

Harmony For All

INCLUSIVE GUITAR

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AN INCLUSIVE GUITAR DESIGNED TO MAKE MUSIC MORE
ACCESSIBLE, ADAPTABLE, AND COMFORTABLE FOR PEOPLE
WITH PHYSICAL DISABILITIES.

DESIGN PROBLEM

Research from ARBSM states that 74% of adults currently play or have previously played a musical instrument in their lifetime (Figure 1). (Bank, 2021) states that 15% of the world’s population experiences some form of disability, ranging from physical, developmental, behavioral, and sensory impaired disabilities (landman, 2018), depriving them of access to musical instruments. Traditional instruments are not designed with inclusivity in mind as they are designed to accommodate able bodied users resulting in frustration for consumers (figure 2). (Appendix 3,) 100% of a specific focus group claimed that their condition affected the way they access musical instruments.

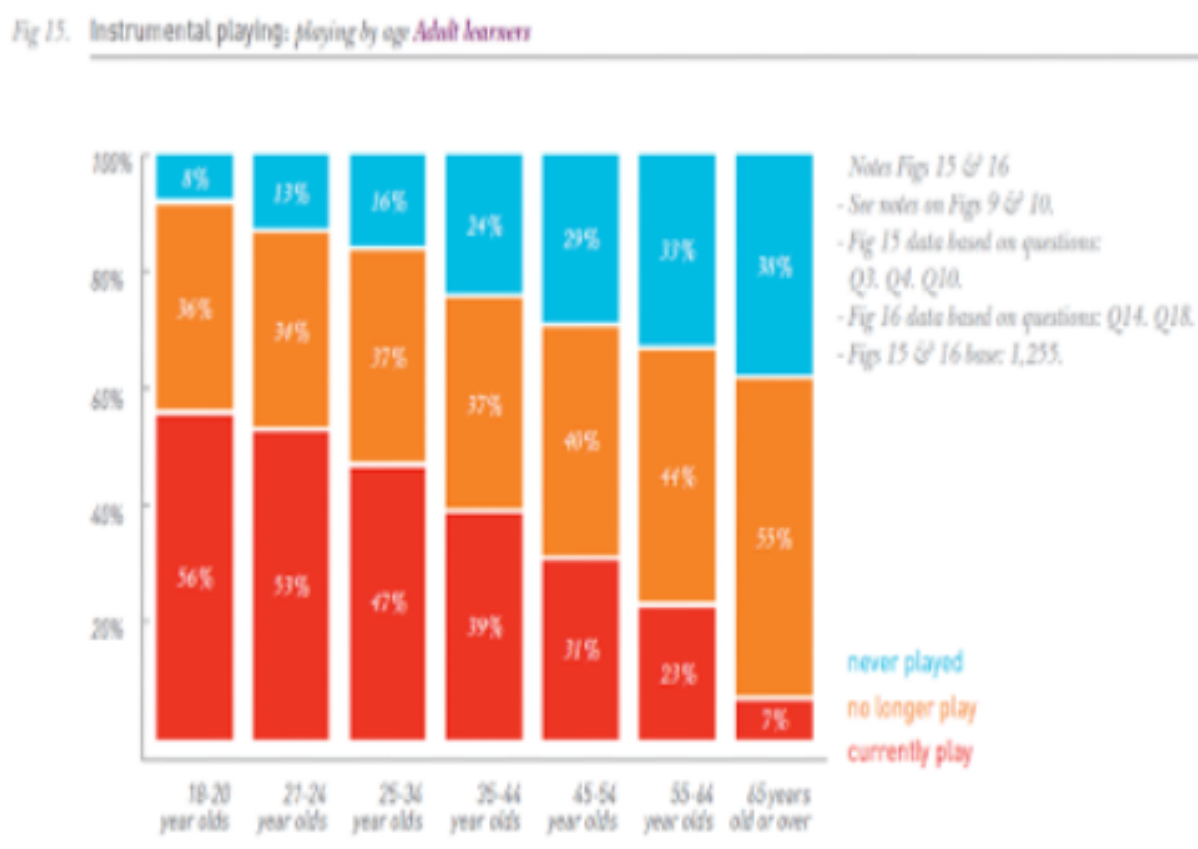


figure 1 - percentage of adults who play/no longer play an instrument.



figure 2 - all respondents from the focus group who claimed that their condition affects how they play instruments

A focus group of varying disabilities emphasized concerns around ergonomics, functionality, proportionality when playing instruments (figure 4) that resonate with their requirements (figure 5). (Appendix 3, figure 8) highlighted that current adaptive musical instrument are designed incredibly child-like and unsophisticated. (figure 5)

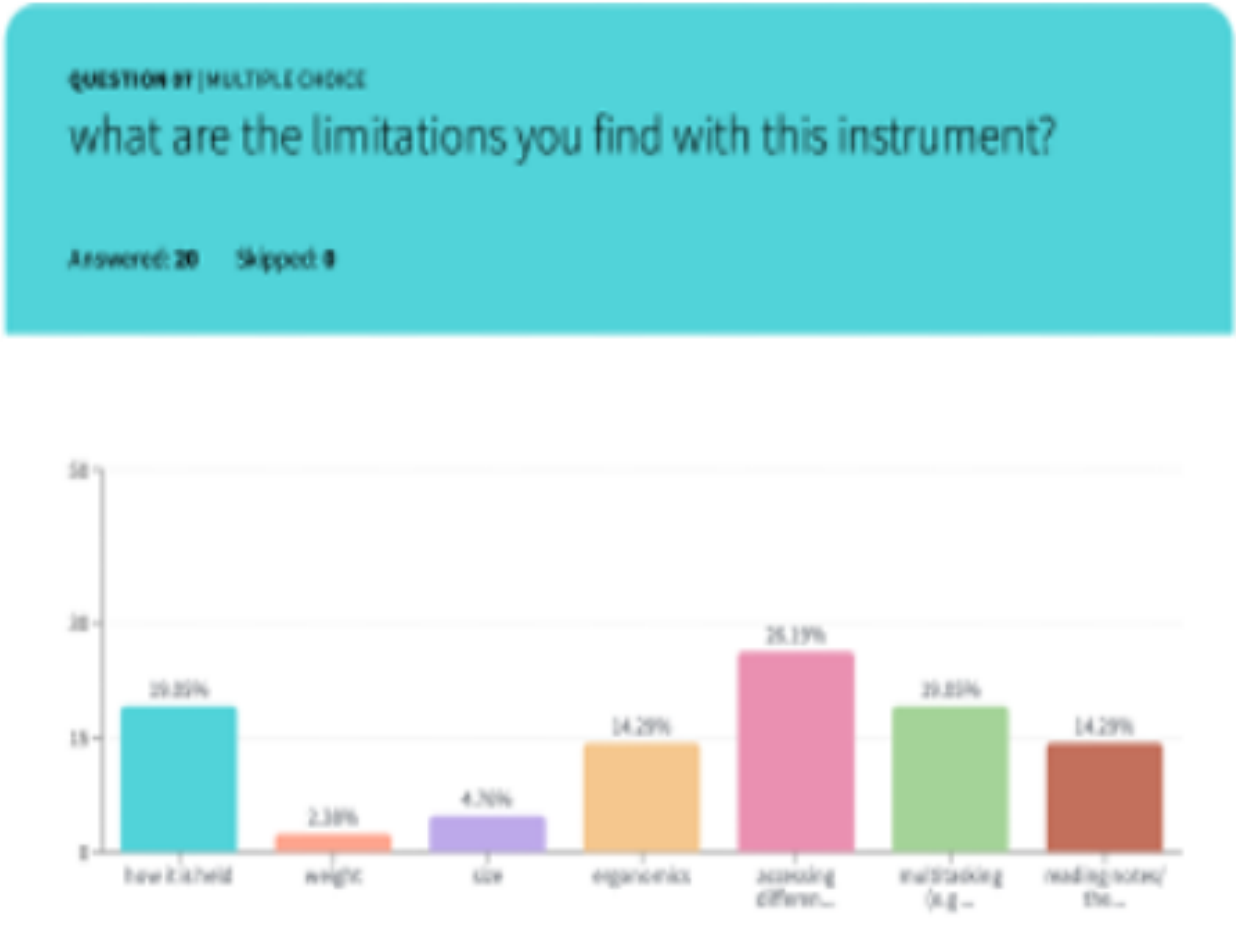


figure 3 - variety of options depending on the condition the posses.

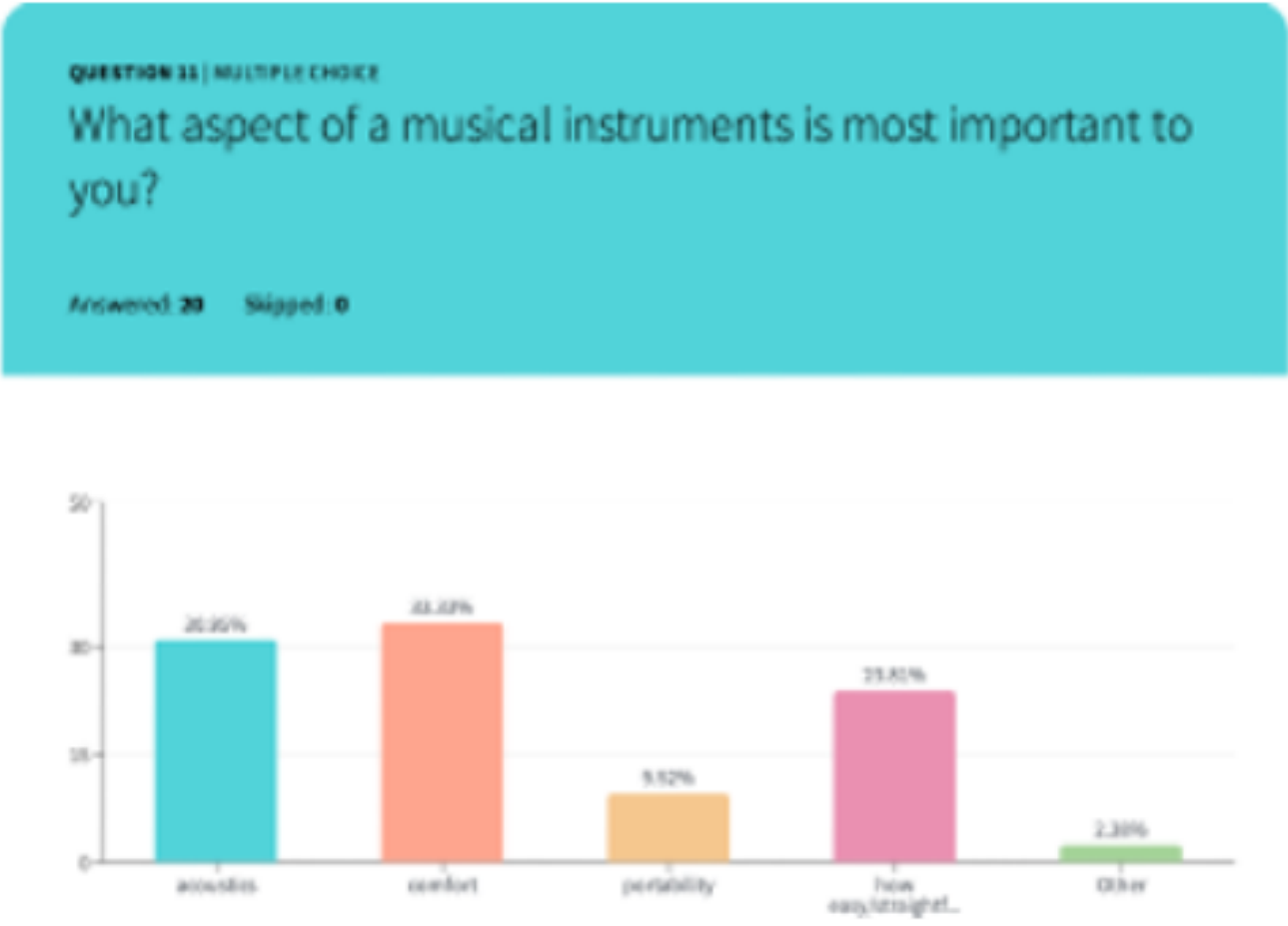


figure 4 - most favored comfort and acoustics as the most important feature

DESIGN PROBLEM

When compared to traditional instruments (figure 6), (appendix 3, figure 8) responses that aesthetics is disregarded affecting the disabled's desire and perception of playing the instrument. Some respondents suggested traditional instruments are degrading adults with disabilities therefore making them feel less capable than those in their surroundings (appendix 5,).

This has highlighted a problem that I can solve by trying to design inclusive musical instruments for people with physical disabilities.



figure 5 - toy-like aesthetic to the adapted instrument.



figure 6 -traditional drum set for those who are able bodied.



figure 7 -Rick Allen who lost his arm in an unfortunate car accident.



figure 8 - Django Reinhardt lost the use of his third and fourth finger.

DESIGN BRIEF

The aim of the product designed will be an inclusive guitar that reflects the desires of my target market (appendix 8). In (appendix 3, figure 9), 39.13% plays the guitar making it the most played instrument by those with physical disabilities. Most respondents claimed their conditions affects playing instruments. (Appendix 3, figure 2) (Appendix 11, figure 1& 2). Designing adaptive instruments will give users confidence to play music publicly. The product must be a new adaptive way to play the instrument, which should resemble a traditional instrument, guaranteeing proper functionality, acoustics, proportionality, ergonomic enhanced user experience and embellished design with captivating aesthetics. The product's size should allow comfortable handling over prolonged periods, meanwhile the length of different components should accommodate the 50th wide percentile range of the demographic (appendix 9, figure 11, 12). It must be light weight, made to ensure portability and to avoid physical strain, and Materials used should be durable to ensure longevity of the product. (Appendix 10, figure 13) stated that users are willing to pay 500-1000 dollars and would pay more for an inclusive instrument whilst also depending on the brand, materials, and quality (figure 14)



figure 1 - Gaelynn lea who suffers from osteogenesis.



figure 2 - Cassie Wilson who suffers from dwarfism and plays the guitar one handed.

