Pento

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Pento

Degree Project for Bachelor of Fine Arts in Design,
Main Field of Study Industrial Design

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Abstract

The rich cultural heritage of China is becoming less relevant and forgotten as a result of rapid urbanization and modern lifestyles. This project aims to preserve the Chinese music heritage by designing an instrument based on the Chinese zither guzheng.

Despite the rising interest of traditional instruments, there are factors that are holding people back from practicing them. There have been attempts of modernization but with very small alterations and a high focus on electrification. However, these qualities do not only misalign with the contemporary lifestyles in term of functionality and aesthetics, but also take away the genuineness when incorporating unsustainable materials.

We challenged the idea of taking an iconic instrument and changing it to fit contemporary lifestyles and aesthetics. One of the main focuses was also to design for a worldwide market, with the ambition of breaking cultural barriers.

Pento is a 15-stringed zither designed to harmonize with modern society. In contrast to the traditional instruments, it is small and portable enough to sit in a small living space or to be carried around in a busy city.

With new technologies as CNC-milling and 3D-printing, the old-established production process is redesigned to be more efficient and sustainable. The production is also developed to be applicable in any geographical location, using the local hardwood as the body of the instrument.

Traditional Chinese Culture

Chinese culture is one of the world's oldest cultures, with a recorded history of over 4,000 years. The main area in which the culture is dominant includes a large geographical region in east Asia, where lifestyles and traditions vary vastly between cities and provinces. Throughout the history of Chinese civilization, its artisanship and agriculture have been notable for their high level of complexity. China has nurtured many great inventors, artists and thinkers, who all have had a deep influence on the rich cultural heritage and philosophies of Asia today.

琴 棋

Qin Qi

書 画

Shu Hua

The Four Arts

四藝 (siyi), or the Four arts of the Chinese scholar, were the four main artistic and academic accomplishments required of the aristocratic ancient Chinese scholar-gentlemen caste.

Even though the four separate qualities befitting a well-educated person, the earliest written source putting the four together was found during the Tang Dynasty (618-907) in Zhang Yanyuan's 法書要錄 (Exemplars of calligraphy). The four arts was later established in Li Yu's "闲情偶寄" (On the pleasure of idleness), in the 1600's.

In contrast to the ancient times, these skills are today considered as hobbies and way more optional than they were thousands of years ago. The art forms separately could today be associated with more general categories such as any games or just writing in general, and these have had a clear development in line with society and technology. However, the different artforms refer to quite specific techniques and products, for instance, board games refer to a specific Chinese strategy board game, which have in fact not changed a lot since then. Although very few changes these art forms are still relevant and practiced today, the only distinct difference is that they are fading away and are not exposed anymore.

Even though the concept of four arts is not relevant for our self cultivation today, it has had a large impact on Chinese culture and set an important foundation of the contemporary practices of art and leisure activities. We found this topic very intriguing and came up with the idea of bringing back useful, somewhat forgotten, traditional Chinese objects or lifestyles in the modern day.

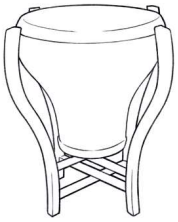
Qin

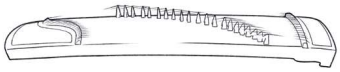
After discussing the four arts we came to conclusion that Qin (instrument) would be the biggest area with opportunities to develop a new product in. What we found while researching about the other categories was that compared to Qin, most products and techniques were already too established and had less room to design something new within.

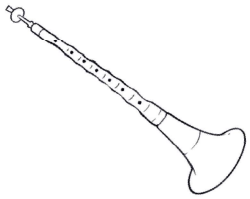
Originally, Qin refers to the Chinese instrument guqin, a seven stringed zither which is the oldest zither to be found (gu meaning antique). The guqin is iconic for the Chinese music heritage and is sometimes referred to as "the father of Chinese music" or as "the instrument of the sages". The qin has evolved and nurtured a range of different zithers, for example the guzheng and the yangqing.

Music - the Universal Language

Quite early in the project we decided that we wanted to design with an ambition to break down cultural barriers. With this in mind we thought that music was relevant since it is considered a universal language. Music is often used and practiced in the purpose of expressing emotions, it has the power of impacting the mood and is often used at celebrating events. Music is what connects people and is something anyone can emotionally relate to, no matter cultural or ethnic background.







Traditional Instruments

Chinese musical instruments were traditionally grouped into 8 categories - silk, bamboo, wood, stone, metal clay, gourd and skin - known as bayin (八音). Nowadays, Chinese musical instruments can be divided into four basic categories based on the method by which they are played. They are bowed strings, plucked strings, winds and percussion instruments.

Chinese Musicology

Chinese musicology is the academic study of traditional Chinese music theory. The tonality in Chinese music differs from Western music and use a numerical note system rather than alphabetical.

The first musical scales of Chinese musicology derived from the harmonic series, which is a sequence of pure tones produced by vibration in an exact fraction of its length. This is quite recognizable on the guqin, which has a scale of 13 positions, all representing a natural harmonic position marked as dots on the body to the open string.

The Pentatonic Scale

Most traditional Chinese music instruments are based on the pentatonic scale. It can be found in every culture of the world but is especially common for Chinese music, both in folk and traditional music and in contemporary songs with newer genres. This scale has five notes per octave and is universally known as a scale that "sounds good however you play it" because of its lack of the tension and suspense. By eliminating the tritone, you get a pleasant sounding scale which is easy to layer over chords and other scales.

The notes of the Chinese scale are called gōng 宫, shāng 商, jué 角, zhǐ 徵 and yǔ 羽. Similar to modes in Western music, a scale with a different interval sequence can be created by starting from a different point of the sequence. These are named after its starting note.

宫
Gōng

商
Shāng

角
Jué

徵
Zhǐ

羽
Yǔ

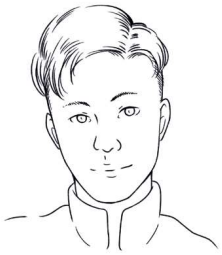
”

Interviews

Interviews with five University students at the Central Conservatory of Music in Beijing, China.

Jiaoxu Bai / Ruan Major

- There are four different sizes of the ruan, each one has a different key and unique role in orchestras.
- The way of play ing the ruan is very similar to acoustic guitars, by using a plectrum or plucking the strings
- The soundboards are exchangeable and has to be replaced once broken.
- Compared to the pipa, the ruan is more intuitive to learn as a beginner .



Wei Lin / Suona Major

- The dizi, suona, sheng and guanzi are the four most common wind instrument majors at my university, and most of the academic wind instruments are reed (mouthpiece which vibrates to produce sound) instruments, except the dizi.
- The musical theory of Suona is similar to Oboe and the dizi's are similar to Western concert flutes.
- There are smaller versions of each wind instrument to simplify learning as a beginner, and larger versions for different keys and tone ranges.
- Basic wind instruments such like hulusi, wuba and taodi are reedless and generally easier to control
- Chinese wind instruments are mostly made of bamboo, except the suona, the body of the suona are solid wood and the mouthpiece and the bell are typically made of brass or copper.

Shuyang Guo / Pipa Major

- There are two different sizes of Pipa, one for children and one for adults
- The pipa is known as the instrument that has the most complicated playing techniques
- Characteristic overtone, has the brightest and loudest sound among all traditional instruments

Yi Xin / Guzheng Major

- The guzheng is one of the most popular traditional instrument today
- There are various sizes but the average length for a standard guzheng is 1.62m
- Shorter versions have a worse sound quality than the regular ones, but people still buy them for the portability
- Some high-end guzheng models are completely made by one piece of solid wood, with this production method the thickness of the body could be decreased. Simultaneously, the market price will then be higher.
- In cases where guzheng players want to carry their guzheng with them, to concerts for instance, it is particularly difficult because of its size and weight.

Junqi Zou / Percussion Major

- One of the most common Chinese percussions in traditional music is huapenggu (meaning "flowerpot" drum). This is the drum beginners usually start with.
- Chinese percussion technique and mallets are the main thing that makes them different from Western drums.
- In school, percussion major students have to master various percussion instruments, even the western ones

Field Trip to Shanghai

In the middle of the research phase we traveled to Shanghai, China, to gain deeper knowledge of the Chinese musical heritage. We visited various academies and museums, while interviewing experts and musicians in the field. The aim was also to get a profound insight of the contemporary production of the musical instruments, by studying the materials, processes and techniques in the factories of central Shanghai.

Shanghai No 1 Music Instruments Factory

Shanghai No 1 National Musical Instrument Factory (上海民族乐器一厂) was founded in 1958. It's a comprehensive traditional musical instrument factory who produce and develop various kinds of percussion-, string- and wind instruments. During the 1960's, Shanghai No 1 Musical Instrument Factory introduced the S-21 type Guzheng. This model is still the standard model and the most popular kind of guzheng today.


民族樂器一廠
400

Production

When visiting the factory we found out that most of the production has not been modernized and the same technique from many years ago were still in practice. Only a few industrial machines were needed and most of the process including sanding and finishing were done by craftsmen.

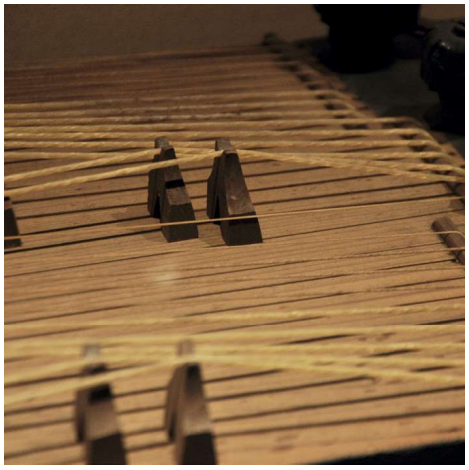
In the factory tour we were able to study the whole production process of the erhu and some parts of the pipa and the ruan. An interesting thing we documented while in the factory was that the Chinese traditional instruments lack bassline instruments. Because of this, a craftsman was in the process of inventing a double bass instrument in the same fashion as the other instruments.

