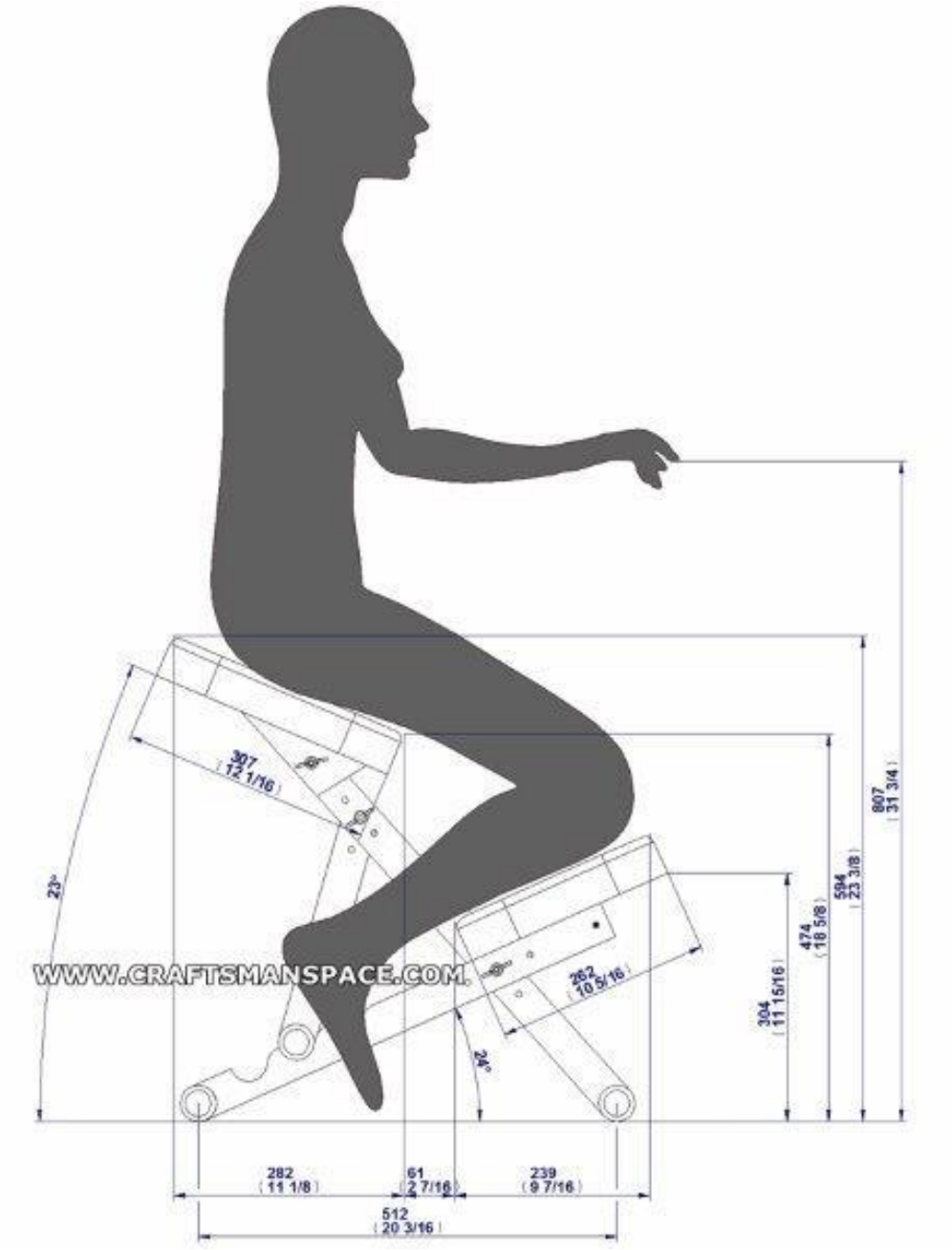
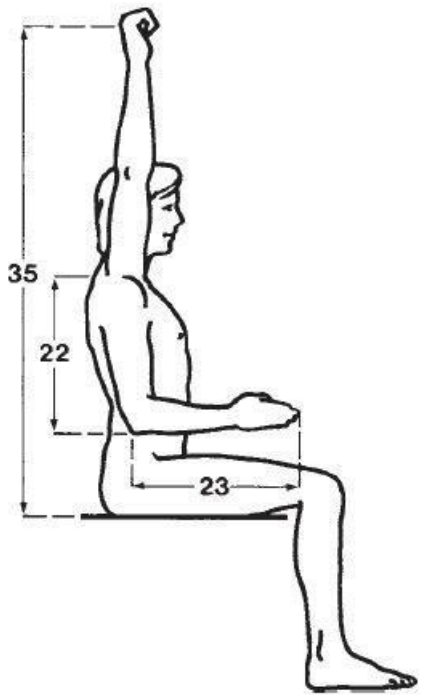