DESIGN SPECIFICATION

	specification	Justification
1. aesthetics	1.1 the product must have a sleek and embellished design aesthetics.	1.1 (appendix 3, figure 8) respondents claimed that most inclusive instruments had child-like aesthetics degrading their demographic.
	1.2 The Surface finish of the product should be of high quality	1.2 (appendix 12) A smooth, lustrous and high-quality finish will reflect how luxurious the product is, enhancing components appearance, function, performance and appeal towards consumers whilst providing surface protection.
	1.3 The product should have a dark and elegant color palette.	1.3 (appendix 13) Dark colors are associated with sophistication, glamour, and luxury, this will make the design look more expensive and of a higher quality satisfying the needs of my target market that feel disregarded in the music industry.
	1.4 the product should have a smooth texture rubber grips where needed.	1.4 (appendix 3, figure 3) Those with disabilities found how instruments are held as a huge limitation, therefore adding ergonomic grips avoids hand discomfort while playing, making consumers feel more secure and increasing their efficiency.
	1.5 The product must be designed ergonomically with a rounded body shape.	1.5 (appendix 3, figure 4) Comfort is the most important aspect when playing instruments, ergonomic design will ensure ease of use.
	1.6 The product should have no sharp edges/corners.	1.6 ensures personal safety and comfort while playing the instrument.
	1.7 aesthetics must accommodate to both male and female users.	1.7 allows for wider adoption within the specified target market.

DESIGN SPECIFICATION

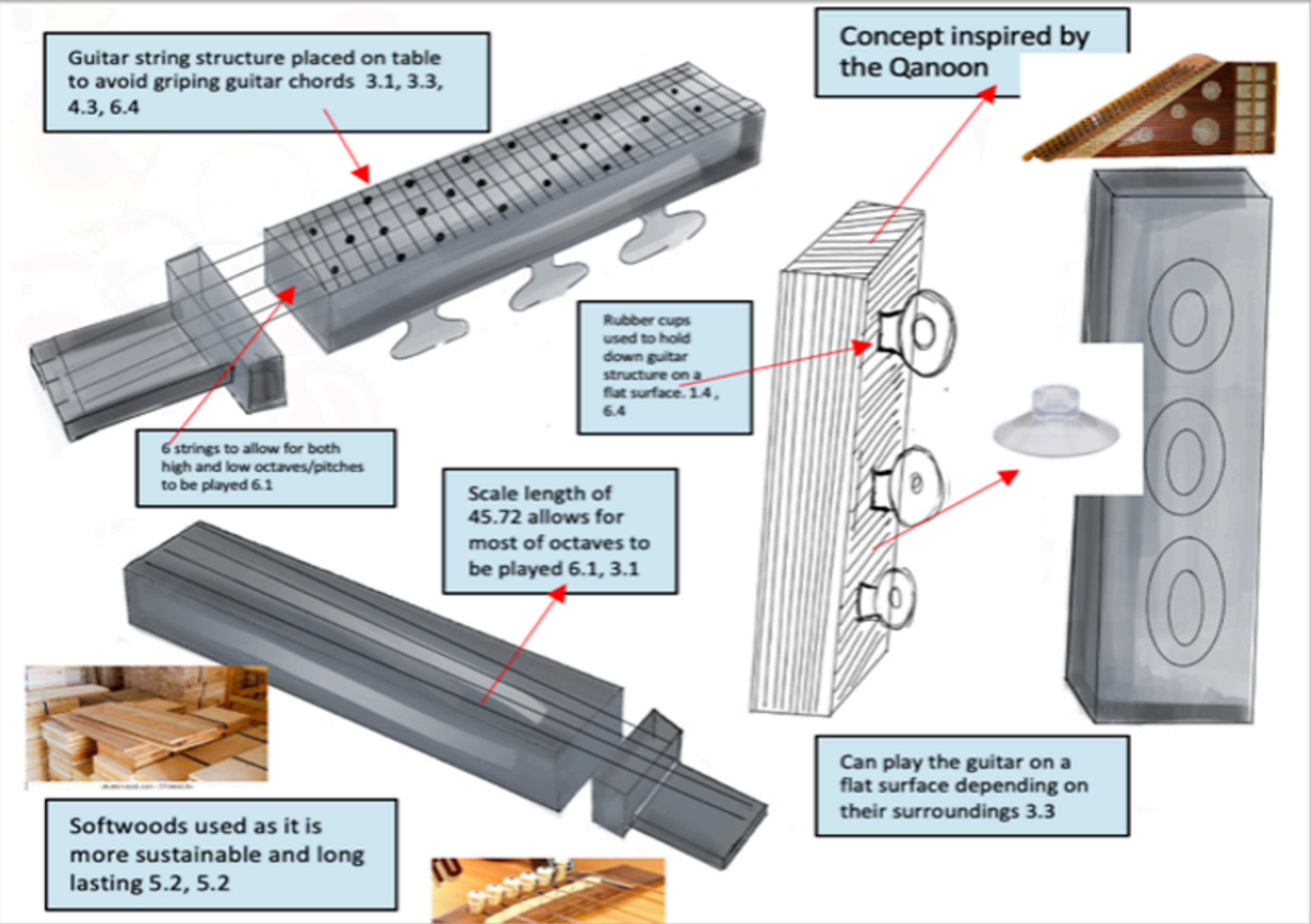
	Specification	Justification
2. target market	2.1 Persona A: musicians with physical disabilities that play the guitar. 2.2 Persona B: - Those who work with people with physical disabilities in a learning environment/ working environment. - people who may buy the inclusive instrument for the person has a physical disability. 2.3 anti-persona: people without disabilities.	2.1 (appendix 3, figure 9) Largest number of people with physical disabilities that play the guitar 2.2 teachers teaching students in school/adults learning how to play an instrument, working with colleagues and teammates in musical activities such as the orchestra 2.3 Those without disabilities who don't know anyone with disabilities and are not interested in the music industry.
3. function	3.1 product must be able to produce music with an adaptive functionality. 3.2 Different components must be proportional. 3.3 should allow those with physical disabilities to play with comfort and ease. 3.4 The product must have the ability to be transported easily. 3.5 users should be able to reach all components (knobs, buttons, strings) with ease 3.6 the product should have the option of being held by hands or being placed on a flat surface.	3.1 (appendix 3, figure 10) Respondents suggested that they would buy an inclusive instrument that has the same outcome as a traditional instrument. 3.2 (Appendix 3, figure 11) The proportionality of the product was one of the most important features to be redesigned. 3.3 (appendix 11) Those with physical disabilities/invisible disabilities feel physical stress on their body when playing traditional instruments and must adapt to things that aren't fully accessible to them. 3.4 A carrier case can be designed specifically to suit the adapted shape of the inclusive guitar. 3.5 appendix 3, figure 3) Consumers found the accessibility of components in traditional instruments limiting. (Appendix 18 figure 1,2) 18.02cm for hand length and 68.51 cm to accommodate the 50thpercentile of females since they have smaller dimensions than the male body. 3.6 versatility of the product allows the users to decide how to play the product depending on how much physical pain they are feeling.

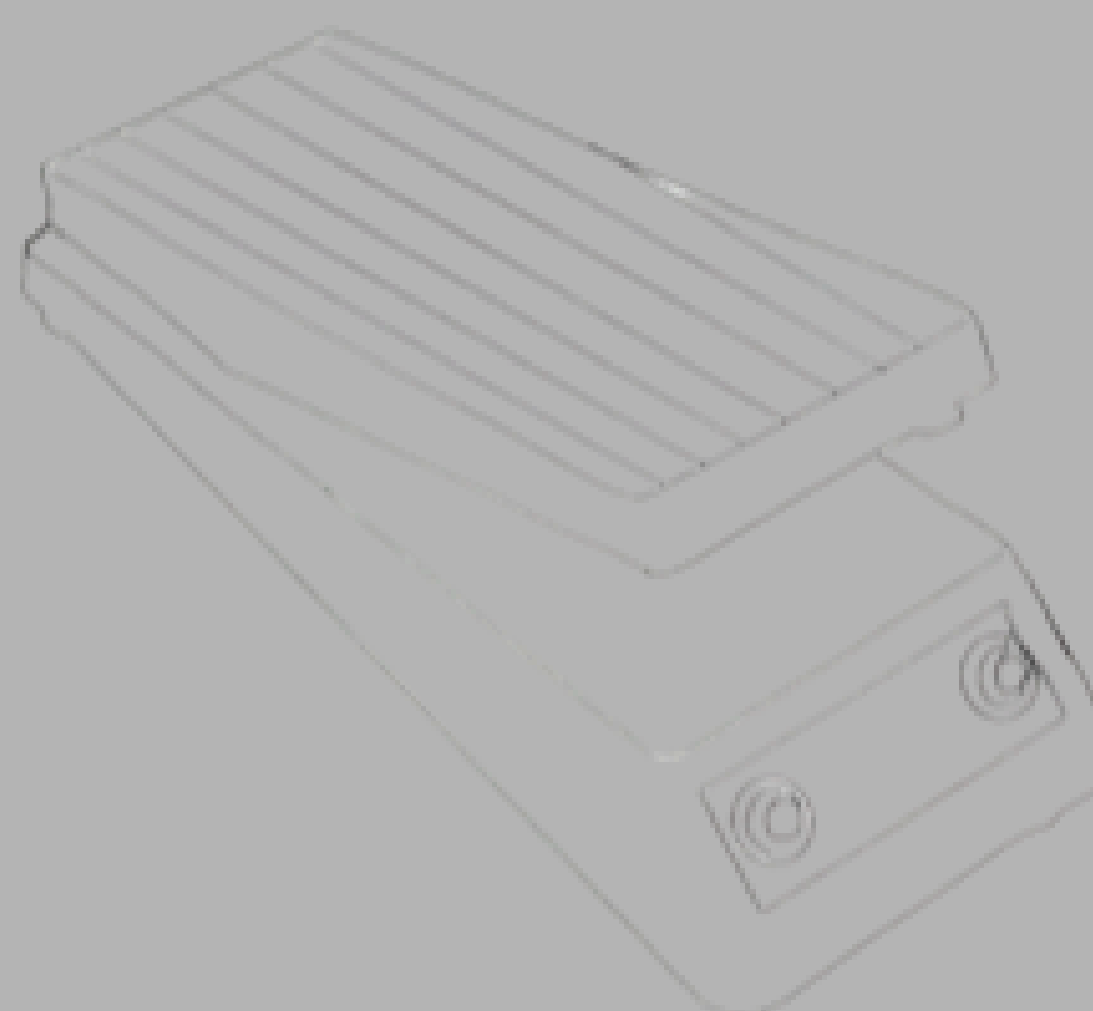
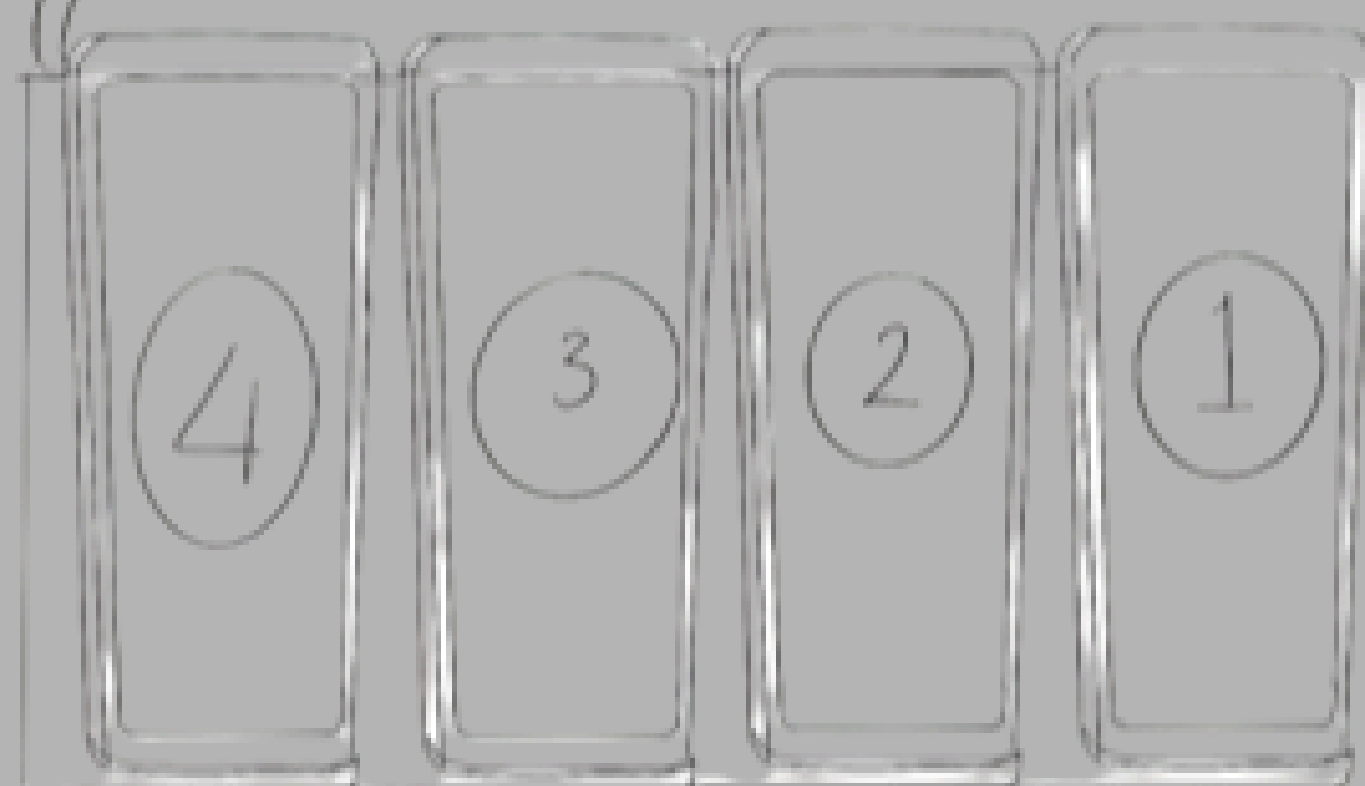
	specification	Justification
4.Product constraints	4.1 Must be made from softwoods such as pine. 4.2 the product must be manufactured and sourced from within Europe. 4.4 must be able to ergonomically fit into users' hand/on users' body comfortably. 4.5 must be able to fit in a carrier case according to dimensions of the instruments 4.6 the product cost must range from \$500-\$1000 dollars	4.1 (appendix 3, figure 12) 44.83% of Respondents preferred softwoods over other materials. (appendix 14) Spruce or cedar has a significant effect on acoustic properties that works best with string vibrations 4.2 Preventing the transport of timber decreases carbon emissions therefore decreasing the overall carbon footprint, which also reduces operational costs and increases the value of the prestigious product. 4.4 (appendix 21) Dimensions of the 50th percentile Functional grip reach (74.95) Elbow center grip length (35.92cm) hand breadth (9.03 cm) Hand circumferences (21.34 cm) Thumb breadth (2.41) Shoulder to elbow length (36.88) 4.5 (appendix 20) Should have a hard-shell case with larger than dimensions of the instruments to ensure protection. 4.6 (appendix 9, figure 14) Stated would pay \$500-\$1000 for an inclusive instrument, others don't mind paying depending on the brand, materials, quality, time/effort that is in the product.