Material

The instruments all have the same or very similar materials. For instance, the material used for the soundboards on various instruments is Paulownia, a fast grown type of wood, found widely in China. For the bodies of the instruments, there are several types of rosewoods that are being used. The quality of the rosewood and paulownia decides the whole instruments sound quality, weight and price. The saddles and frets are mostly made of bamboo, and the strings are made of steel wire coated in nylon. Nails and screws were not necessary in the process.

Museum of Oriental Musical Instruments

Shanghai, China



Instrument Lessons

Traditional music instrument classes in Shanghai were not difficult to find. A variety of music schools were located around the Daxuecheng area, and most of the music teachers there were newly graduated university students who wished to pursue a career in teaching within their musical field.

Prior to this trip we had made an exclusion of wind- and percussion instruments. As a result of our research, we came to an conclusion that it would be the most beneficial if we chose instruments we saw potential of improvement on, and decided on Yangqin, Pipa and Guzheng. By meeting experts within the field and being able to physically interact freely with the instruments we gained a lot of knowledge to analyze and discuss what we wanted our project to focus on.

Yangqin Teacher at Lucy Music

Yangqin / Percussion zither / Cymbalom

Played with bamboo mallets with rubber or leather heads. The range of yangqin covers one octave below middle C and two and a half octaves above it.

"Yangqin is known as one of the few Chinese Instruments that have the possibility for players to play solo with"

Pipa Teacher at Lucy Music

Pipa / Short-necked lute

Prominent as a solo instrument and in orchestras. Playing the pipa is considered as quite a sophisticated activity.

"Pipa requires complicated playing techniques and might be difficult for beginners to learn."

Guzheng Teacher at ArtistEight

Guzheng / Zither

The most common guzheng today has 21 strings which covers 4 octaves of the pentatonic scale. The earliest sign of guzheng was more than 2000 years ago, making it of the oldest found instruments in China.

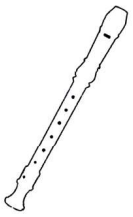
"Guzheng is getting more popular nowadays as a lot of kids want to learn it"

Research Conclusion

After a thorough research we realized that we had to limit our project to one specific instrument or category to be able to start ideating design opportunities. Since we had already limited us to three instruments from three different categories within stringed instruments (percussion, zither and lute) we now had the possibility to choose between these.

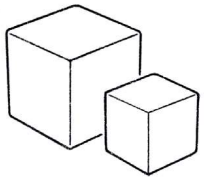
When evaluating these we came to the conclusion that the pipa already has an established and recognizable playing technique even though it is quite difficult for beginners to learn. It also has the same general characteristics as an acoustic western guitar. The yangqing is a relatively newer instrument compared to the others and has, just like the Pipa, a quite advanced playing technique. The instrument's wide range of octaves makes it a complex instruments with a huge potential of playing intricate music pieces. On the other hand, the guzheng is the instrument that is the most iconic for Chinese musical culture which carries the most historical value. We chose to continue the project with the guzheng as a core instrument because it is the most relevant one between the three. In addition, we thought that the guzheng highlighted important theoretical matters as it is constructed with 4 octaves of pentatonic scale linear to each other.

Design Opportunities



Introducing

Create an easier instrument that introduces people to the other traditional Chinese instruments



Size

Make the instrument more compact and portable

Sound

Replicate the sound or create a new sound that is still recognizable as a Chinese instrument

Playing technique

Keep the same playing technique or invent a new way to play

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Design a zither based on a Guzheng and inspired
by other Chinese traditional string instruments

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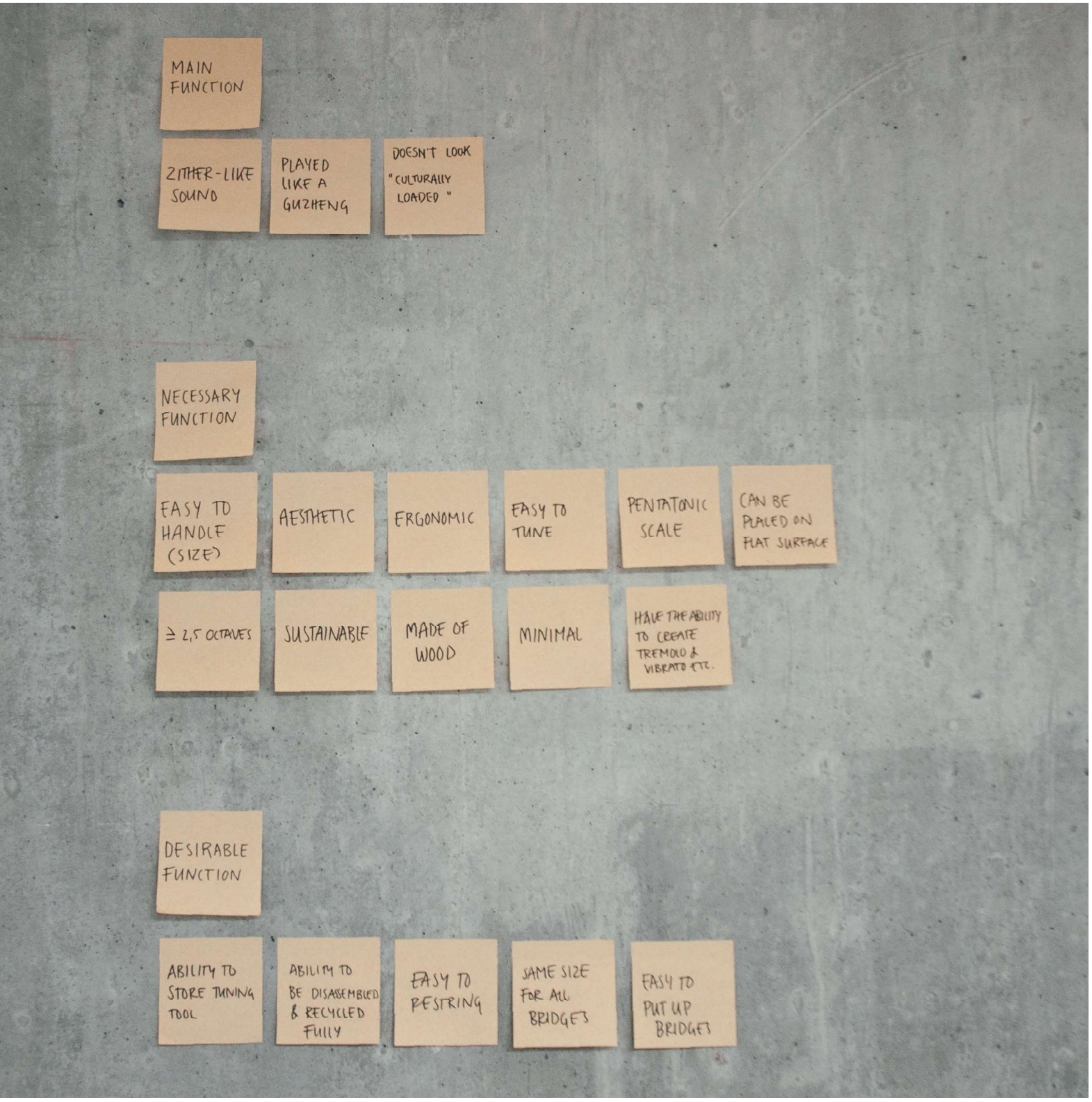
Design Objectives

- Introduce, expose and preserve the Chinese traditional music culture
- Break cultural barriers and design for a worldwide market
- Make an addition to an already existing range of music instruments

Function Analysis


MAIN FUNCTION
ZITHER-LIKE SOUND
PLAYED LIKE A GUZHENG
DOESN'T LOOK "CULTURALLY LOADED"
NECESSARY FUNCTION
EASY TO HANDLE (SIZE)
AESTHETIC
ERGONOMIC
EASY TO TUNE
PENTATONIC SCALE
CAN BE PLACED ON FLAT SURFACE
≥ 2,5 OCTAVES
SUSTAINABLE
MADE OF WOOD
MINIMAL
HAVE THE ABILITY TO CREATE TREMOLO & VIBRATO ETC.
DESIRABLE FUNCTION
ABILITY TO STORE TUNING TOOL
ABILITY TO BE DISASSEMBLED & RECYCLED FULLY
EASY TO RESTRING
SAME SIZE FOR ALL BRIDGES
EASY TO PUT UP BRIDGES

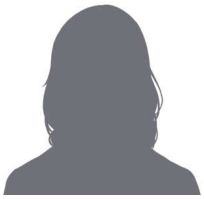
Personas

2nd generation immigrant Chinese

Interested in their culture that's not as exposed in their countries, but there's no market for the instruments there.

Young adult living in China

Wants to learn how to play a zither. They want to play modern popular music, because they've been inspired from Youtube, but wishes that the aesthetics matches the modern culture.