307
(12 1/16)
23°
WWW.CRAFTSMANSPACE.COM
262
(10 5/16)
24°
807
(31 3/4)
594
(23 3/8)
474
(18 5/8)
304
(11 15/16)
282
(11 1/8)
61
(2 7/16)
239
(9 7/16)
512
(20 3/16)

Table 2.3 Anthropometric estimates for British adults aged 19–65 years (all dimensions in mm, except for body weight, given in kg).

	Men				Women			
Dimension	5th %ile	50th %ile	95th %ile	SD	5th %ile	50th %ile	95th %ile	SD
1. Stature	1625	1740	1855	70	1505	1610	1710	62
2. Eye height	1515	1630	1745	69	1405	1505	1610	61
3. Shoulder height	1315	1425	1535	66	1215	1310	1405	58
4. Elbow height	1005	1090	1180	52	930	1005	1085	46
5. Hip height	840	920	1000	50	740	810	885	43
6. Knuckle height	690	755	825	41	660	720	780	36
7. Fingertip height	590	655	720	38	560	625	685	38
8. Sitting height	850	910	965	36	795	850	910	35
9. Sitting eye height	735	790	845	35	685	740	795	33
10. Sitting shoulder height	540	595	645	32	505	555	610	31
11. Sitting elbow height	195	245	295	31	185	235	280	29
12. Thigh thickness	135	160	185	15	125	155	180	17
13. Buttock–knee length	540	595	645	31	520	570	620	30
14. Buttock–popliteal length	440	495	550	32	435	480	530	30
15. Knee height	490	545	595	32	455	500	540	27
16. Popliteal height	395	440	490	29	355	400	445	27
17. Shoulder breadth (bideltoid)	420	465	510	28	355	395	435	24
18. Shoulder breadth (biacromial)	365	400	430	20	325	355	385	18
19. Hip breadth	310	360	405	29	310	370	435	38
20. Chest (bust) depth	215	250	285	22	210	250	295	27
21. Abdominal depth	220	270	325	32	205	255	305	30
22. Shoulder–elbow length	330	365	395	20	300	330	360	17
23. Elbow–fingertip length	440	475	510	21	400	430	460	19
24. Upper limb length	720	780	840	36	655	705	760	32
25. Shoulder–grip length	610	665	715	32	555	600	650	29
26. Head length	180	195	205	8	165	180	190	7
27. Head breadth	145	155	165	6	135	145	150	6
28. Hand length	175	190	205	10	160	175	190	9
29. Hand breadth	80	85	95	5	70	75	85	4
30. Foot length	240	265	285	14	215	235	255	12
31. Foot breadth	85	95	110	6	80	90	100	6
32. Span	1655	1790	1925	83	1490	1605	1725	71
33. Elbow span	865	945	1020	47	780	850	920	43
34. Vertical grip reach (standing)	1925	2060	2190	80	1790	1905	2020	71
35. Vertical grip reach (sitting)	1145	1245	1340	60	1060	1150	1235	53
36. Forward grip reach	720	780	835	34	650	705	755	31
Body weight	*55*	*75*	*94*	*12*	*44*	*63*	*81*	*11*

See notes on pp. 30–44.