	specification	Justification
1. Material	5.1 must be made from softwoods.	5.1 (appendix 15) It takes 25-30 years to mature so can be regrown quickly and therefore is always in demand, making them a more sustainable option compared to hardwoods.
	5.2 materials must be durable.	5.2 The product should be able to remain undamaged for long periods of time especially due to constant transportability, to ensure efficiency in being sustainable.
	5.3 materials should have stiffness.	5.3 for the product to avoid deformation and to keep its shape when a force is applied.
	5.4 materials should have high hardness properties.	5.4 the material will ensure the product resists any scratch or indentation therefore avoiding any harm on the product.
	5.5 materials used should be lightweight 2.7-3.6 Kg to ensure portability.	5.5 Musicians need to be able to transport their instruments easily from different places they practice in, so they need to be lightweight to avoid any further physical strain on their bodies. (Appendix 16) states average weighted guitars are 3-5 kg and so lightweight guitars are 2.7-3.6 kg.
	5.6 The product should have an Epoxy surface finish to ensure water resistance	5.6 Epoxy surface finish can influence the texture and give it a glossy aesthetic, making it water resistant and giving it the ability to resist wear and fatigue as there's a reduction in friction. (appendix 17)

	Specification	Justification
6. size	6.1 The scale must have a length of 45.72 cm 6.2 the product should be 101.6cm x 38.1 cm	6.1 (appendix19) Short scale length for $\frac{3}{4}$ guitar size, shorter scale allows accessibility for all users while playing the correct notes. 6.2 (appendix 19) average size of a guitar must be able to fit in users' hands/sit on user's body.
7. quantity	7.1 product must use one off production during manufacture. 7.2 can use job off production once final design is established.	Only one prototype will be made to gather feedback from users in user trials in the final evaluation before the product might be mass/batch produced. If it were commercially produced, then Specialized Products can be produced for specific people which adds value and increases the price of the product.

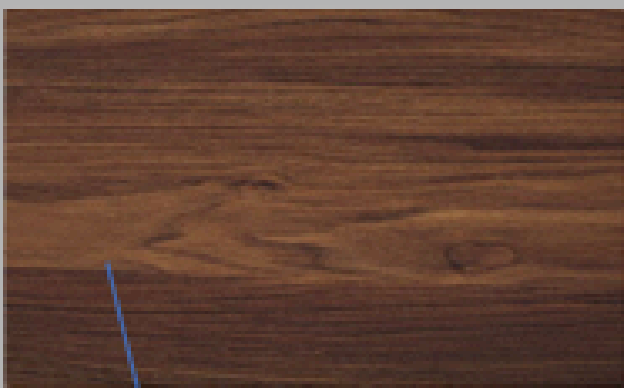
INITIAL SKETCHES



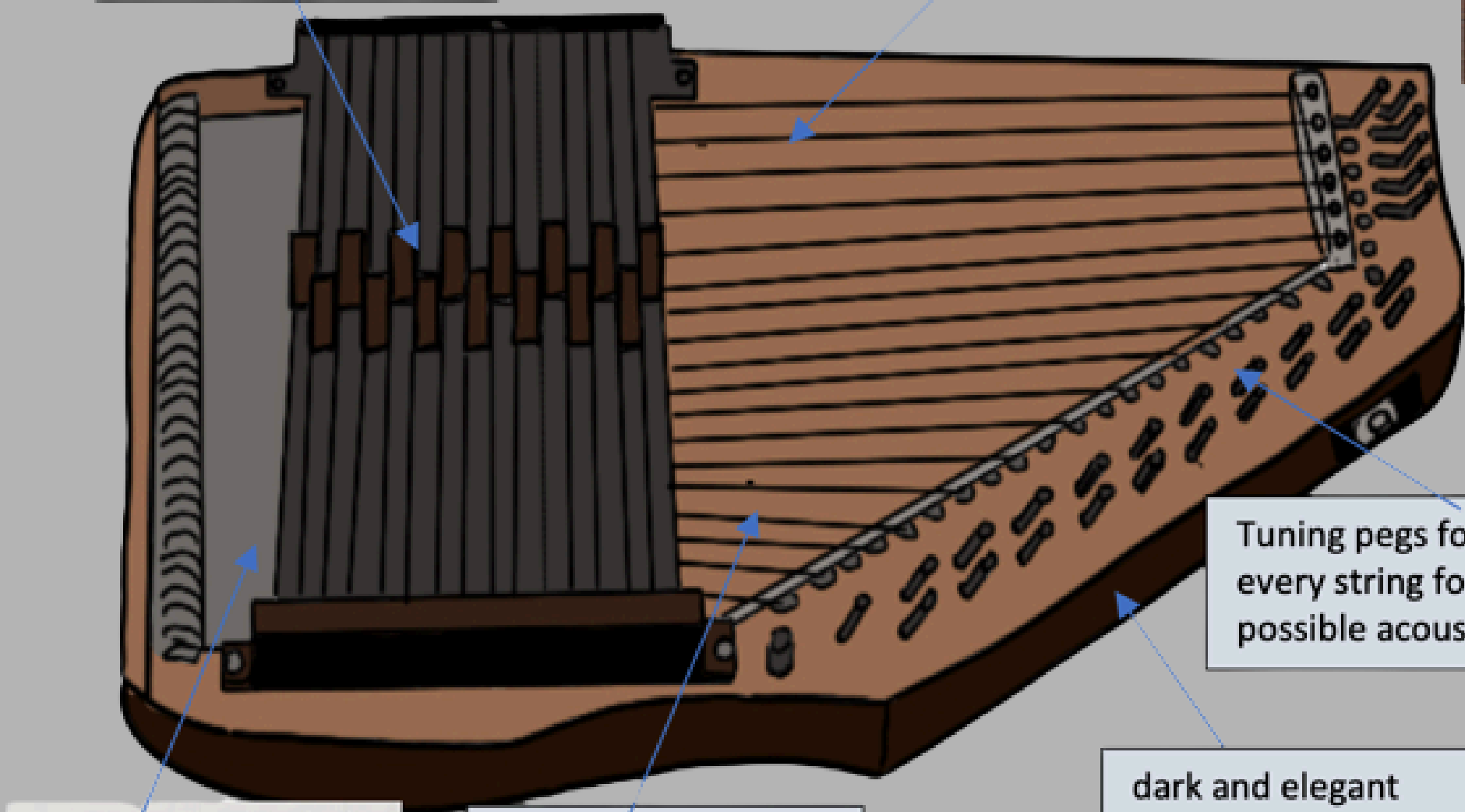


users are able to access all components within a space 4.3, 3.5

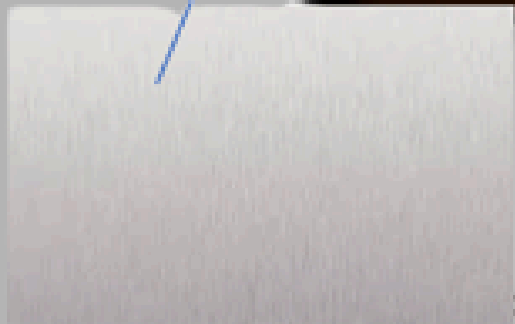
chord buttons slide in order to act as a guide for users to play chords 3.1



Made from spruce which is sturdy, inexpensive, lightweight 5.2, 5.3, 5.4, 5.1



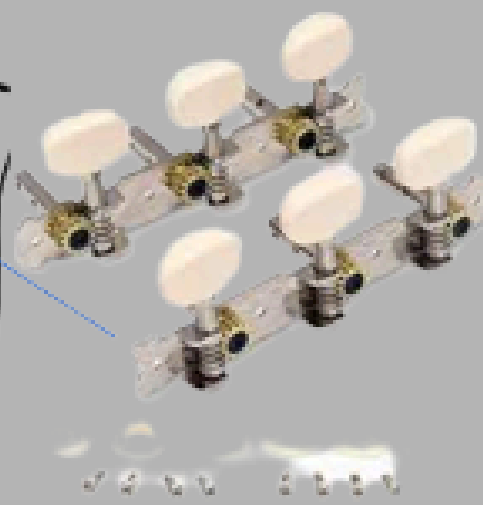
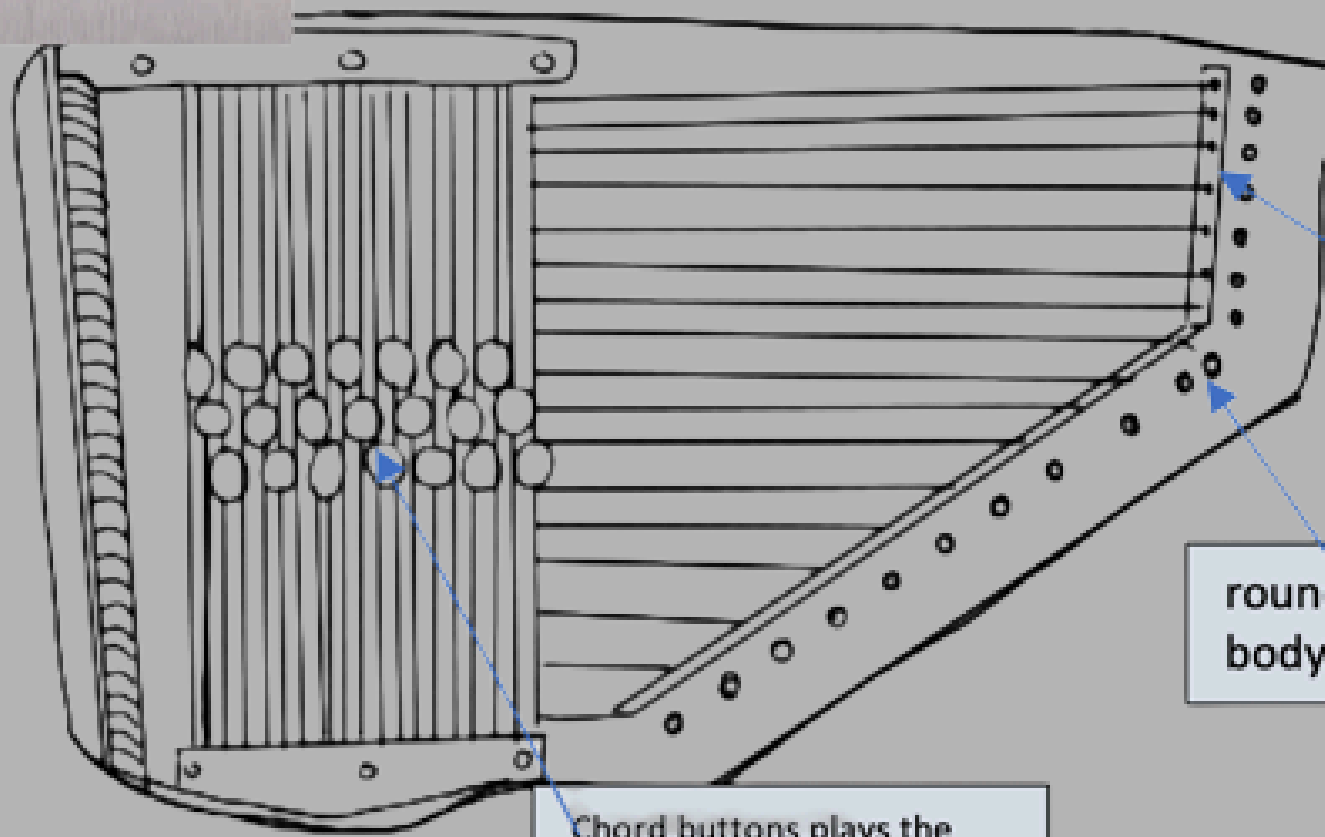
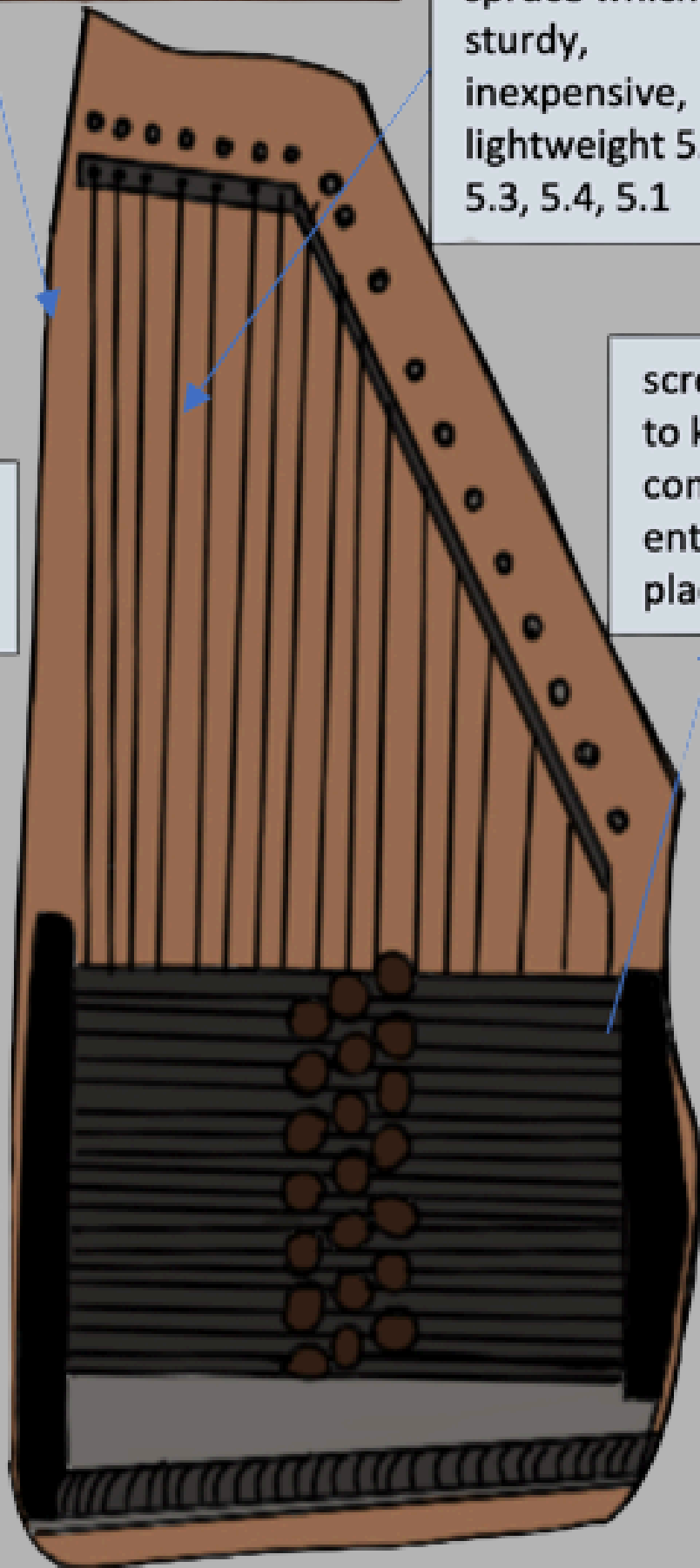
Tuning pegs for every string for best possible acoustics