Musician in Sweden

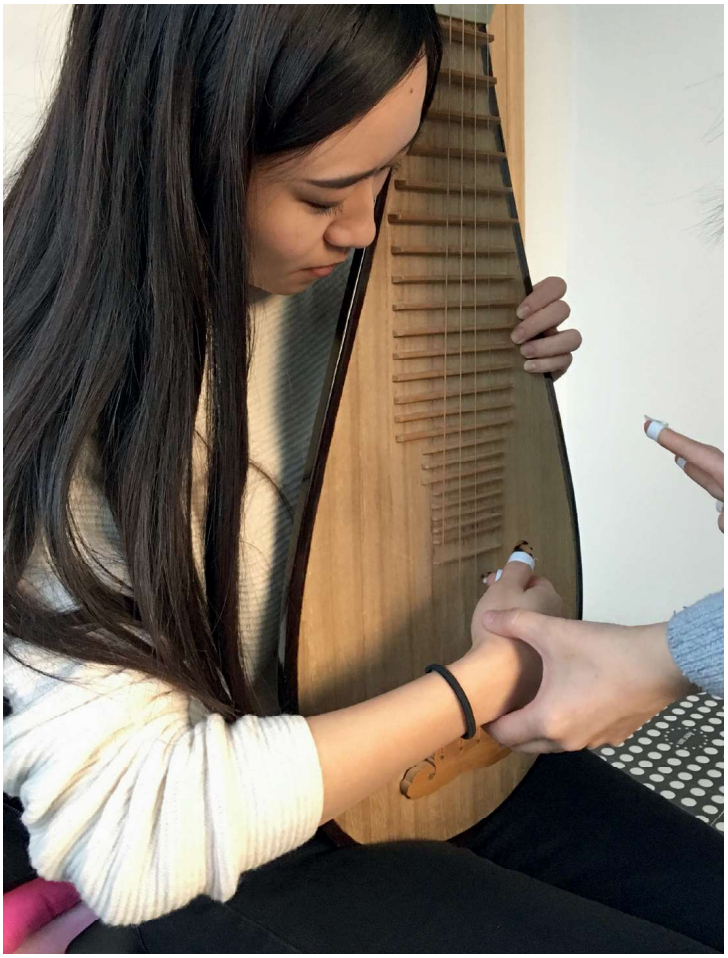
Interested in new instruments. They can play a lot of different instruments and always carries one with them.


福

“Culturally Loaded”

Since a lot of traditional objects derived from different cultures centuries ago, they all had ornaments that today are considered to be the visual sign that a product “looks traditional”. For the purpose of our thesis project we did a study to see how people felt regarding them today. The participants were shown two objects, one with certain cultural ornaments, and the exact same object without. They were asked which one they would buy and what reasons they would base this decision on.

Almost all of the participants responded that ornaments makes a product look “culturally loaded”, and that it makes it harder to relate to than with a product with a minimal aesthetic. This reasoning essentially depended on the fact that they did not have any personal relation to the culture or felt like they did not fully understand what the patterns and symbols were meant to convey. With this conclusion we came to conclusion that one of our design objectives would be to tear down cultural hostility, and to design for a worldwide market.



Society on Traditional Instruments

Unlike the past, traditional musical instruments are now available for anyone to learn. The activity of playing traditional instruments in China are gaining more popularity but is still seen as "old-fashioned", presumably due to its little development of material and aesthetics. Therefore, there are still some factors basing on societal structures or norms that have an impact on people's decisions on whether to begin playing a traditional instrument or not.

Ornaments

Traditional instruments are all decorated with ornaments, that signify cultural associations. However, without the symbolizations and background these ornaments are simply just pretty patterns or illustrations of flowers, which tends to been seen as a "feminine pattern". Due to this, playing certain instruments has gendered and portrayed as a feminine activity, which makes it harder for young males to get introduced to and accepted in the area.

Size and price

Other factors that matter in the decision of getting into the traditional musical field is size, both in terms of dimension and weight, and price. In China, the living spaces are usually very limited and this is problematic since the instruments are often large and require a lot of space in the home. Price could also be a considerable factor since most instruments range up to a quite expensive price as a result of a required long and complex, mostly handcrafted, process.

Purchasing Traditional Instruments Outside of China

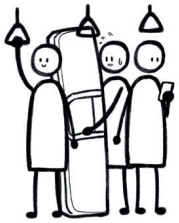
All large scale production of Chinese traditional instruments today are limited within China. So if you live anywhere else it is near impossible to buy a traditional instrument that is locally produced. For a lot of people the only option would be to purchase the instruments online, but since the traditional instruments often are very heavy and large, this option is very expensive even if you choose to buy the cheapest version.

When browsing the internet we could see a recent expansion of interest in the Chinese traditional instruments globally. The culture and instruments have especially gained exposure in websites like YouTube, where it has become very common to post home made cover videos of ones favorite songs and reach out to as many as possible. When reviewing a large amount of these kinds of videos and its comments it was fair to say that most people outside of China never had encountered the Chinese music culture or instruments before. There was also a fair amount saying they have longed to get a hold of a Chinese traditional instrument but that it was difficult regarding their geographical location and the lacking knowledge of reading Chinese language.

From Shanghai to Malmö

While in Shanghai, we decided to purchase a guzheng and document the whole process including transportation, additional costs and other inconveniences. This could have been done differently but our personal experience was documented roughly to show what the process would look like.

Requirements: Mandarin language knowledge, traveling by airplane, smart phone



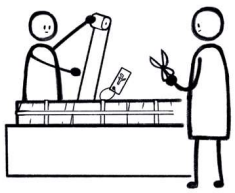
1. Searched on a Chinese second hand market application called "转转" and contacted the sellers.

2. Came to an agreement with the seller and met up for the purchase.

3. Transported it back to our residence. This was especially tricky considering Shanghai's crowded subway and busy traffic.

4. Wired the guzheng with soft clothing to prevent any damage in the transportation process (there were no hard cases available for purchase.)

5. Transported it to the airport, the guzheng had to be placed in the front seat of the taxi because of its inconveniently large size.



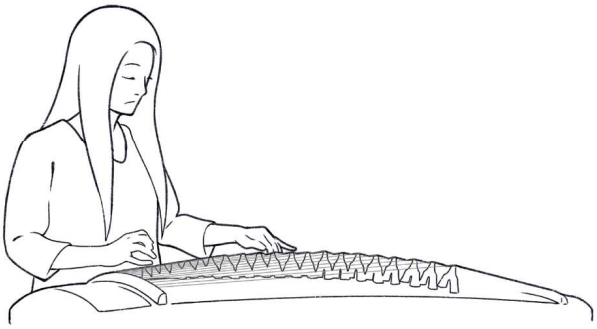
6. Since the guzheng counted as an oversize luggage, we had to pay 300 RMB (~400 SEK) at the airport to have the guzheng wrapped with 3 additional protective layers.

7. Picked up the guzheng at the oversize luggage area at the Copenhagen airport.

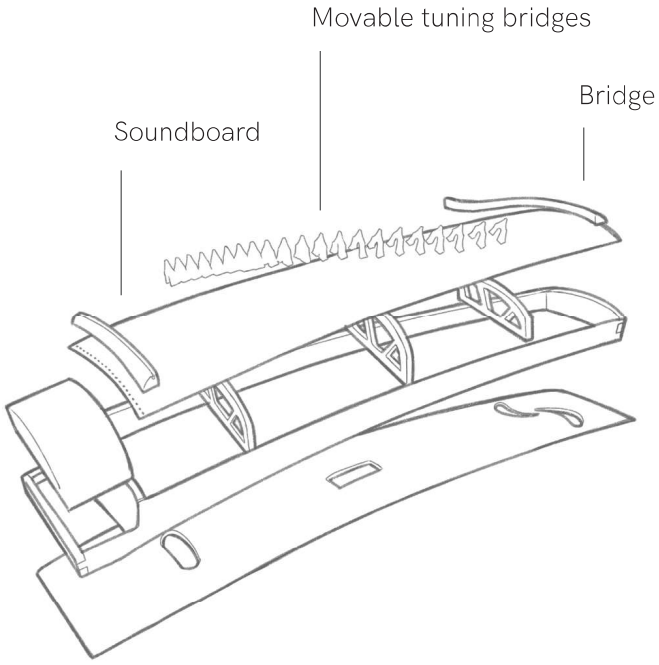
8. Traveled back to Malmö with the guzheng on a crowded train.

Studying the Guzheng

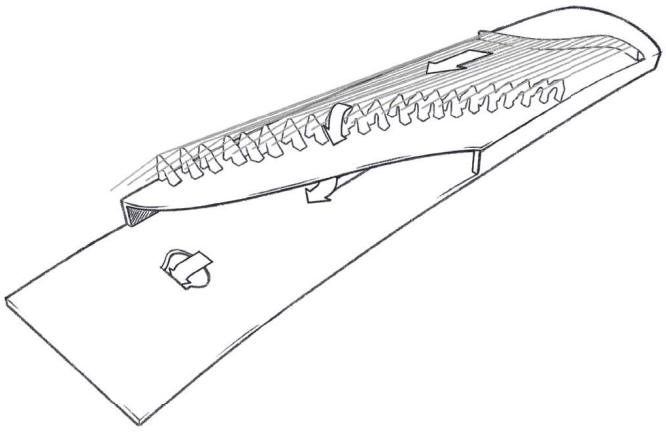
"The guzheng fuses Chinese history and culture as an instrument and decorative art. Artists created unique cultural and artistic content on the instrument, reflecting poetry and the relationship between painting and calligraphy. Decorations include carved art, carved lacquer, straw, mother-of-pearl inlays, painting, shell carving (jade) and cloisonné."



Parts of a guzheng



How it works



The strings and the movable bridges send vibrations down to the sound box and out through the holes.

Guzheng Tone Quality

Soundboard Material

Thickness has an important factor in tone when it comes to the soundboard. If the instrument sounds hollow and broken, it might be because the wood is too thick, which does not allow the vibration to pass through entirely.

Regarding the wood quality it depends which part of the tree is. The quality varies whether it is the root, the middle, the tip, or if it has been more exposed to the sun. What is chosen for the soundboard is not depending on any standard, but is more based on experience and the qualities of the specific tree.

Moisture of the Soundboard

If the water content of the soundboard is too high, it will have an effect on the sound quality (given that the soundboard has an appropriate thickness). The soundboard should be made of Paulownia that has been dried thoroughly. There is three techniques when it comes to drying soundboards.

Air drying: Should be dried for at least a year or two. Should retain the natural color of wood, usually light golden brown.

Oven drying: Dried as long as the moisture content goes down to less than 10%. Usually becomes a warmer tone than the air dried ones.