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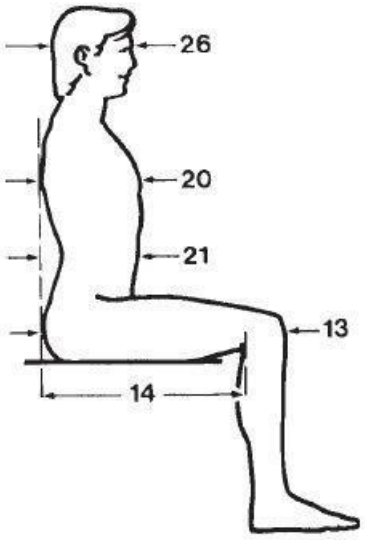

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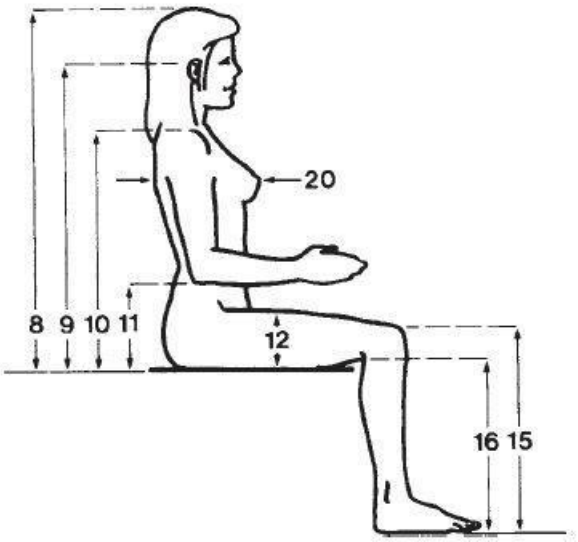