more strings added to allow a range of octaves to be played

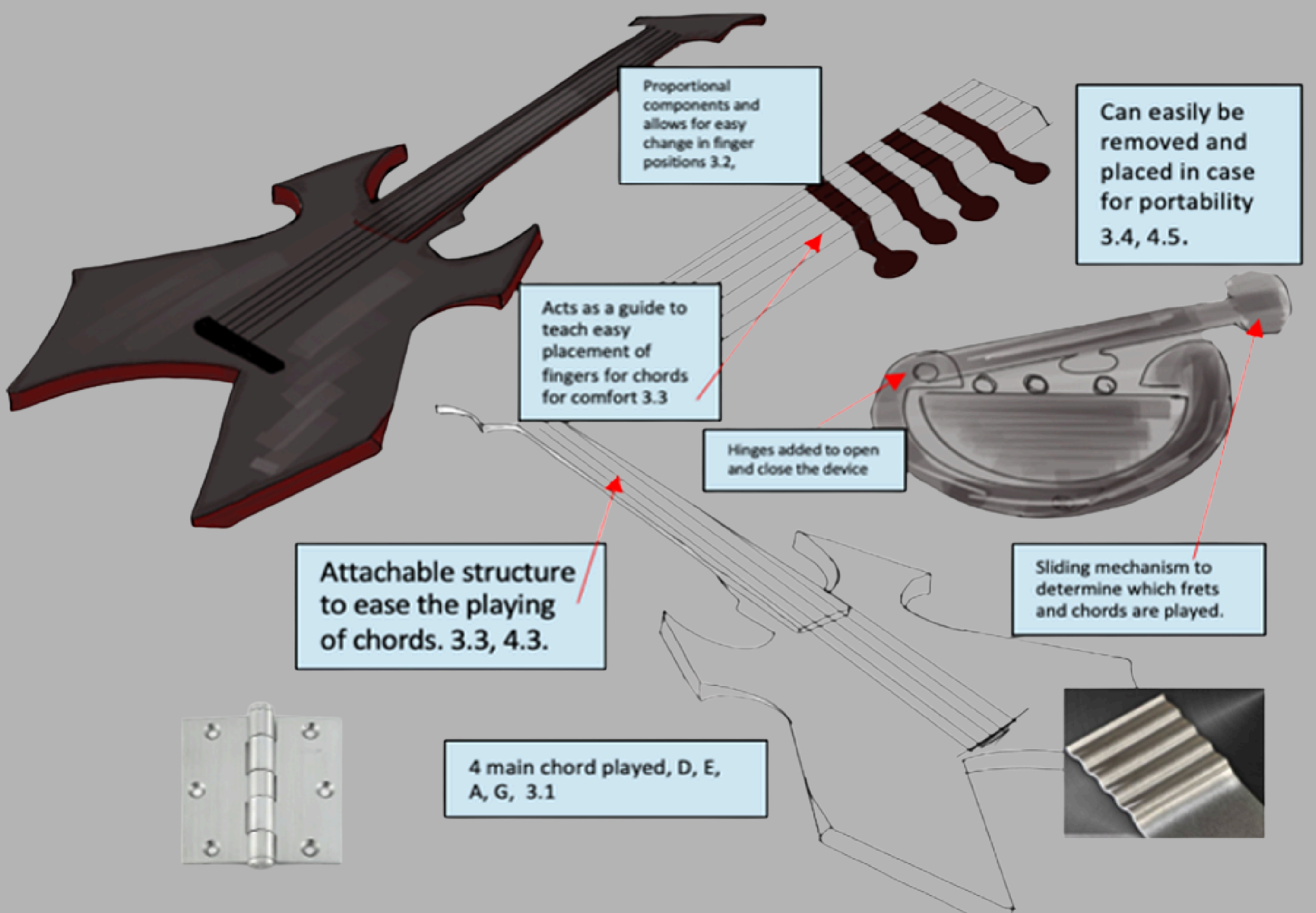
dark and elegant color palette to allow comfort and fitting in 1.3, 3.3

screws to keep component in place



rounded ergonomic body 1.5

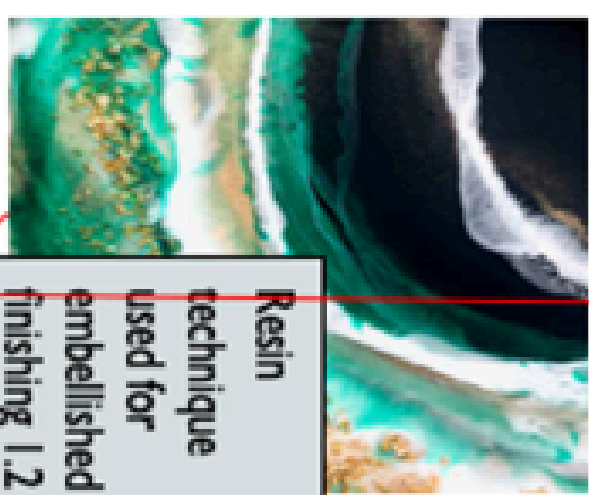
Chord buttons plays the main chords on a guitar 3.1



DESIGN DEVELOPMENT



Emerald green painted onto guitar using laquer paints



Resin technique used for embellished finishing 1.2

Measurements are 101.6cm X 38.1cm to allow accessibility to all components . 4.3,4.5, 6.2

Epoxy surface finish for high quality and aesthetics 1.2, 5.6

Dark green and black make an elegant and sophisticated color palette 1.3, 1.7

Guitar strings attached to tuning pegs to allow for better pitch of strings

6 strings to allow for both high and low octaves/pitches to be played 6.1

Diagonal strings, attached all throughout the guitar for eye catching aesthetics. 1.1

Hidden plug design to amplify guitar sound and improve aesthetics 1.1

Very sleek and modern guitar body structure 1.1

Northern Spruce wood used for the most efficient acoustics and to have the same outcome as traditional instruments 3.1, 4.1

Attachable chord playing device eliminates difficult finger moves. 3.3, 4.3

Can easily be removed and placed in case for portability 3.4, 4.5.

Width depends on the width of the guitar neck

5 cm

15 cm

Aids in playing the main chords in a guitar with a sliding mechanism 3.1

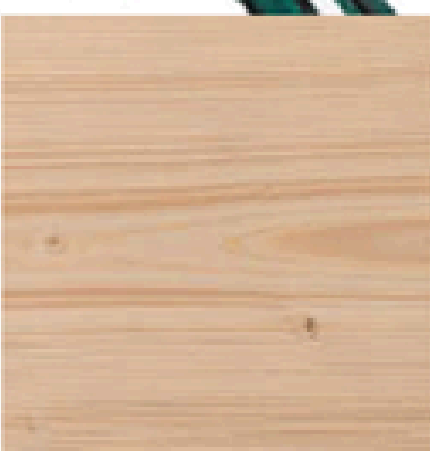
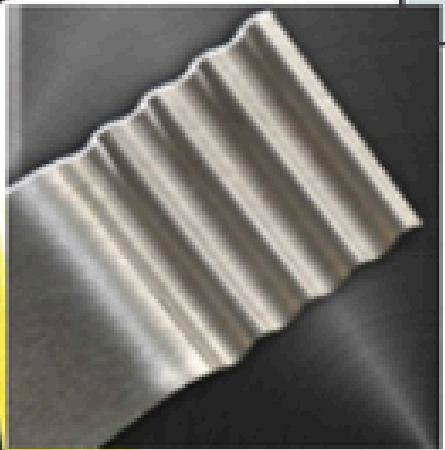
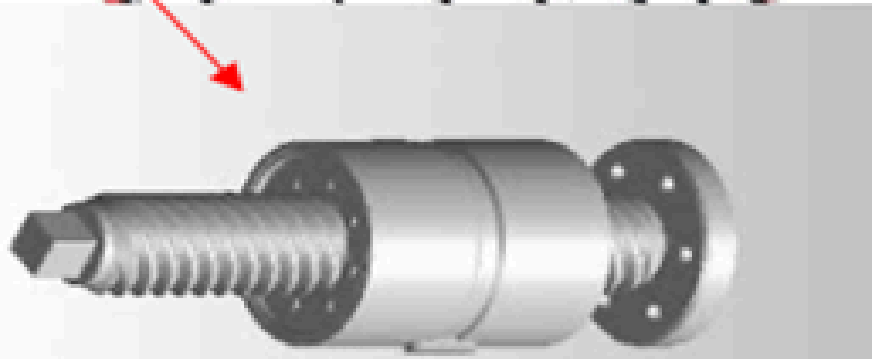
Roller Screws on the side to keep the device in place or for removal.

Acts as a guide to reach easy placement of fingers for chords for comfort 3.3

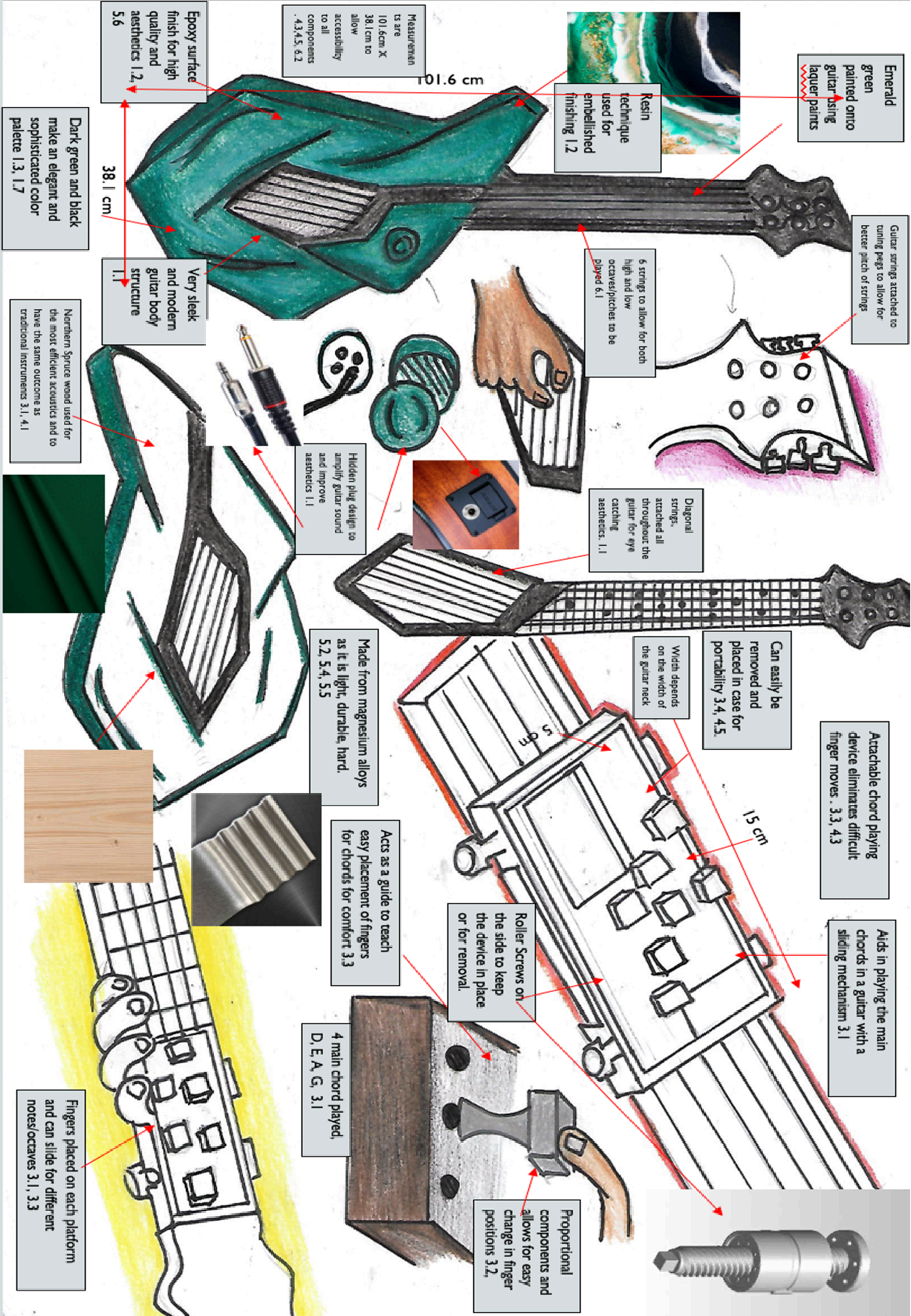
Made from magnesium alloys as it is light, durable, hard. 5.2, 5.4, 5.5

4 main chord played, D, E, A, G, 3.1

Proportional components and allows for easy change in finger positions 3.2,



Fingers placed on each platform and can slide for different notes/octaves 3.1, 3.3



Made from pine which is sturdy, inexpensive, lightweight 5.2, 5.3, 5.4, 5.1

60cm

38.1cm

Box guitar concept changed to a more ergonomic shape 1.5

Handle added to ease transportability and carrying of instrument.