Flame drying: Flame drying speeds up the drying process from 1 year to 30 minutes and is commonly practiced nowadays because of this. The disadvantage is that the fire gun directly pointed to the wooden surface fatally destroys the piece. They could also crack or warp easier. The flame dried soundboards are usually of a darker color.

Resonance

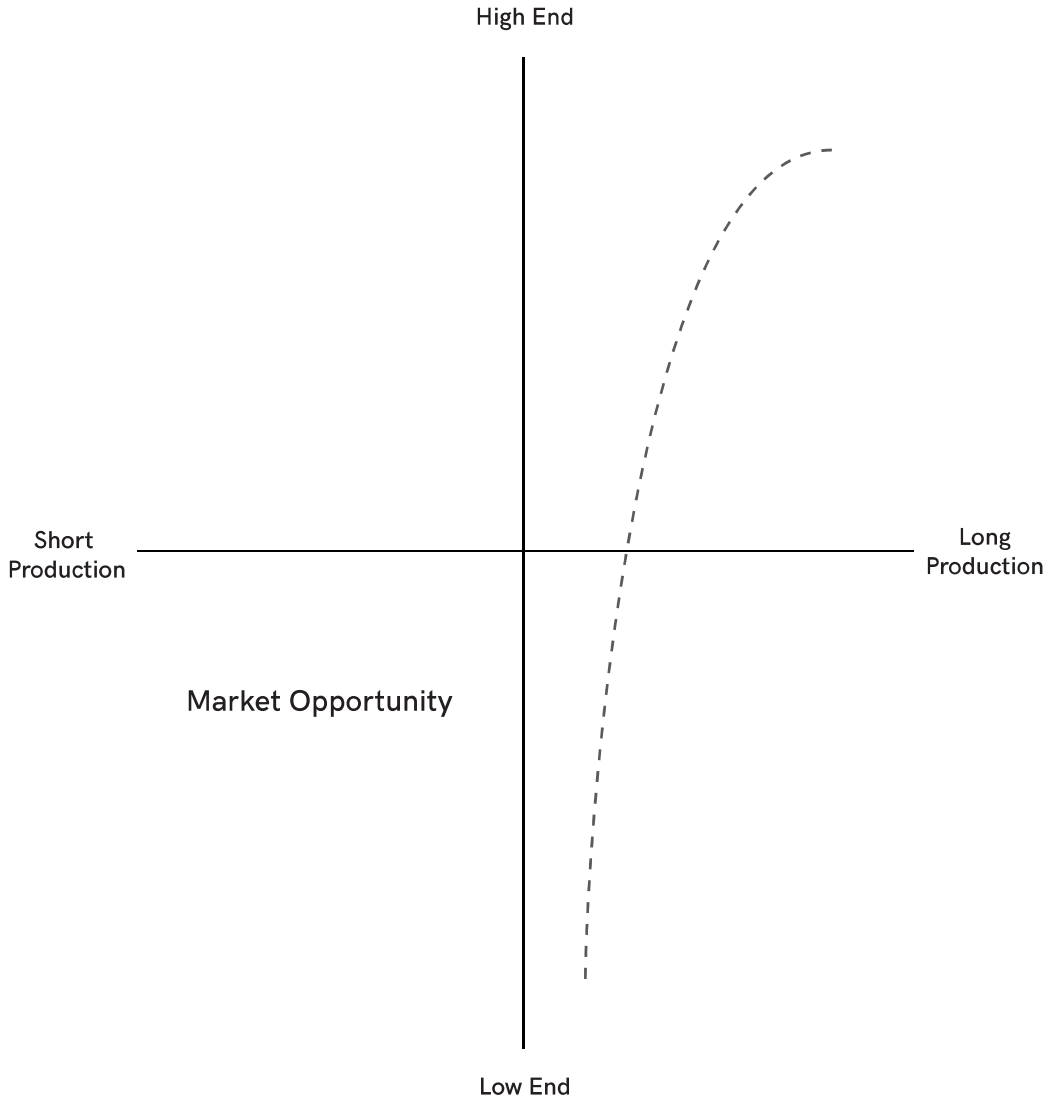
The curvature of the soundboard, bottom holes and size will have a effect on the resonance quality. (Veneer materials are usually added for aesthetic purposes and could also have a little effect on sound).

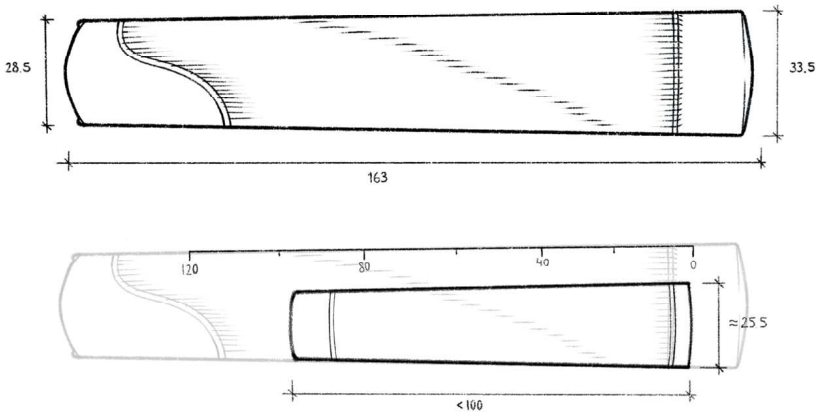
Strings

Good quality strings can improve the tonality of a Guzheng. In the past, silk strings were often used in string instruments. They have however evolved into nylon-covered steel strings

Market Analysis

An analysis of existing products on the market and how their prices relate to their production process time.


High End
Short Production
Long Production
Market Opportunity
Low End


28.5
33.5
163
120
80
40
0
≈25.5
<100

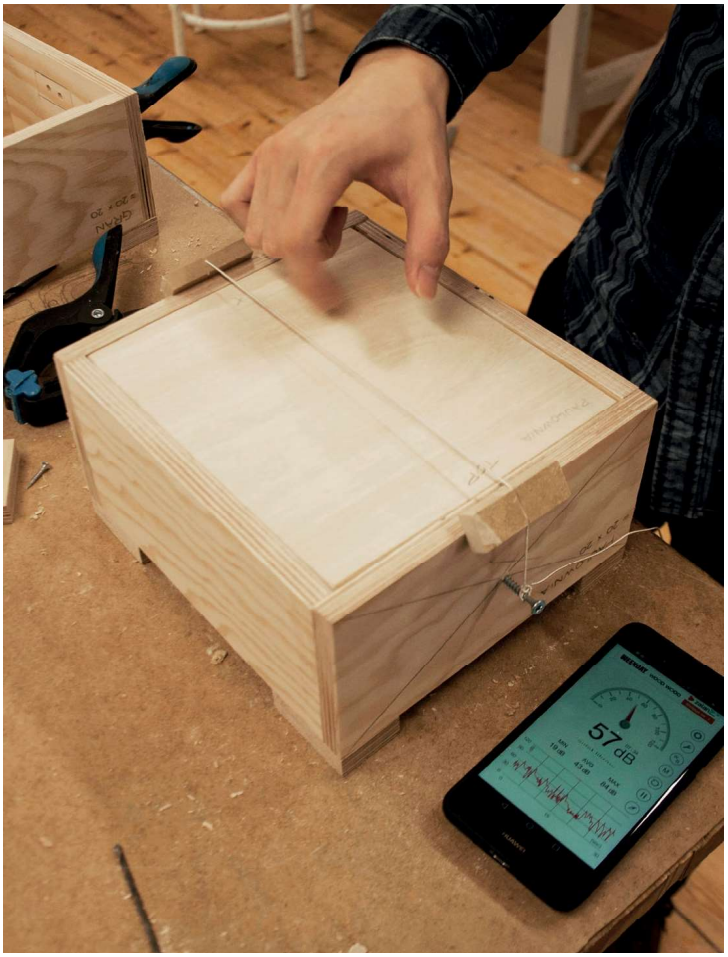
Size Demarcations

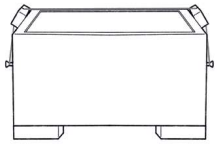
When deciding the size of our instruments there were many things to take into consideration. One of our desired functions was that the instrument should be compact enough to allow portability. The traditional Chinese instruments are mostly heavy and big and not really designed to be carried around from one place to another. We came to a conclusion that a desirable maximum size of a portable instrument would be around the size of an acoustic guitar, which is approximately 1 meter long. Reducing the size of the instrument means less use of material which affects the environment positively.

Regarding the strings we wanted to stick to the theoretical construction of the guzheng, which is 4 octaves of the pentatonic scale in a row (plus one). This decision was based on the fact that the pentatonic scale is iconic for Chinese traditional music and that just by keeping that, the instrument will be recognized as a Chinese traditional instrument. We decided to exclude the lowest octave since beginners usually start to play on the higher octaves and by keeping three octaves we still made room for a quite reasonable range of both novice and advanced playing. Furthermore, excluding the single note on the highest octave - which we found quite insignificant in our case - results in a 15 stringed instrument.

Prototyping

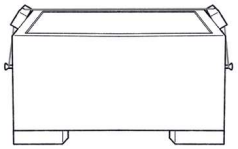
To achieve the best sound quality as possible we built sound boxes with several kinds of constructions, components, materials and dimensions.


57dB



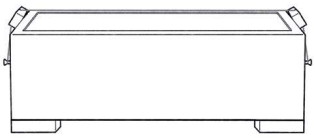
#1

A 20x20x20 cm sound box with a plywood body with a detachable soundboard made of paulownia. One single sound hole on the bottom and nuts made of HDF material.



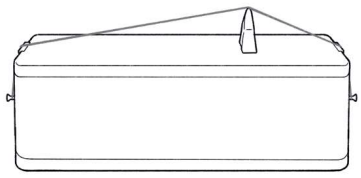
#2

A 20x20x20 cm sound box with a plywood body with a detachable soundboard made of spruce. One single sound hole on the bottom and nuts made of HDF material.