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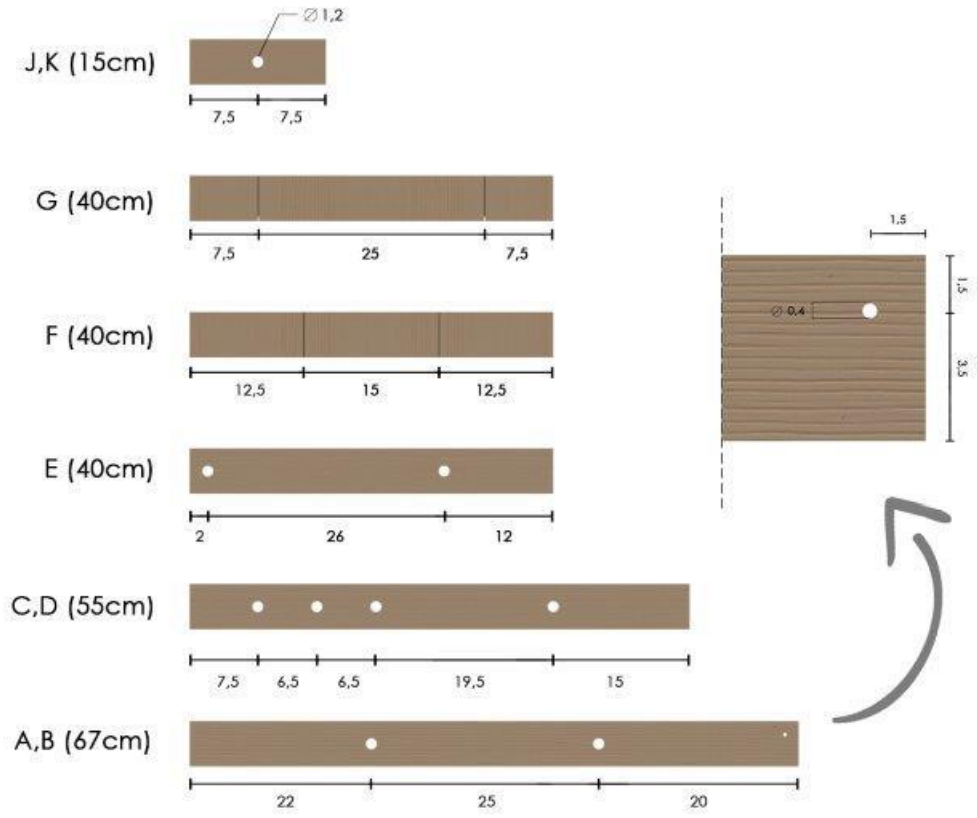
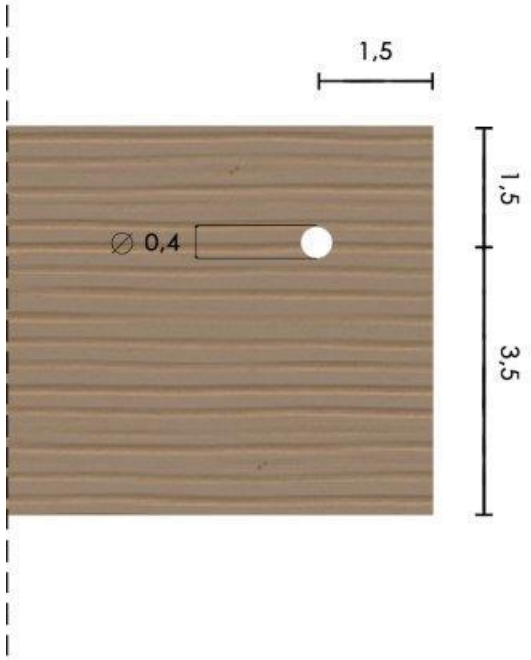