Buttons play the main chords in a guitar 3.1

Hollow grooves added to make it more ergonomic for users placing it on their knee .

Additional round ergonomic piece to increase comfort and usability 3.3, 3.1

Magnetic, so can be detached easily for transportability 3.4

6 strings to allow for both high and low octaves/pitches to be played 6.1

Chord buttons made of different color/types of wood for more classy aesthetics 1.1, 1.3.

Rubber grips added at the four corners to stay in place on a table 1.6, 6.4

Hollow curved structure underneath the guitar to fit onto knees of users

Added component can be placed underneath guitar when playing another way 4.5

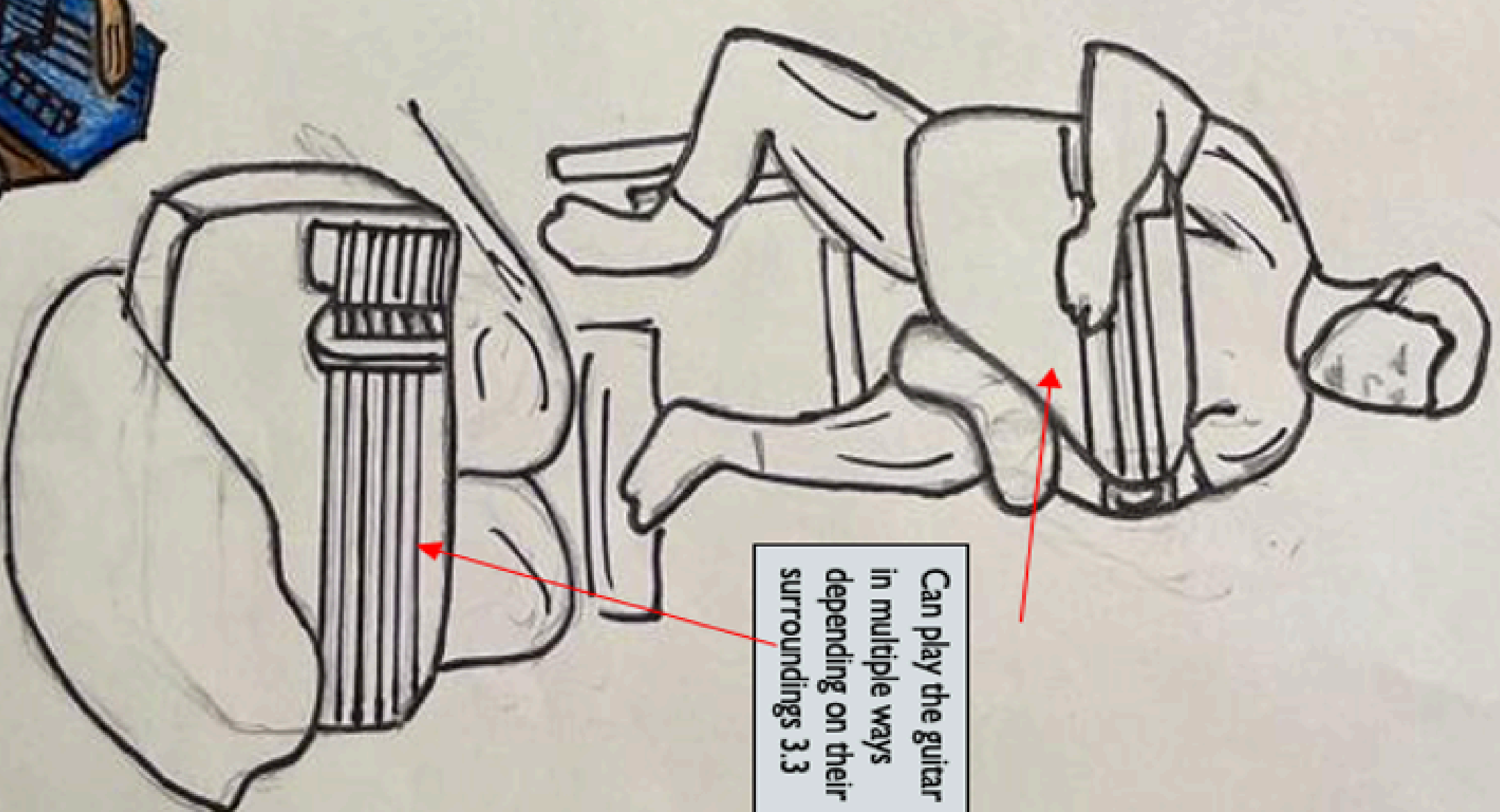
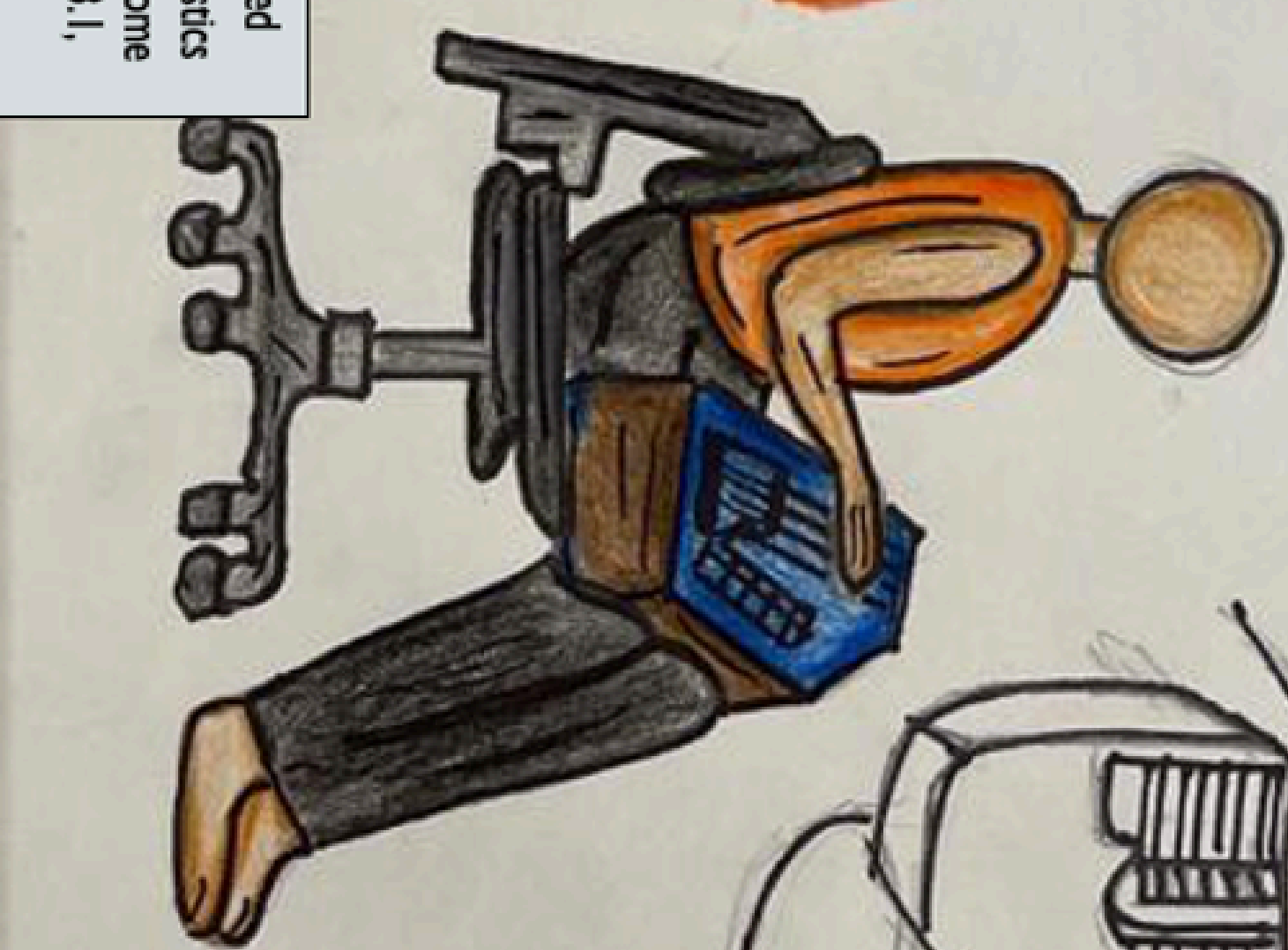
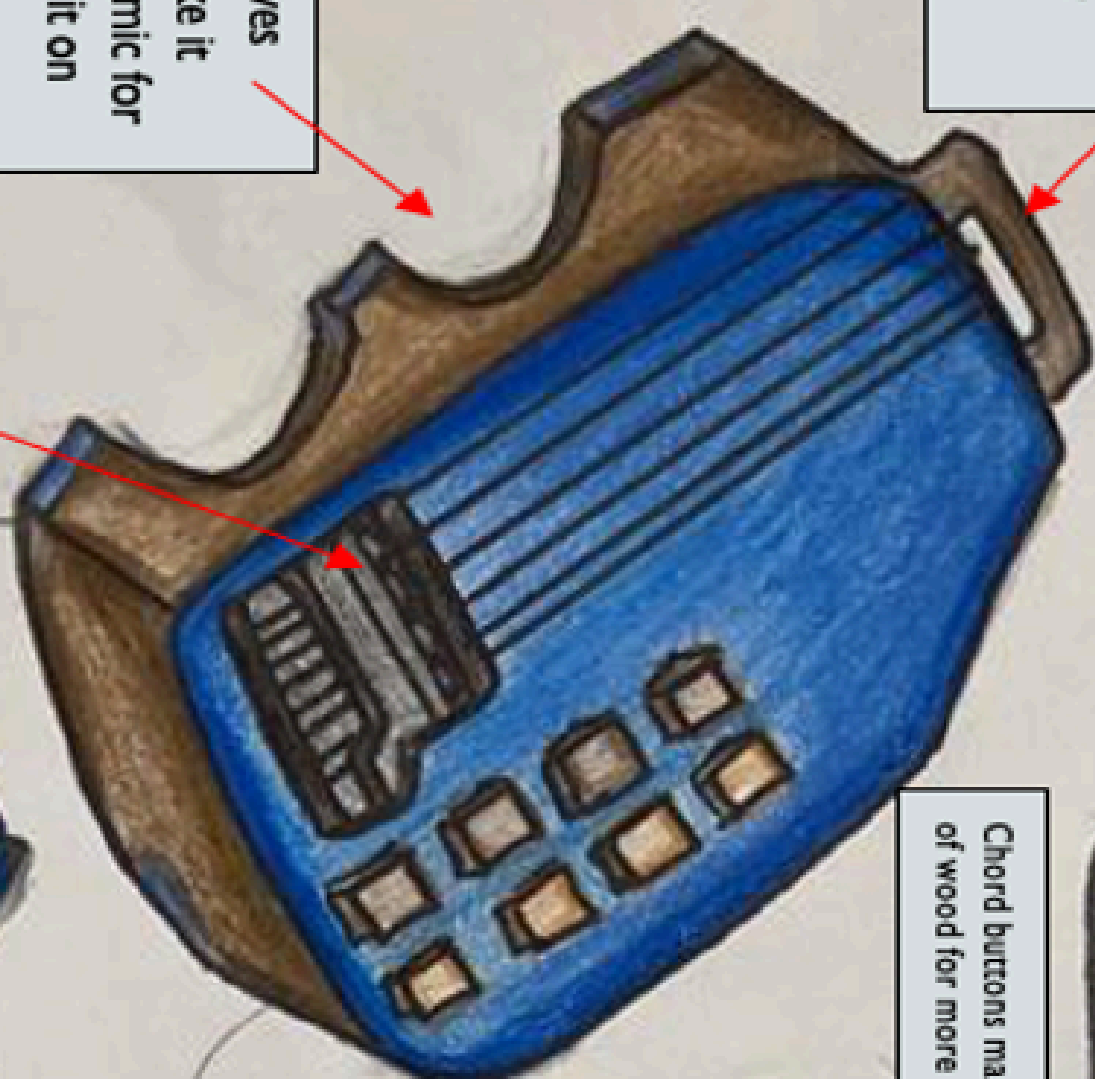
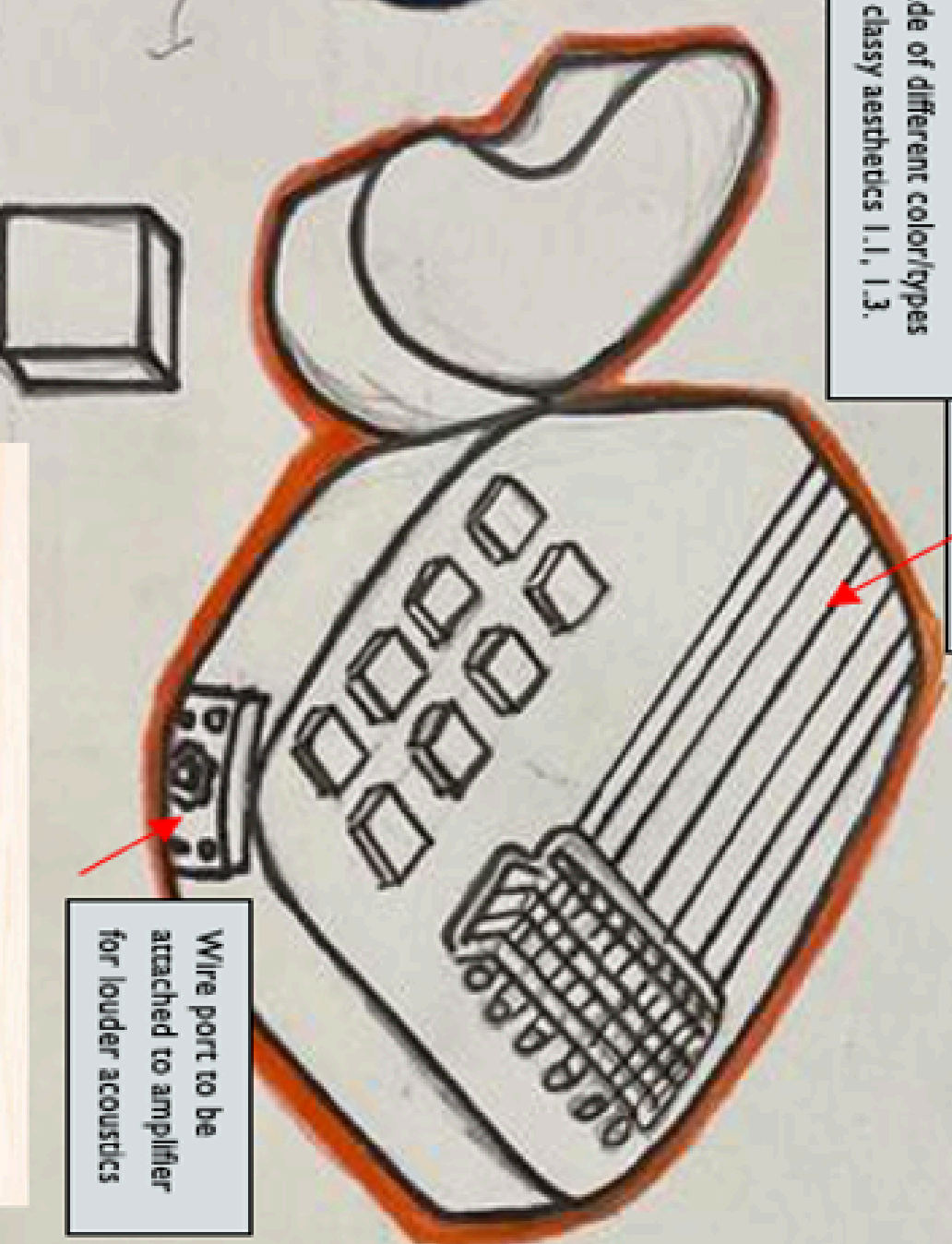
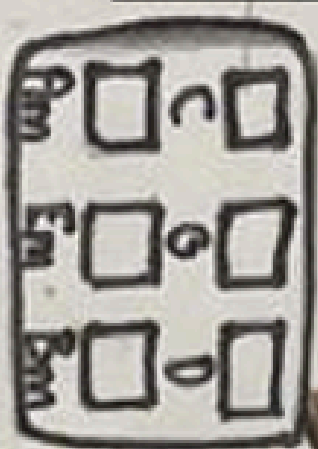
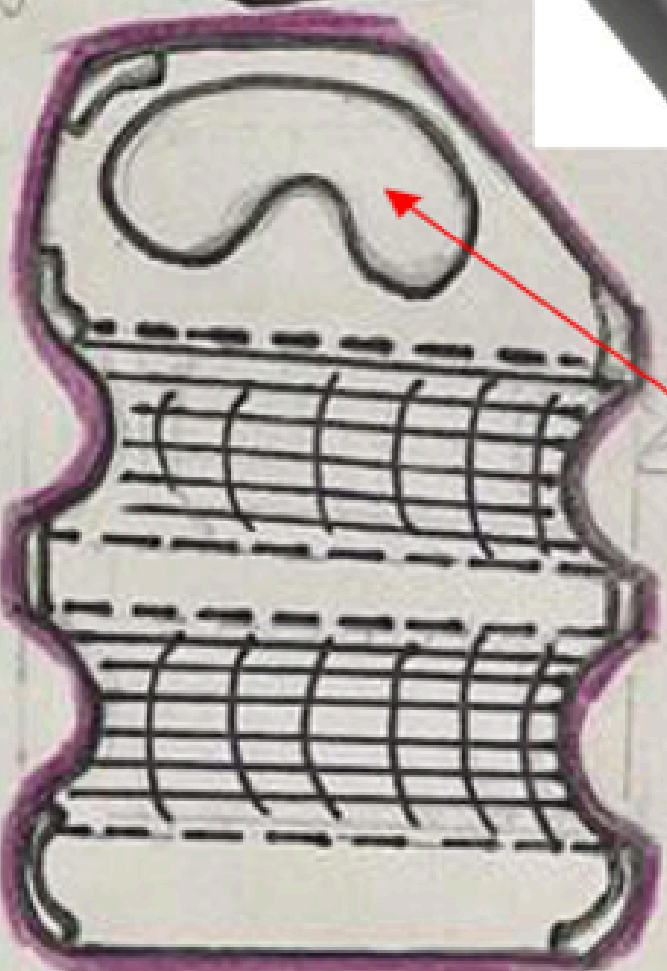
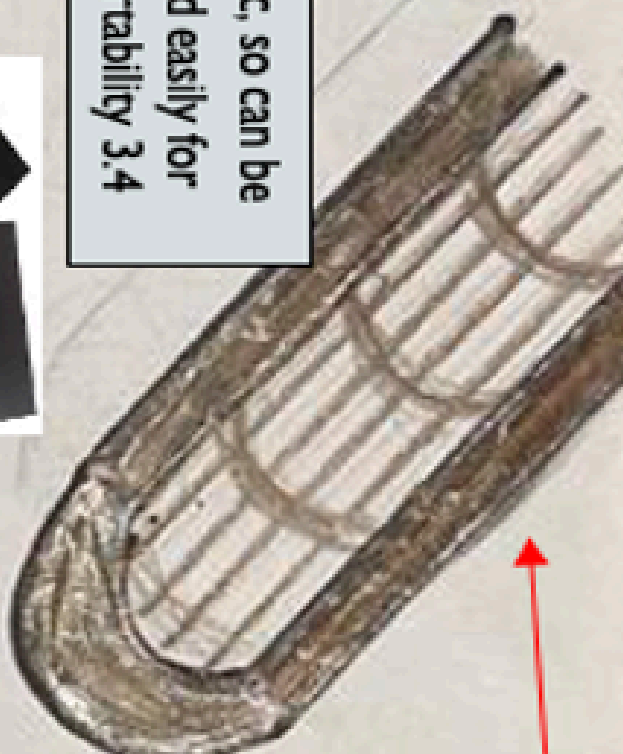
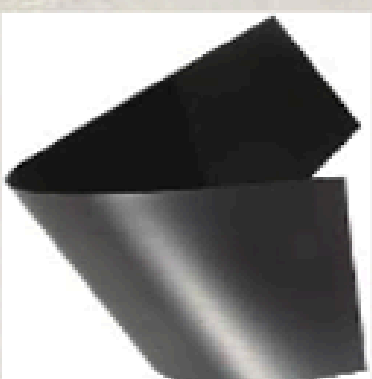
Can play the guitar in multiple ways depending on their surroundings 3.3