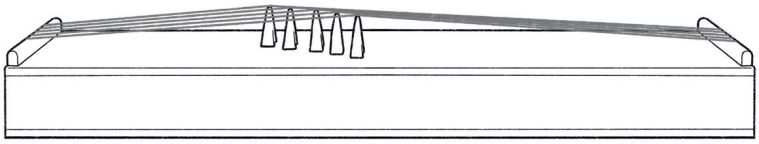
#3

A 40x20x20 cm sound box with the same material as #1 in order to compare sound quality with an increased body size. One single sound hole on the bottom and nuts made of HDF material.



#4

An improved version of #3, with a glued soundboard and tested with a guzheng bridge. One single sound hole on the bottom and nuts made of nylon.



#5

A 100x25x10 cm sound box with a birch body and increased level of craftsmanship. Tested with 5 strings (one octave) and guzheng bridges. It has three sound holes on the bottom and nuts made of steel.

This was a successful final sound prototype. We chose to continue with this structure and size as a base of our instrument. The only exception is that instead of a steel nut, we are going to use one made of nylon. For the body we will use a wood with similar but better properties than birch.

Material Specifications

Body

In order to fulfill the needs of luxury furniture in China, the rosewood forest in Asia and Africa has been extensively felled even though the species are slowly becoming extinct. In China, laws and regulations regarding illegal wood trading has not yet been established, even though the activity is continually increasing. Rosewood is often used for Chinese traditional instruments, and just like the furniture, the wood is often preferred because of its luxurious aesthetics rather than its functional qualities.

The idea is to make the production and material origins as adapted to any geographical location as possible. For this to be possible, we studied the differences of tonewood that is being used for various string instruments. The substitute needed to have similar qualities as the rosewood and be locally grown to where the instrument would be manufactured. However, depending on which country and which wood it would be, the price would obviously differ. In our project, we focused on materials for production in Sweden.

Maple is a popular wood type that is often used for guitar bodies, necks and fret boards, in North America and Europe. It has a hard density that provides a characteristic bright tone, and turned out to be a great substitute for the rosewood.

Nuts

Cow bone and ivory have traditionally been the materials used for making nuts on musical instruments. This because of their outstanding feature of transferring vibrations accurately. However, when the instrument production expanded, these materials were questioned from an ethical point of view. They were later replaced by plastic materials and hardwood, such as TUSQ and ebony. These new materials were developed to have similar tonal characteristic performance as the cow bones.

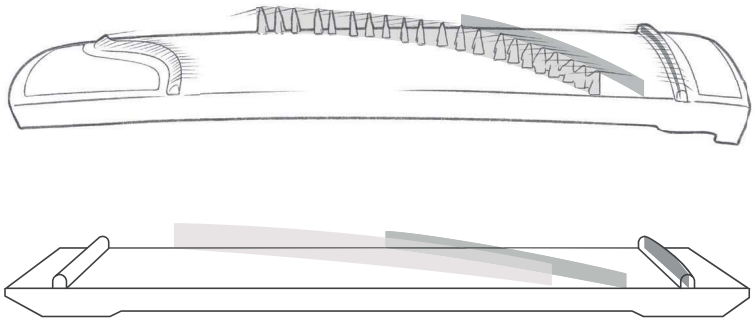
Among the alternatives we had, the 3D-printed nylon was the most similar material to the TUSQ plastic. Additionally, we had the possibility to shape the nylon nuts and bridge tops with 3D-printing technique.

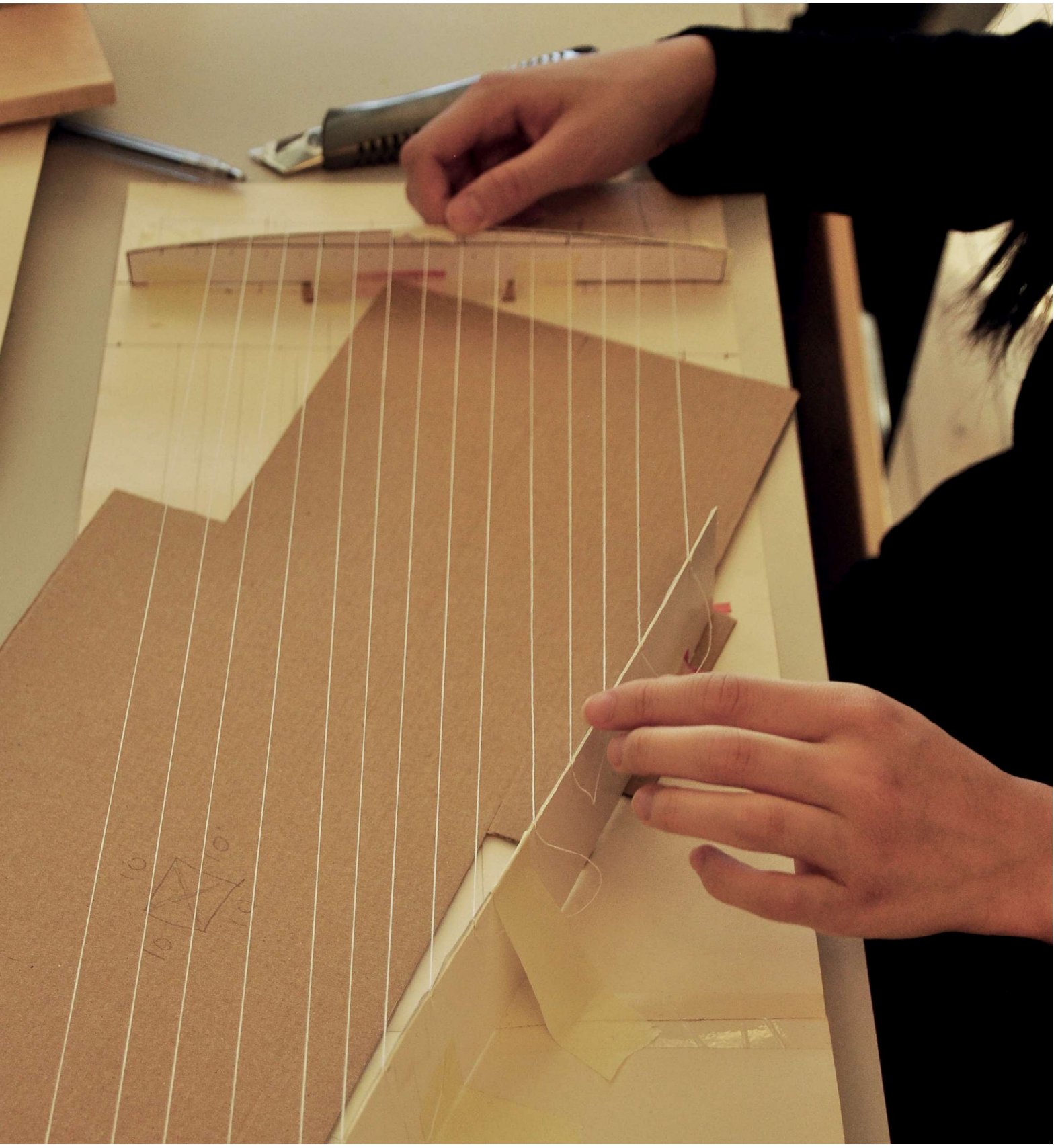
Curve X

The guzheng is designed with a curvature on two different axes, both to create a elegant form and to have an effect on the sound quality. Aside from this, one of these curves provide a natural ergonomic curve to follow when playing.

Since we aimed to design a zither that was portable and had a shorter and more time effective production process, we contemplated whether these curvature were necessary. After ideating several solutions and testing whether the form had that huge of an impact on the sound quality we ended up with a completely flat soundboard. Despite this, we still wanted to keep the ergonomic curve of the strings for a more enjoyable feeling.

After calculating and combining two curves on different axes we ended up with one curve that we could use as a base for the movable bridge heights. By adjusting the bridges we could keep the ergonomic harmony between the instrument and the player.