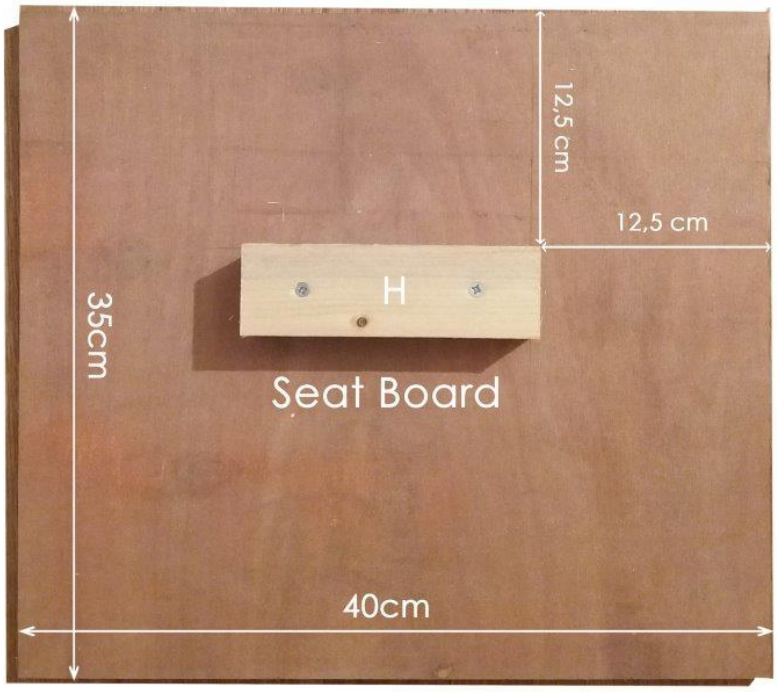
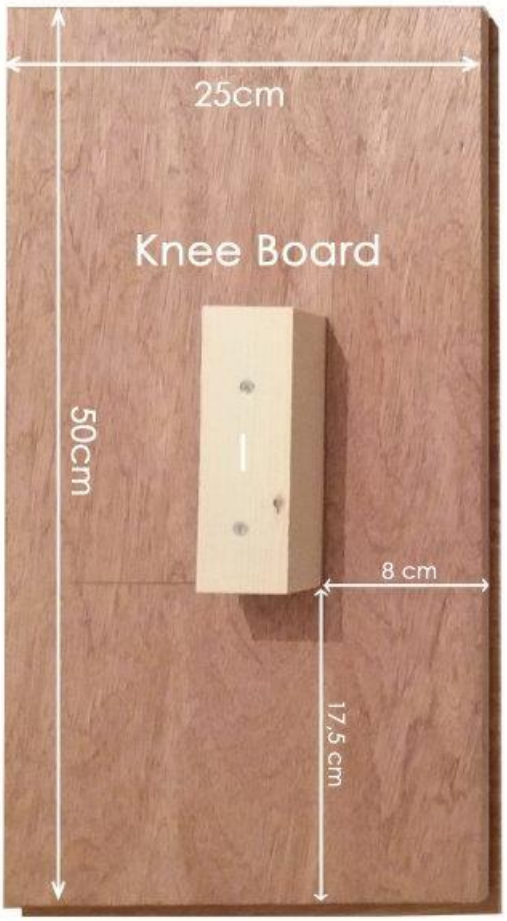
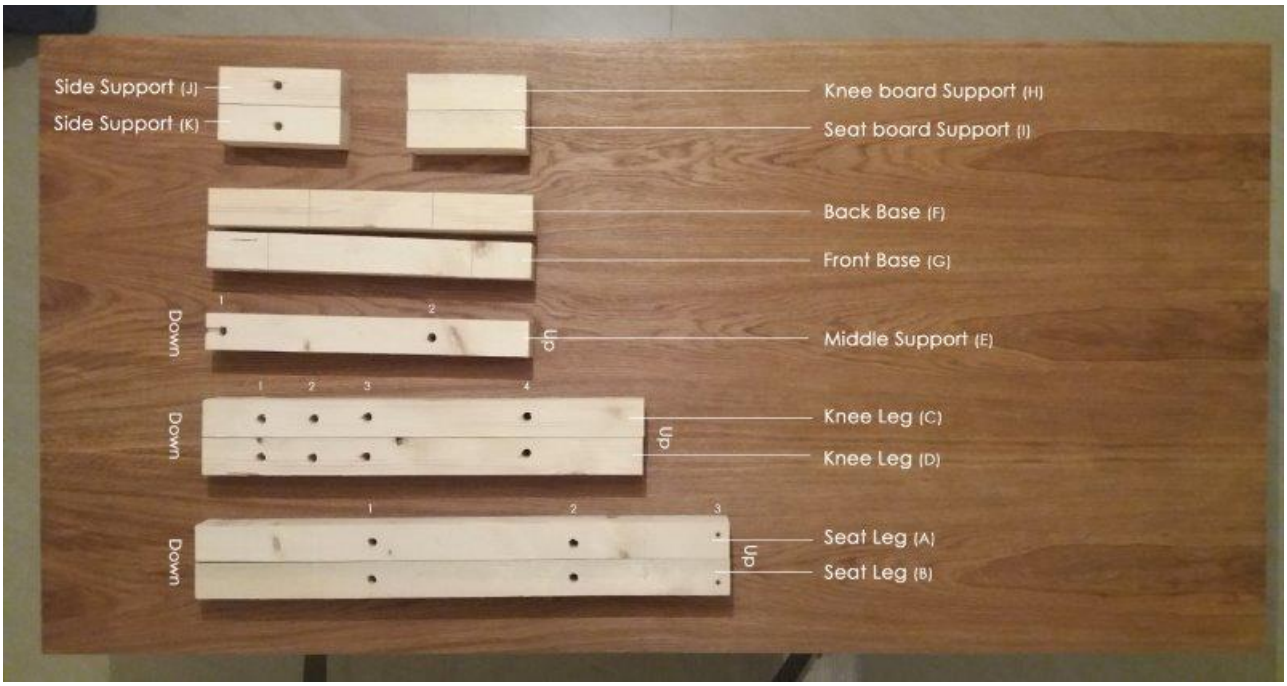
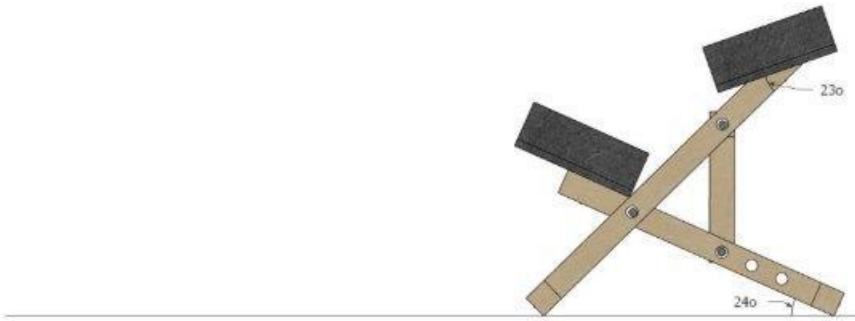