Bottom view

Wire port to be attached to amplifier for louder acoustics

Northern Spruce wood used for the most efficient acoustics and to have the same outcome as traditional instruments 3.1, 4.1

Top view





Royal blue aesthetics for elegance



curved holes at the bottom for leg placement.



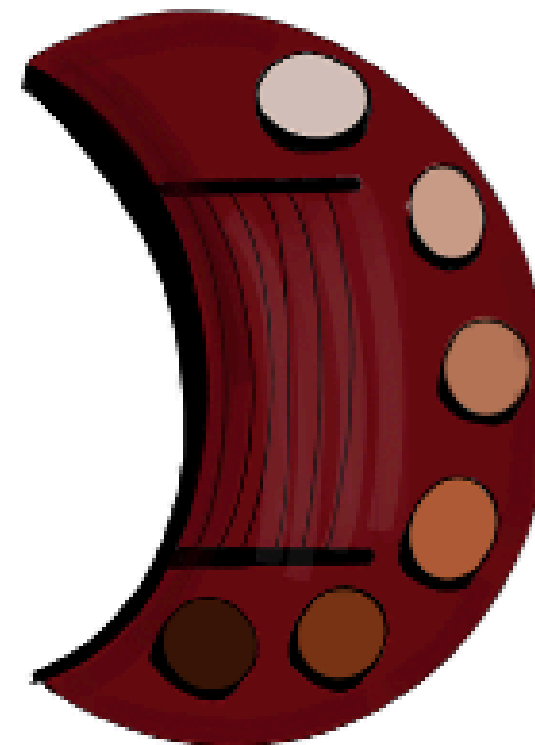
Different colored peices of wood for aesthetics



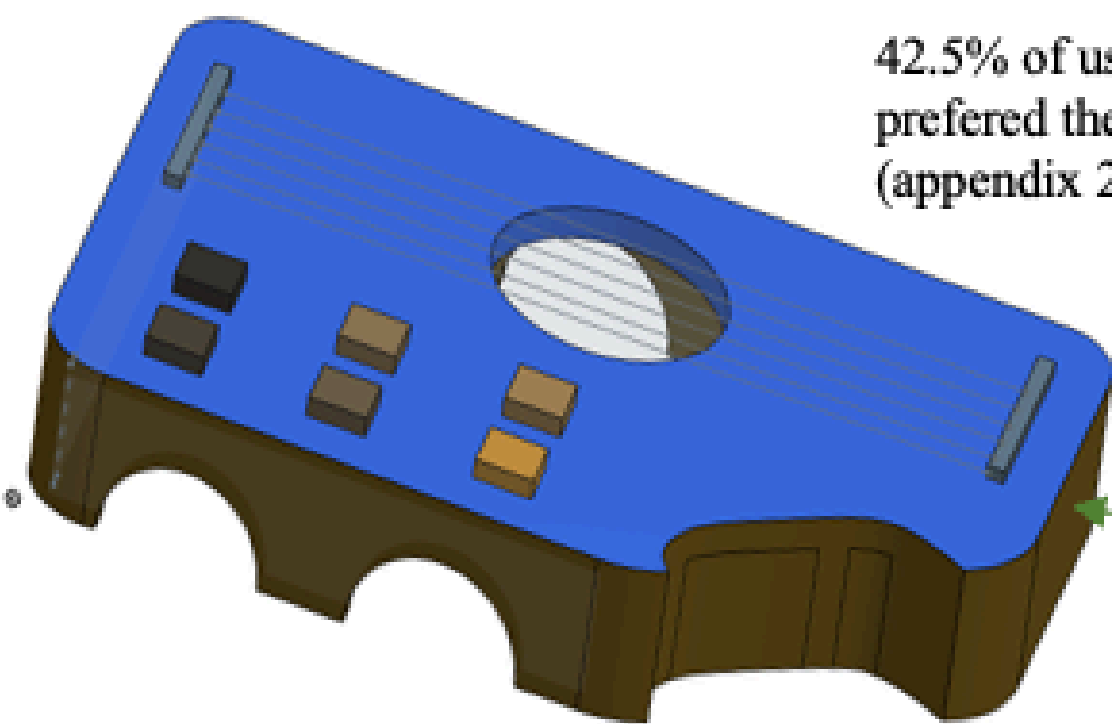
different colored hardwoods to show contrasts,