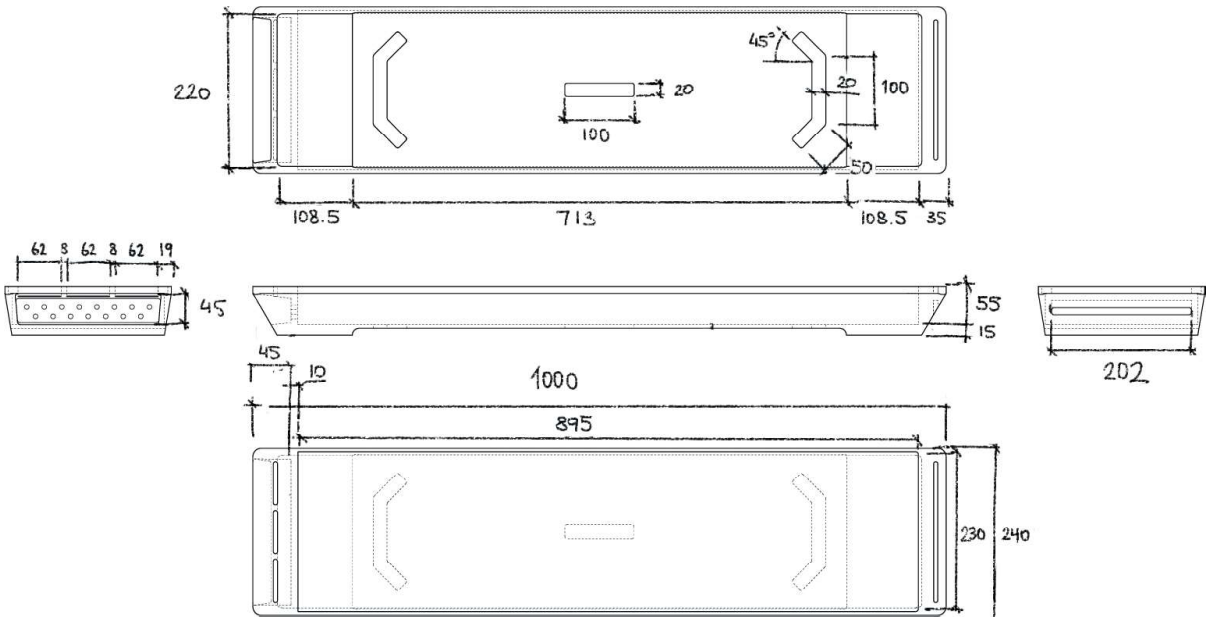

SADDLE
FOLDWING
SQUAREBACK
SQUAREBACK
W PADS
DESIGN ELEMENTS
MAIN BODY
SOLID WOOD
PAULOWNIA
33.5
163

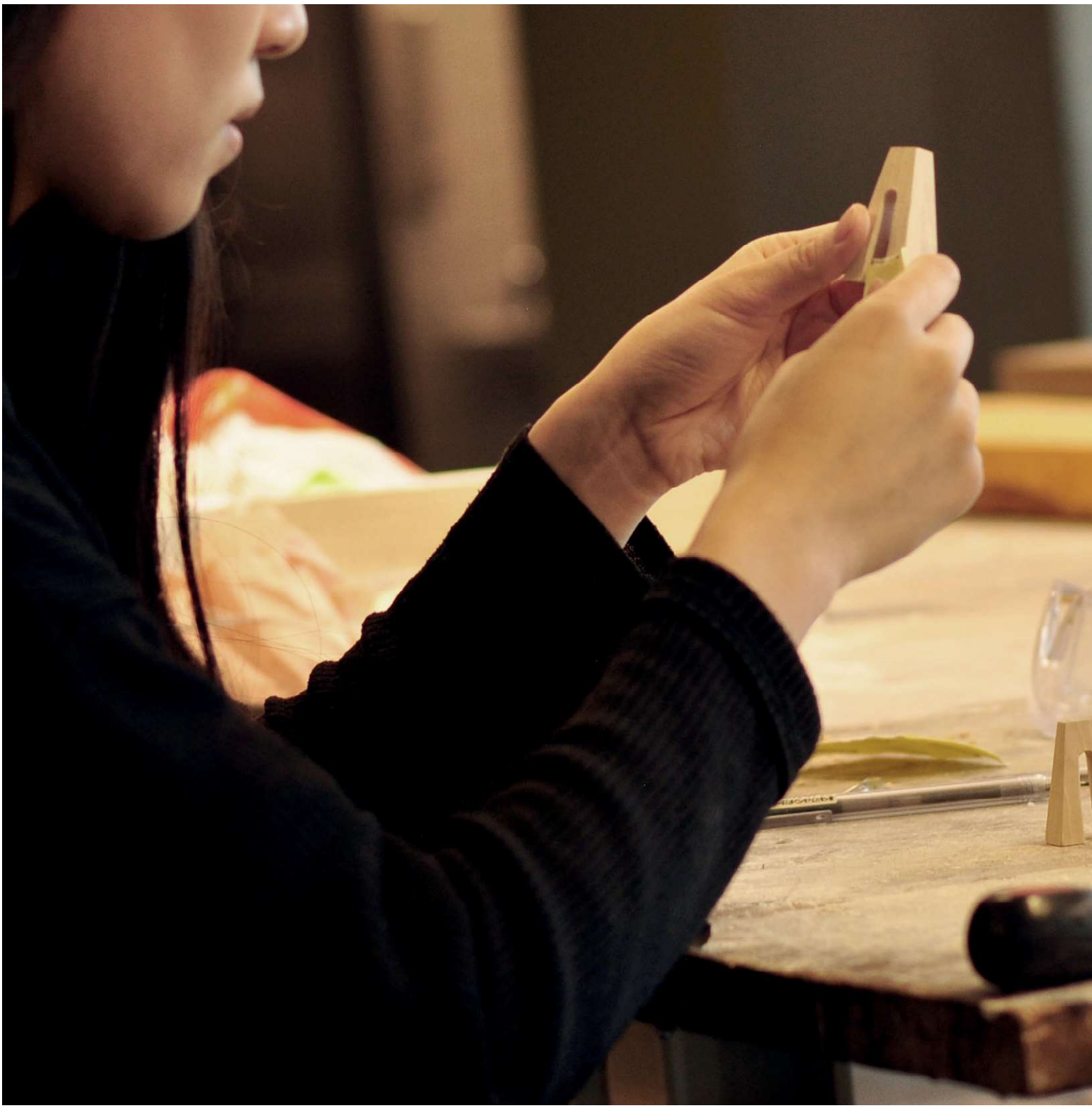

wacom
MAIN FUNCTION

Production

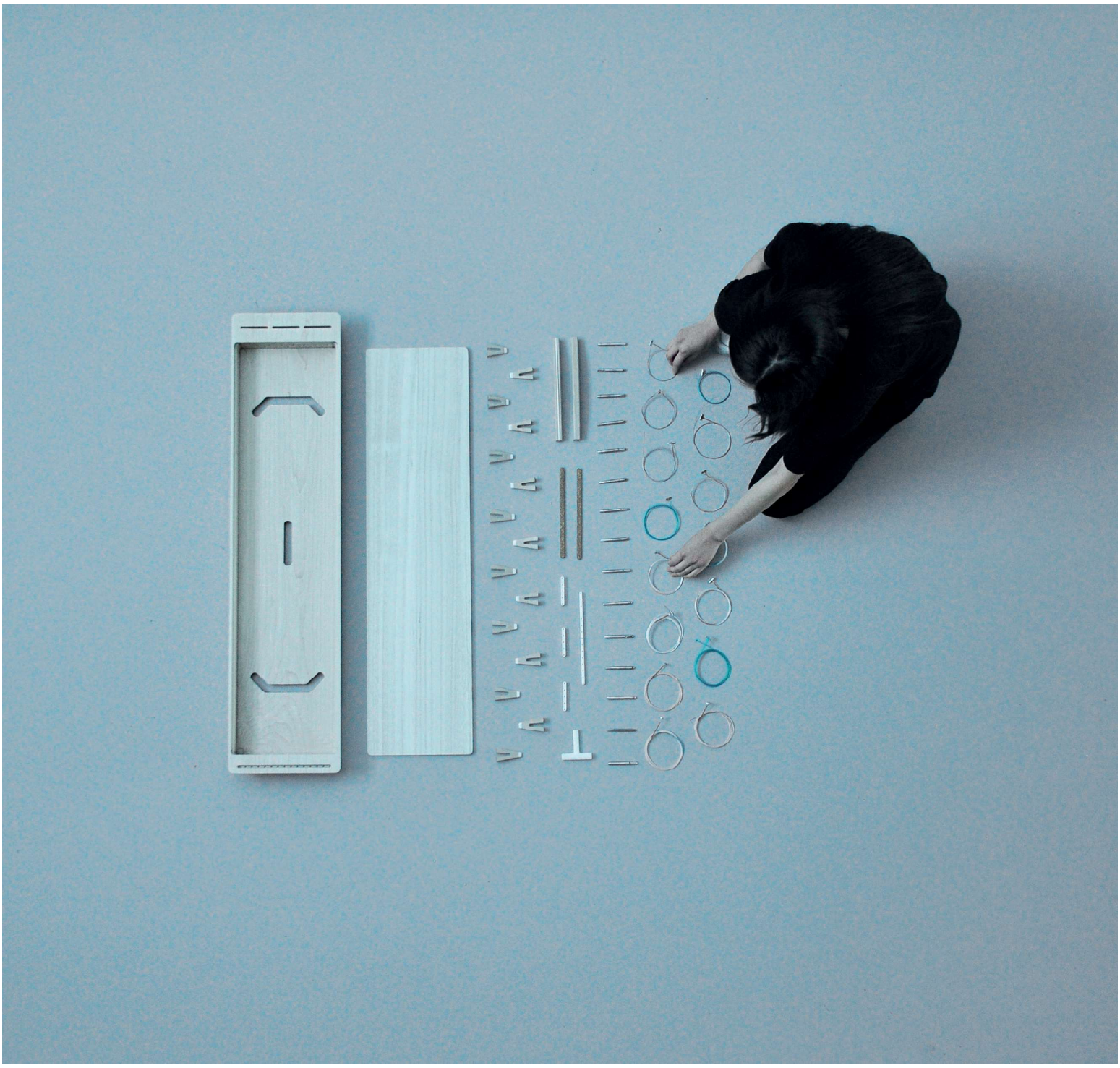
The contemporary production of the guzheng has not changed much through time. It still has numerous production steps, which is heavily time consuming. With CNC-milling, the instrument body can be milled out of one single piece of solid wood. We decided on this production method since it will improve the sound quality at the same time as it reduces the number of the production process. The paulownia soundboard is cut separately to fit the body.