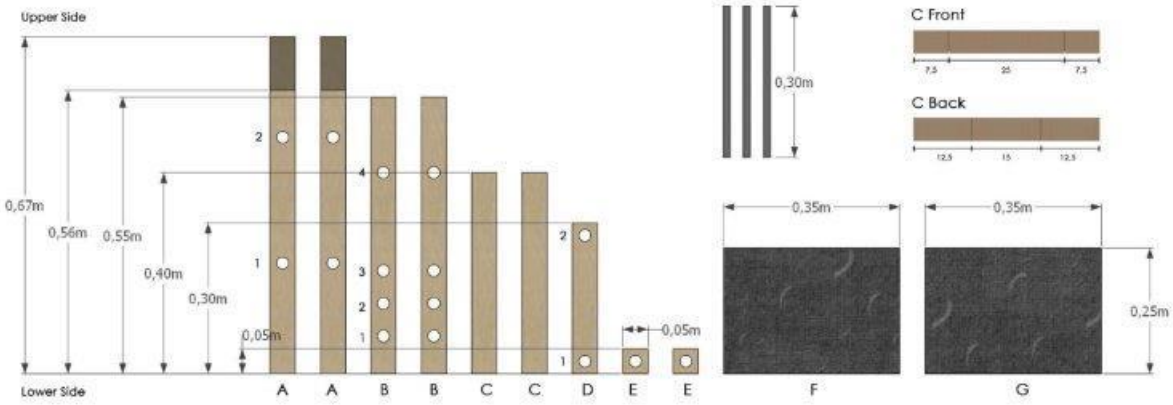

1,5
1,5
3,5
∅ 0,4

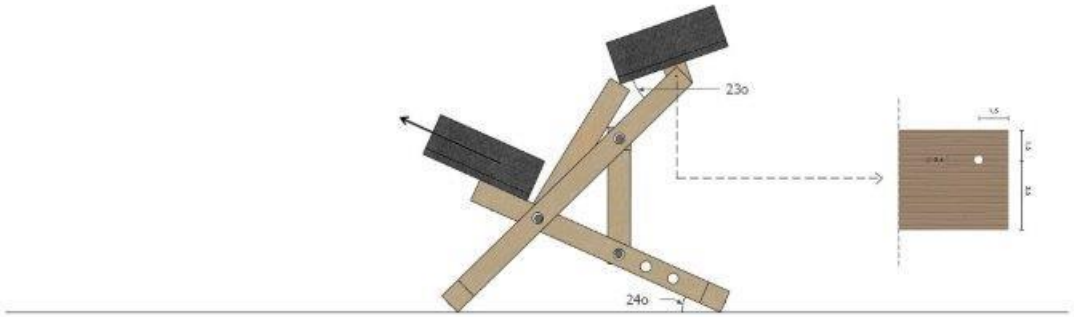

12,5 cm
12,5 cm
35cm
H
Seat Board
40cm

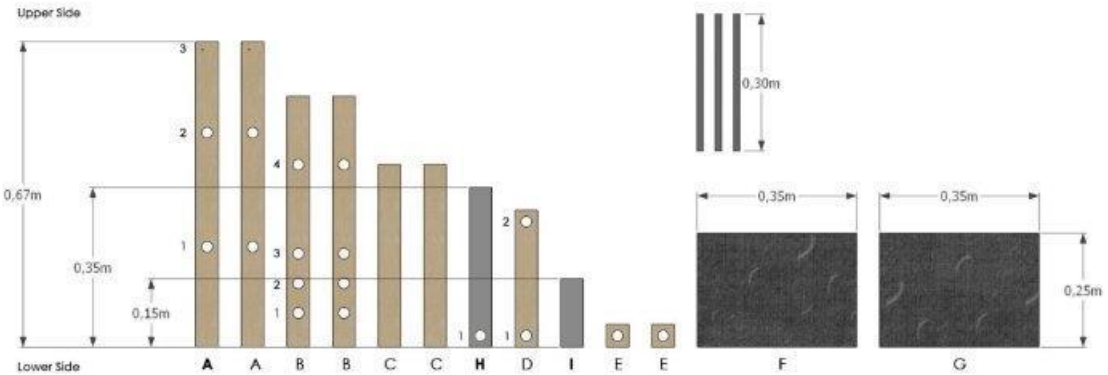

25cm
Knee Board
50cm
8 cm
17,5 cm

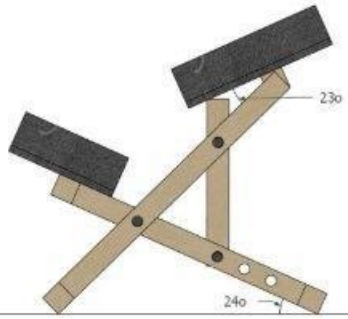

Side Support (J)
Side Support (K)
Knee board Support (H)
Seat board Support (I)
Back Base (F)
Front Base (G)
Down
1
2
up
Middle Support (E)
Down
1
2
3
4
up
Knee Leg (C)
Knee Leg (D)
Down
1
2
3
up
Seat Leg (A)