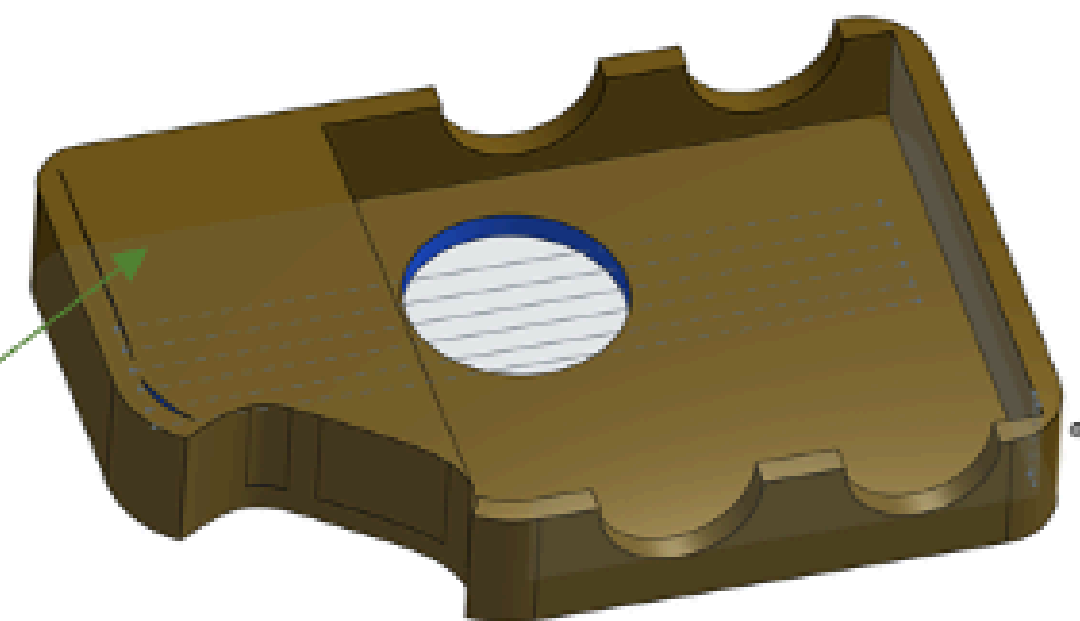
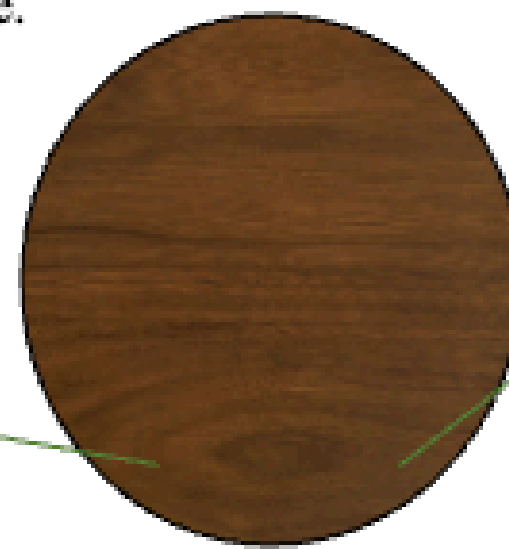
emerald green guitar



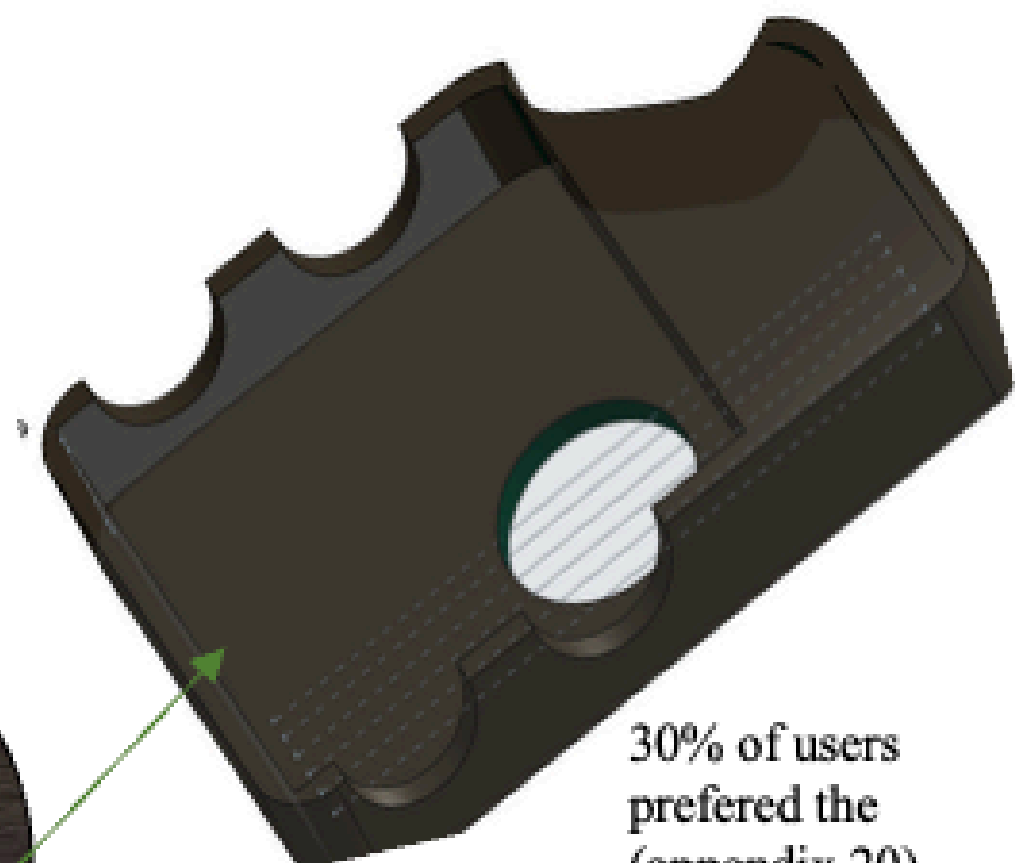
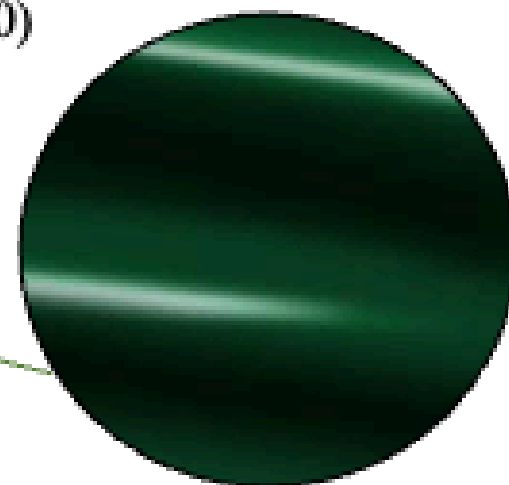
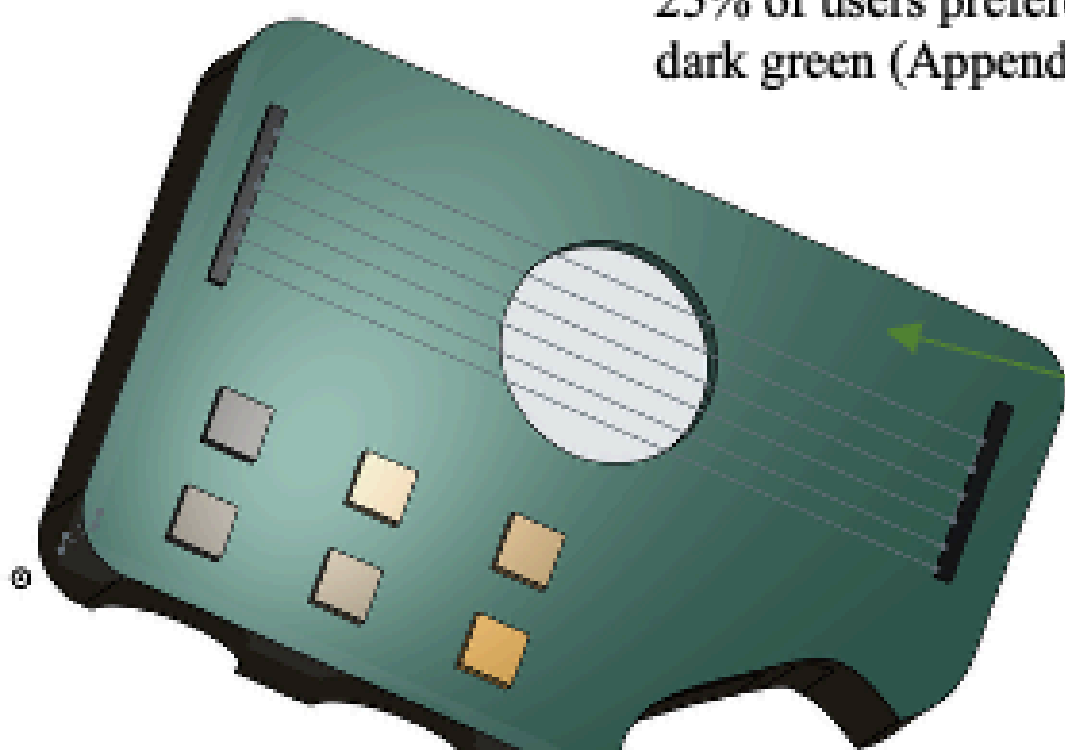
Based on user votes, the target market preferred the original design which will be used.



42.5% of users preferred the light blue. (appendix 20)



25% of users preferred the dark green (Appendix 20)

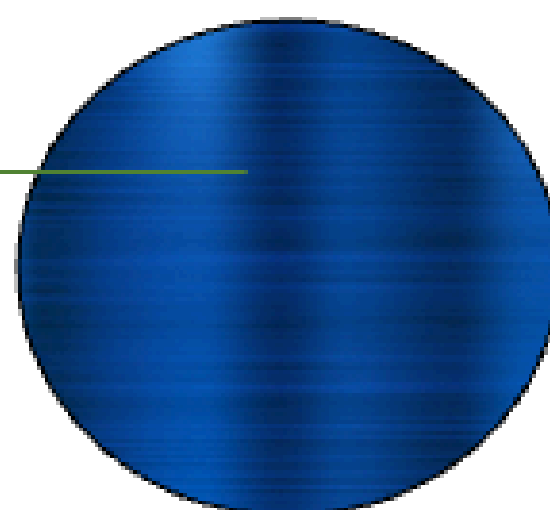
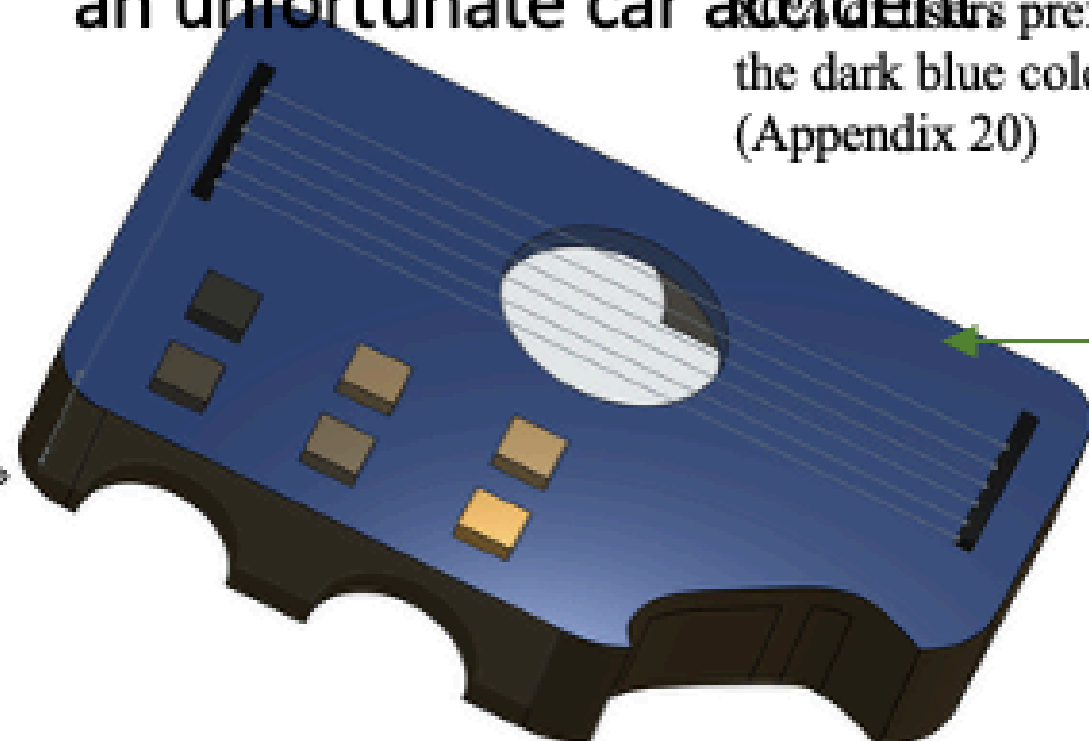


30% of users preferred the (appendix 20)



figure 7 -Rick Allen who lost his arm in an unfortunate car accident

users preferred the dark blue color (Appendix 20)



Royal Blue aesthetics had the highest amount of votes from userfeedback so will be used.



size was developed to ensure portability and comfort for users.