Technical Drawing

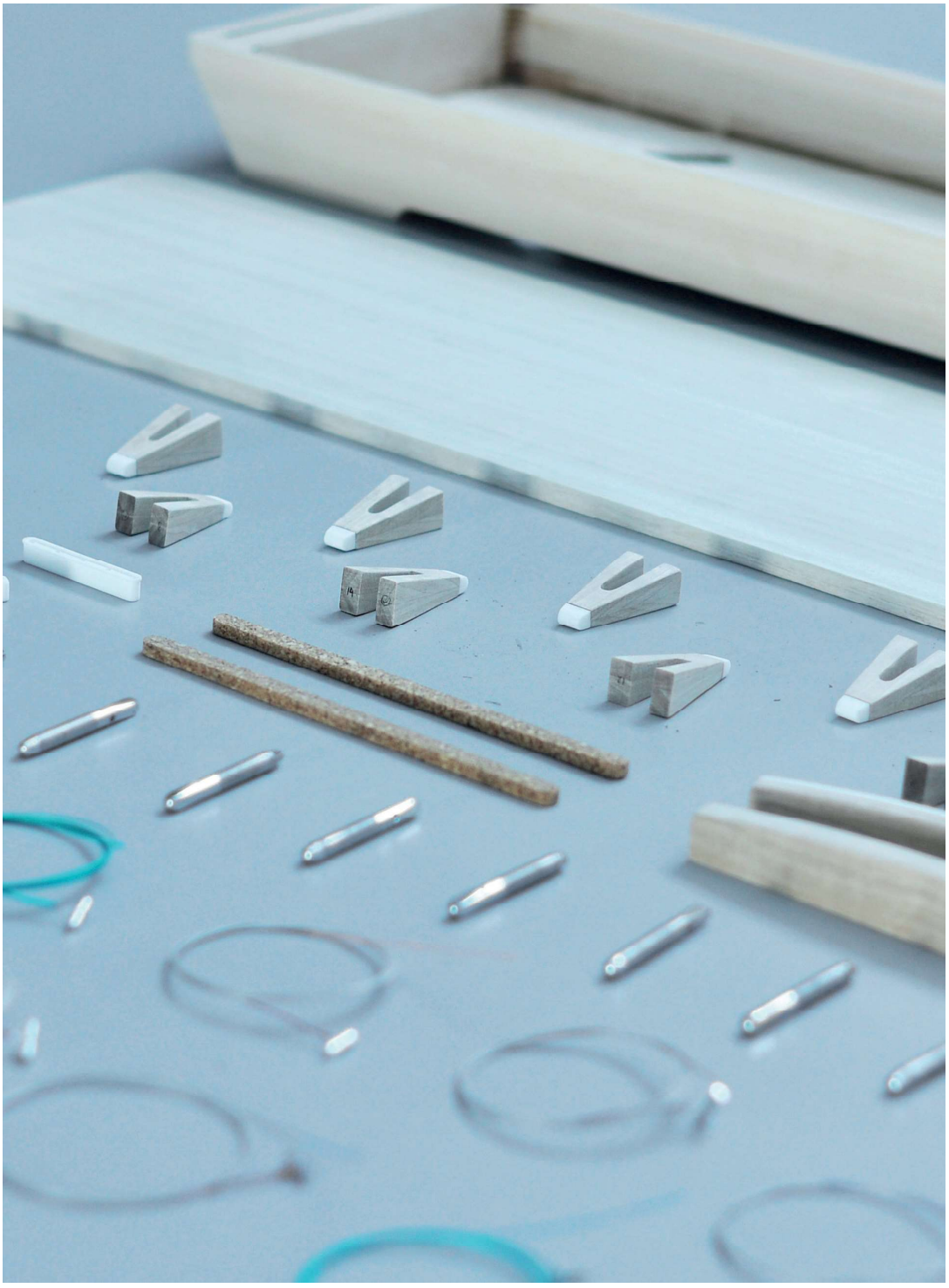


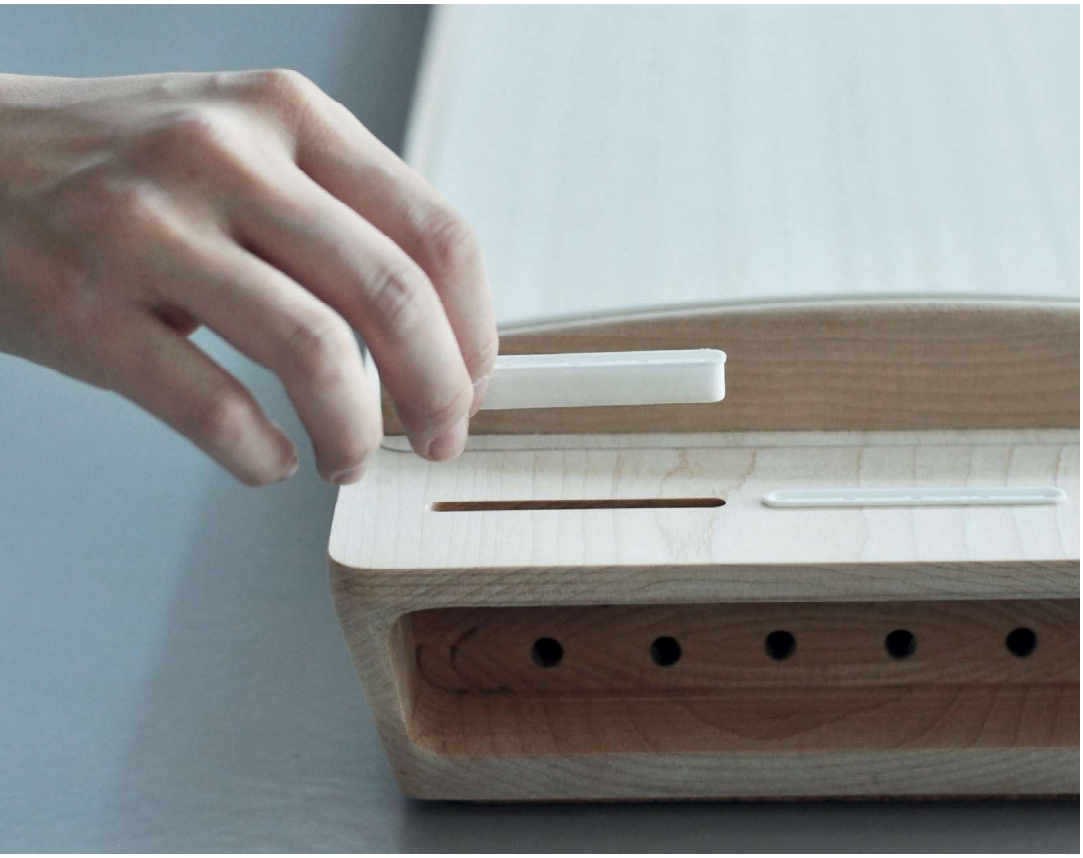


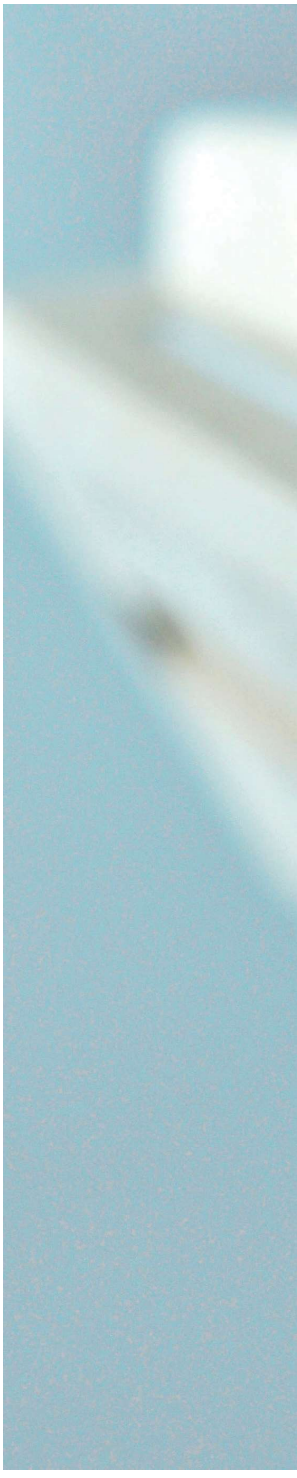
Pento

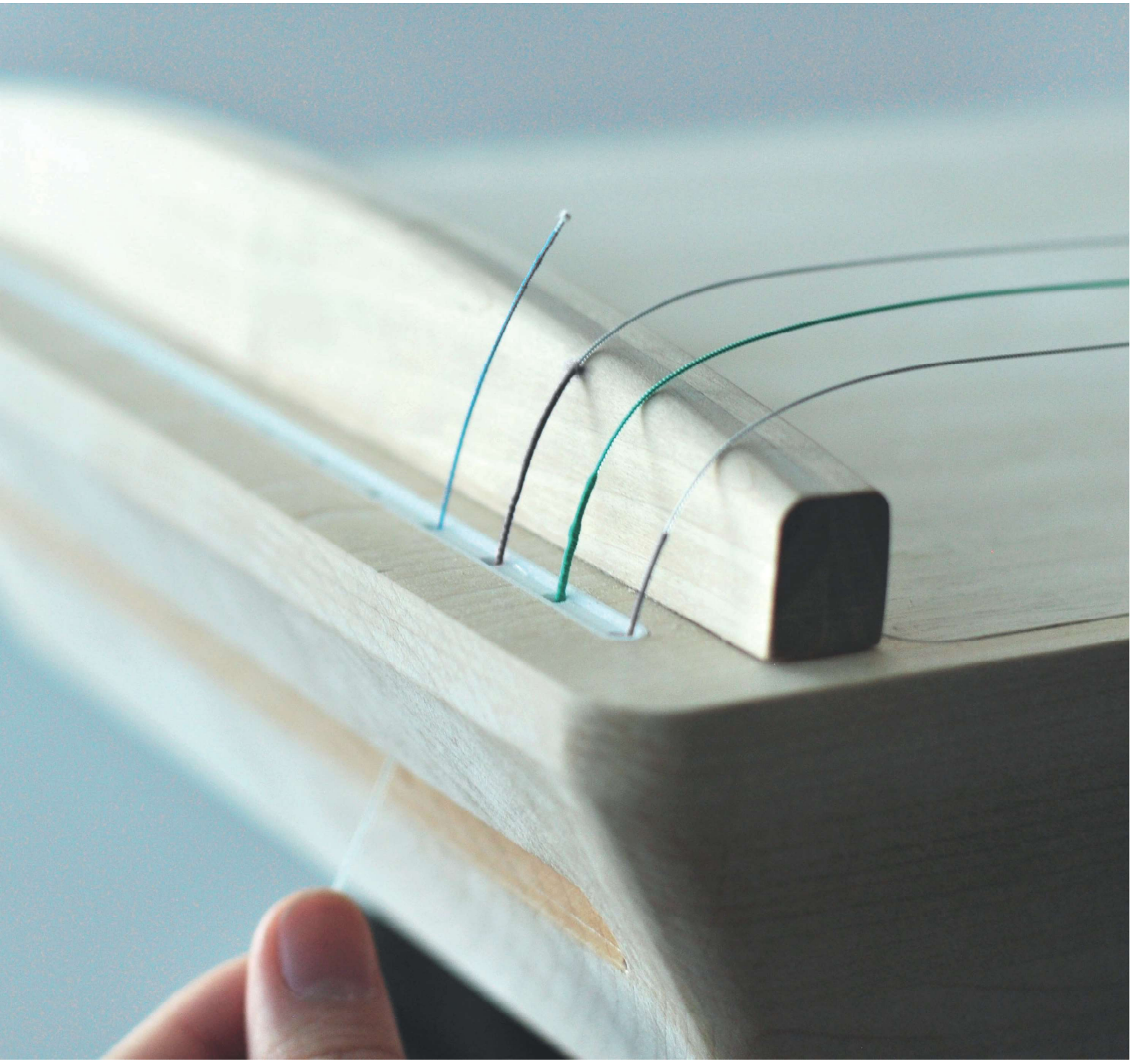


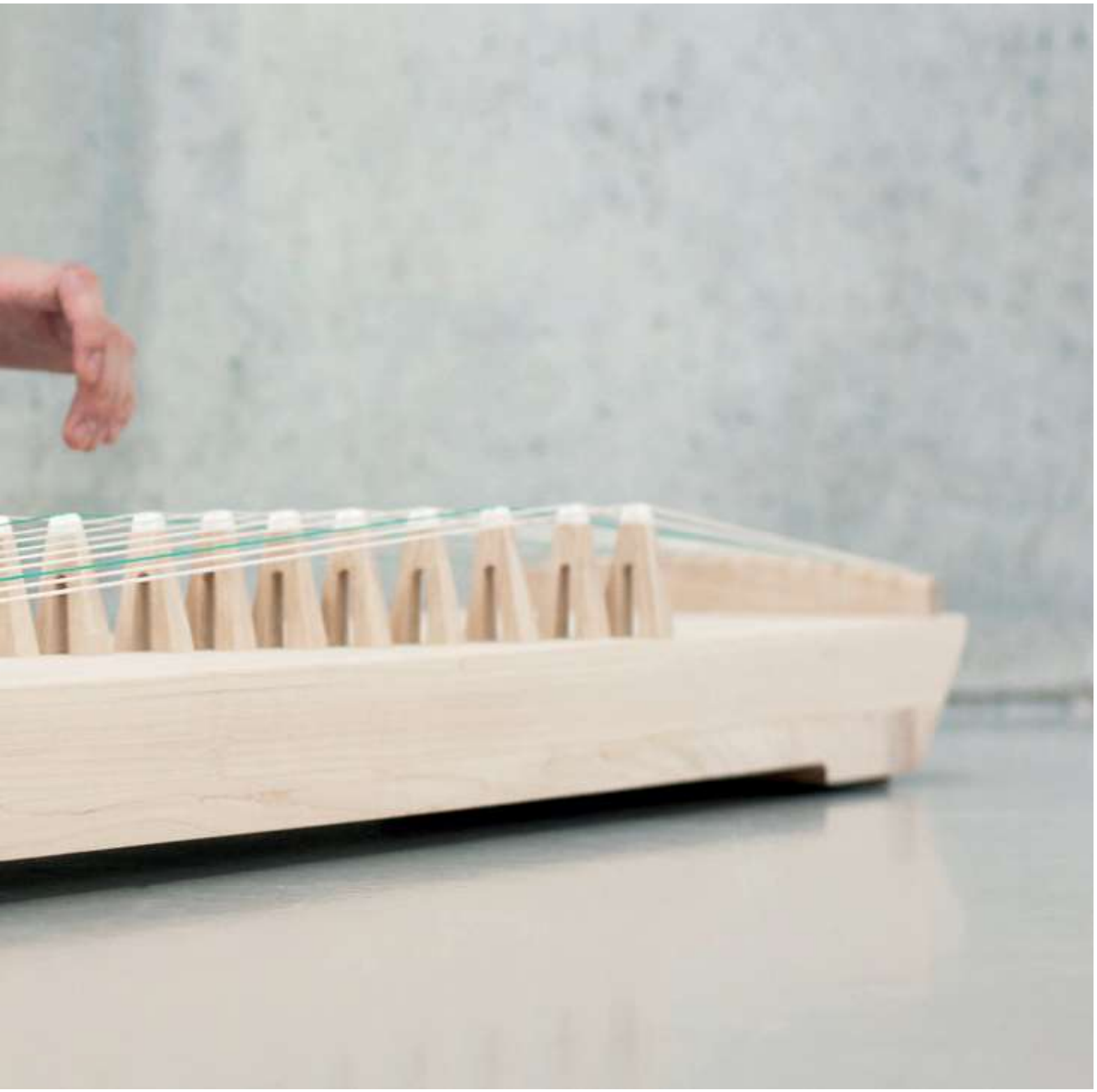
Parts

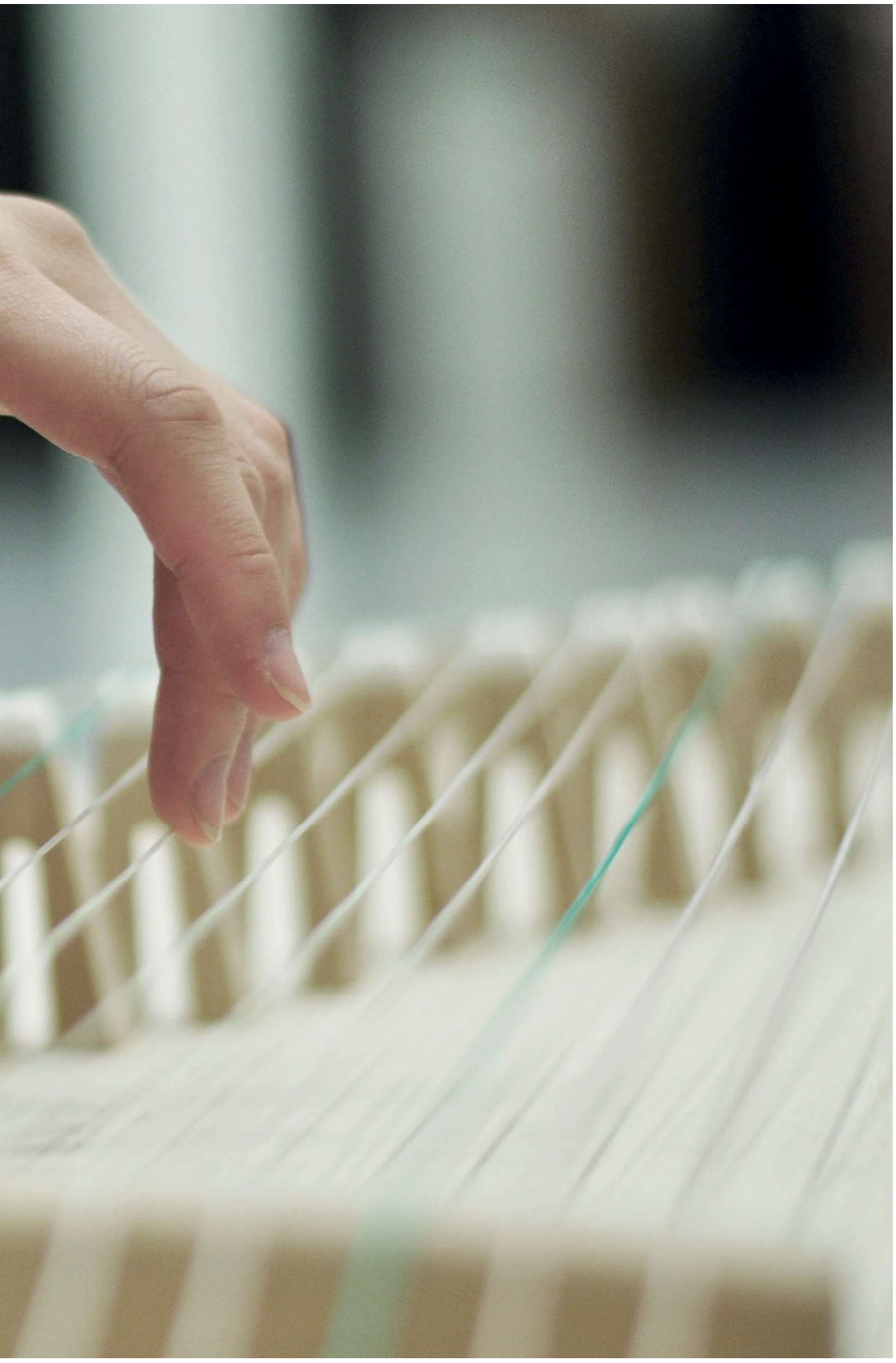












Reflection

This project is an educational project and therefore, there was a certain budget for the prototype making. Because of the budget, material restrictions and time limit, there is many decisions that could have been reconsidered if this product was to be actualized in the market.

The idea of complete solid wood for the instrument body, was to achieve a better tone quality. But during the milling process, more than 70% of the wood had been wasted and that problem should be reconsidered. Alternatively, the body could be divided into multiple parts and assembled together in order to reduce the material waste, but with this method, the whole production process becomes longer. We think further research and testing could be done and on that basis, decide on the best solution. There were also several restrictions with using CNC. With further simplification of the design, there could be room to improve the production efficiency.

Regarding material choice, we choose to use locally produced wood thus reducing the environment impact during transportation. In our case, maple was the best choice available, but there are various of tonewood in Europe that could also be a good choice, for example walnuts, plum and birch.

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