Seat Leg (B)


23o
24o


Upper Side
0,67m
0,56m
0,55m
0,40m
0,30m
0,05m
Lower Side
A A B B C C D E E
0,30m
C Front
C Back
0,35m
0,35m
0,25m
F
G


23o
24o


Upper Side
0,67m
0,35m
0,15m
Lower Side
A A B B C C H D I E E
0,30m
0,35m
0,35m
0,25m
F
G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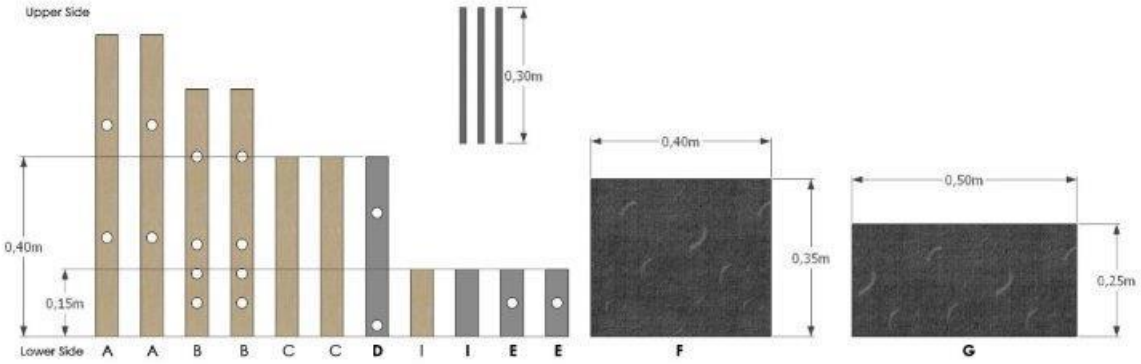
24o


Upper Side
0,30m
0,40m
0,15m
0,40m
0,35m
0,50m
0,25m
Lower Side
A A B B C C D I I E E
F
G


12,5 cm
17,5 cm
12 cm
8 cm