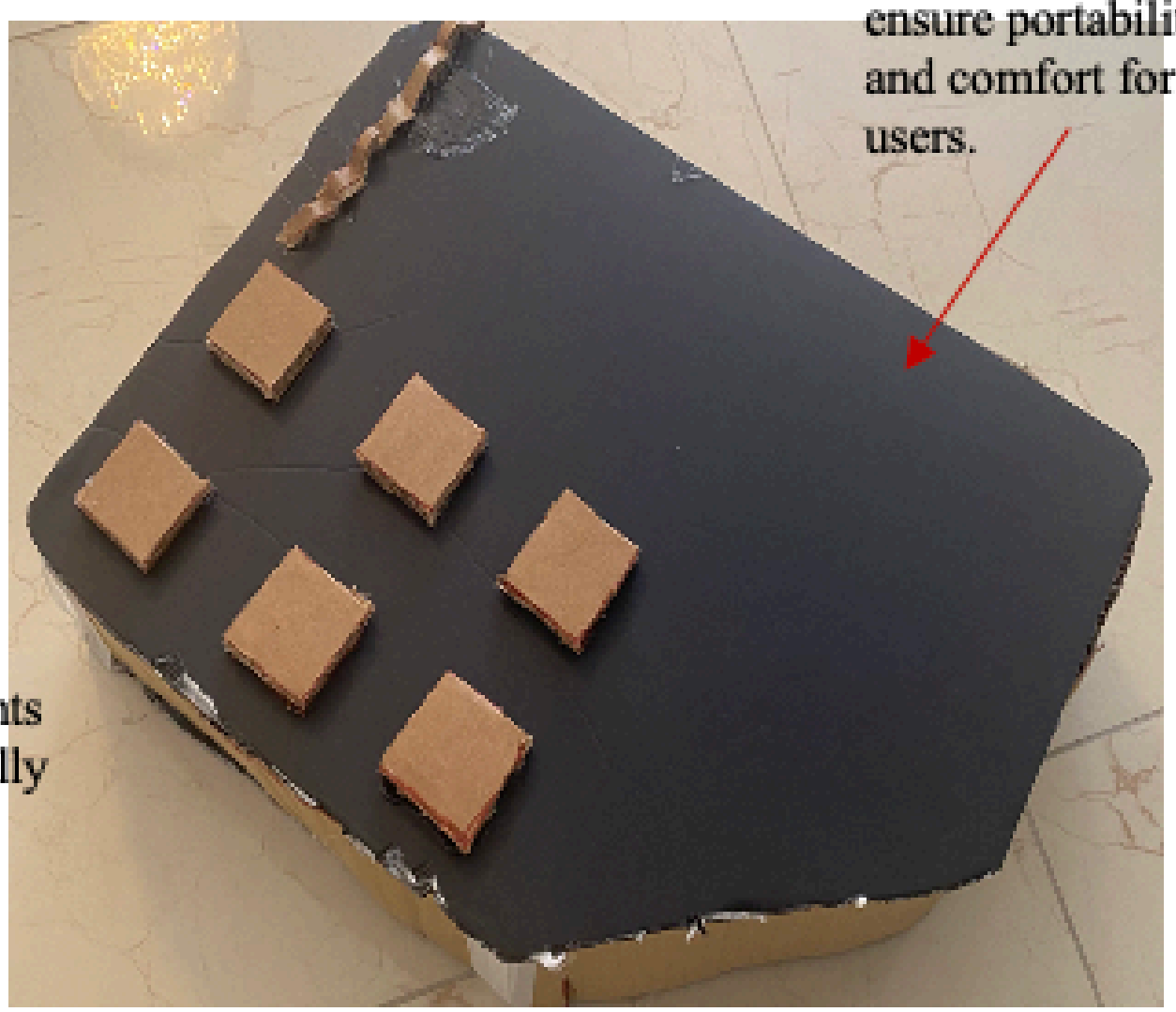


measurements for first physical model
60cm X 38.1cm

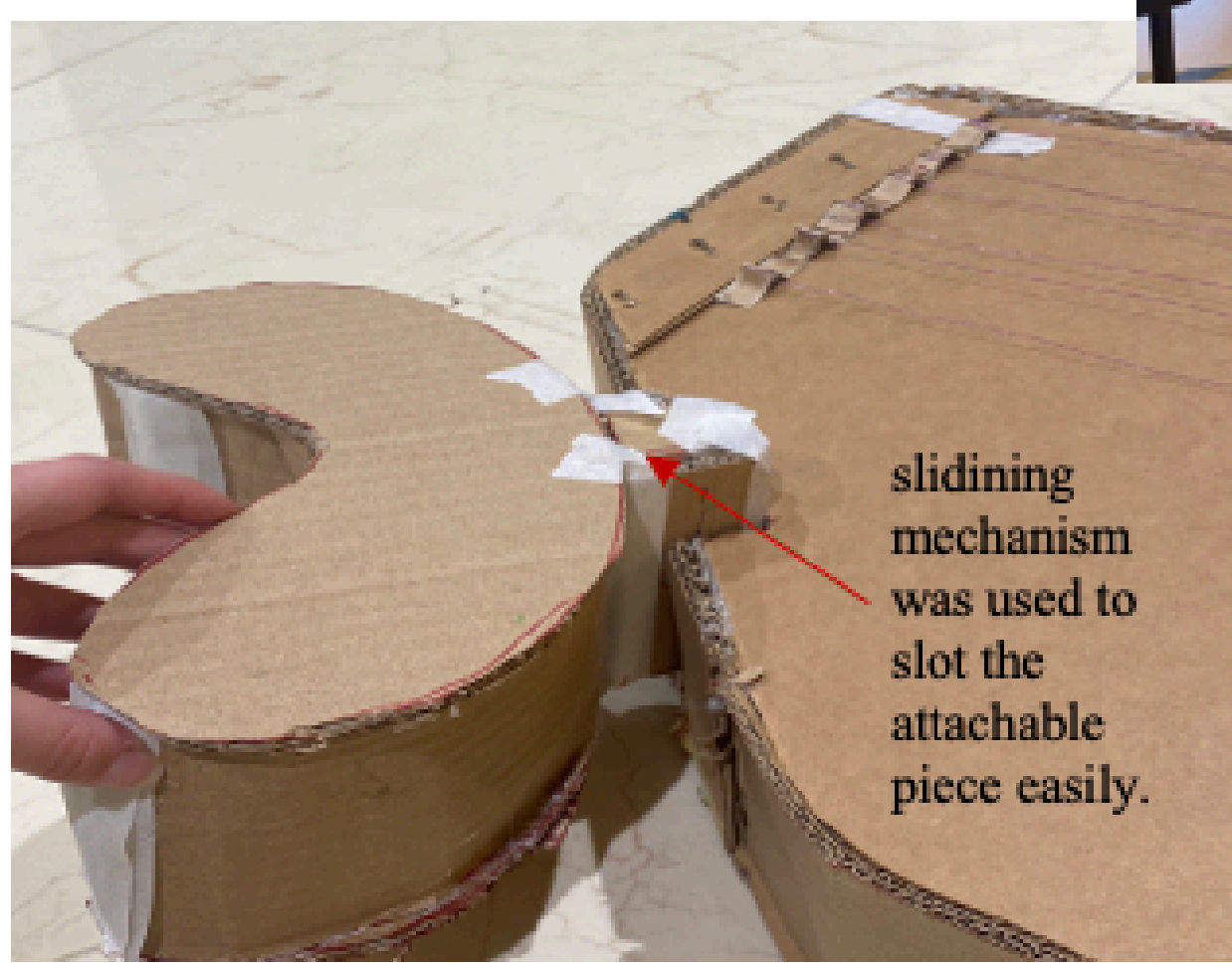
allows the instrument to be versatile as they can choose how to play it



while user testing, the measurements were too large and not ergonomically comfortable



measurements developed to
45cm X 35cm

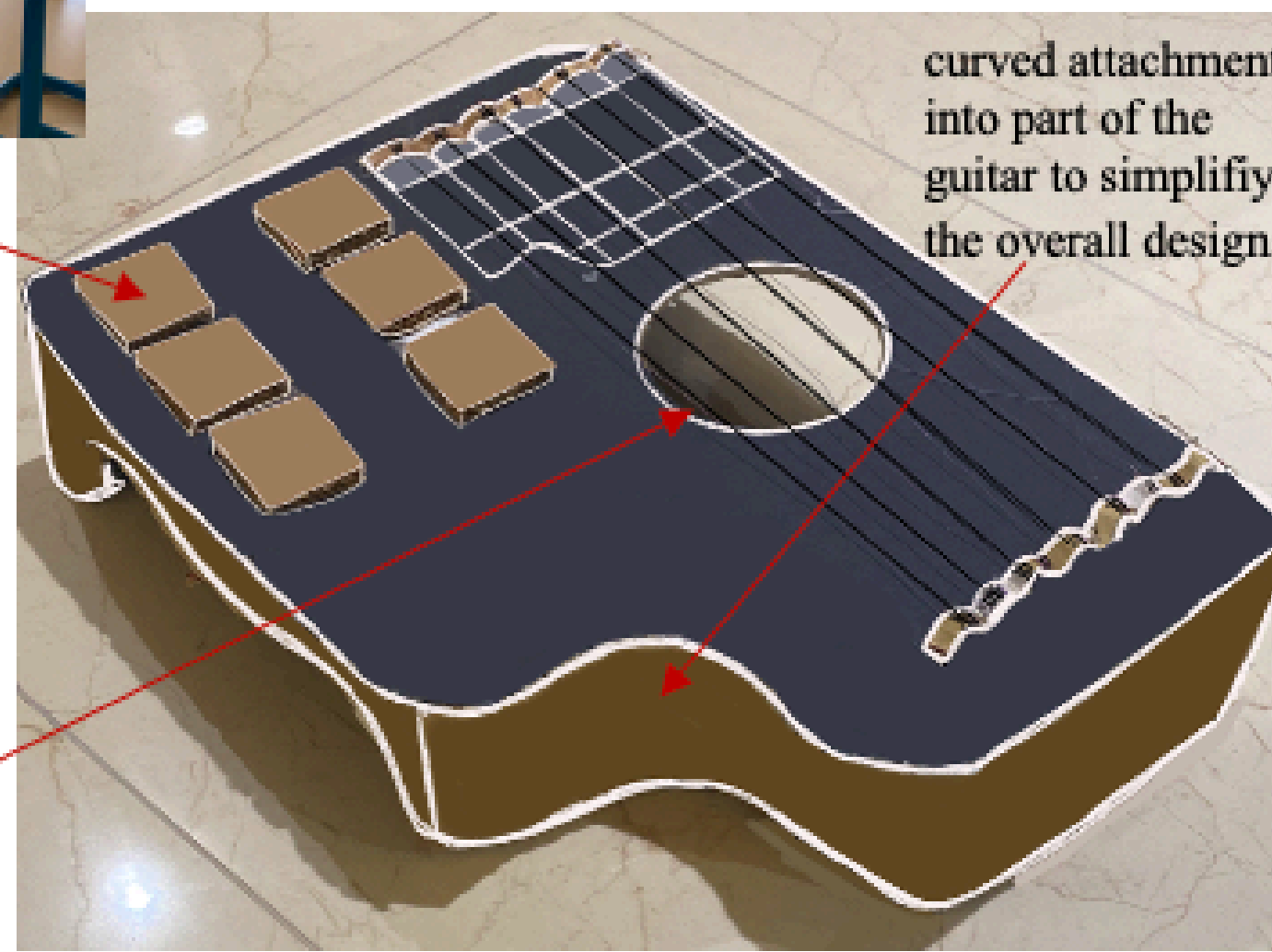


sliding mechanism was used to slot the attachable piece easily.

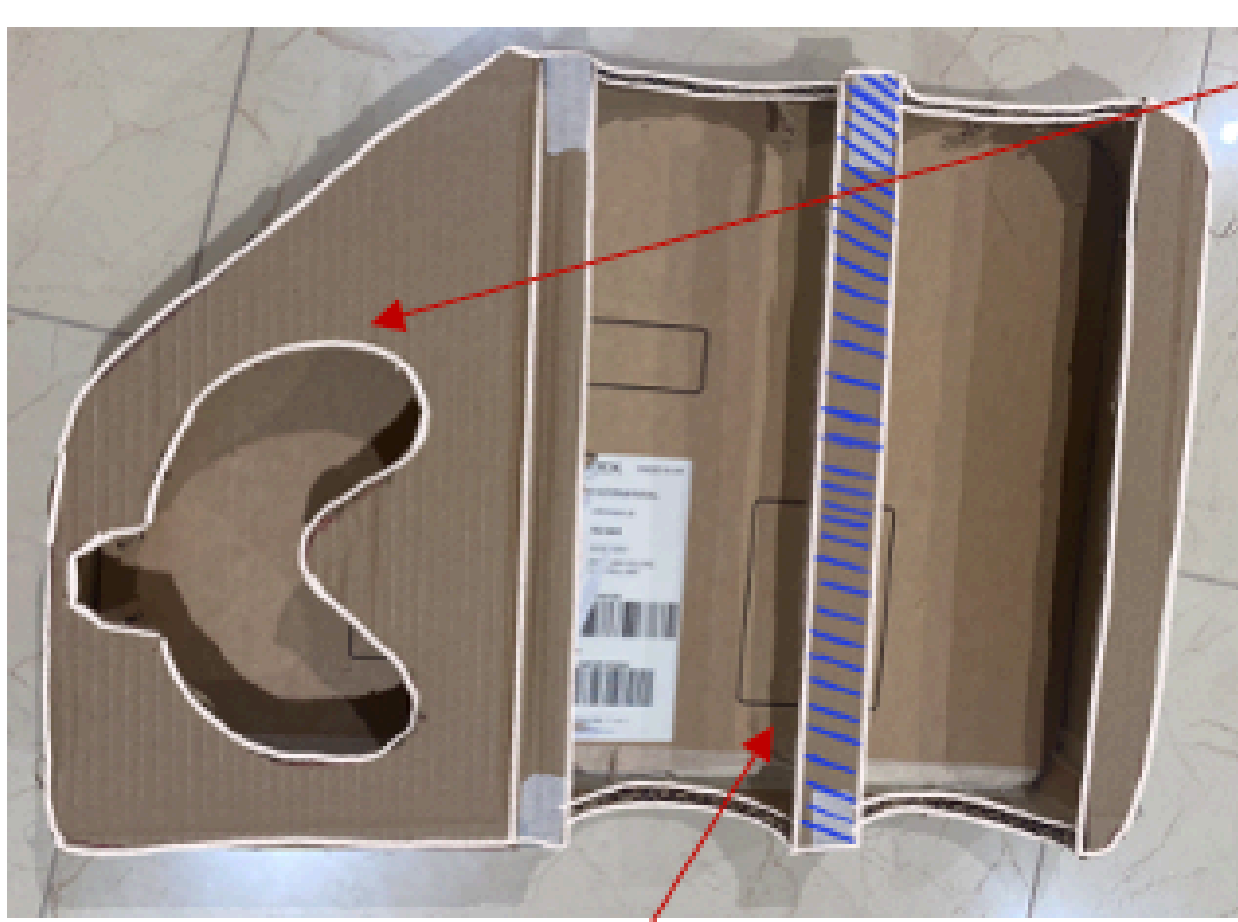
Chord buttons were placed closer together due to the limited space.



soundhole added so sound to resonate throughout the structure and improve acoustics. (appendix 20).



curved attachment into part of the guitar to simplify the overall design.

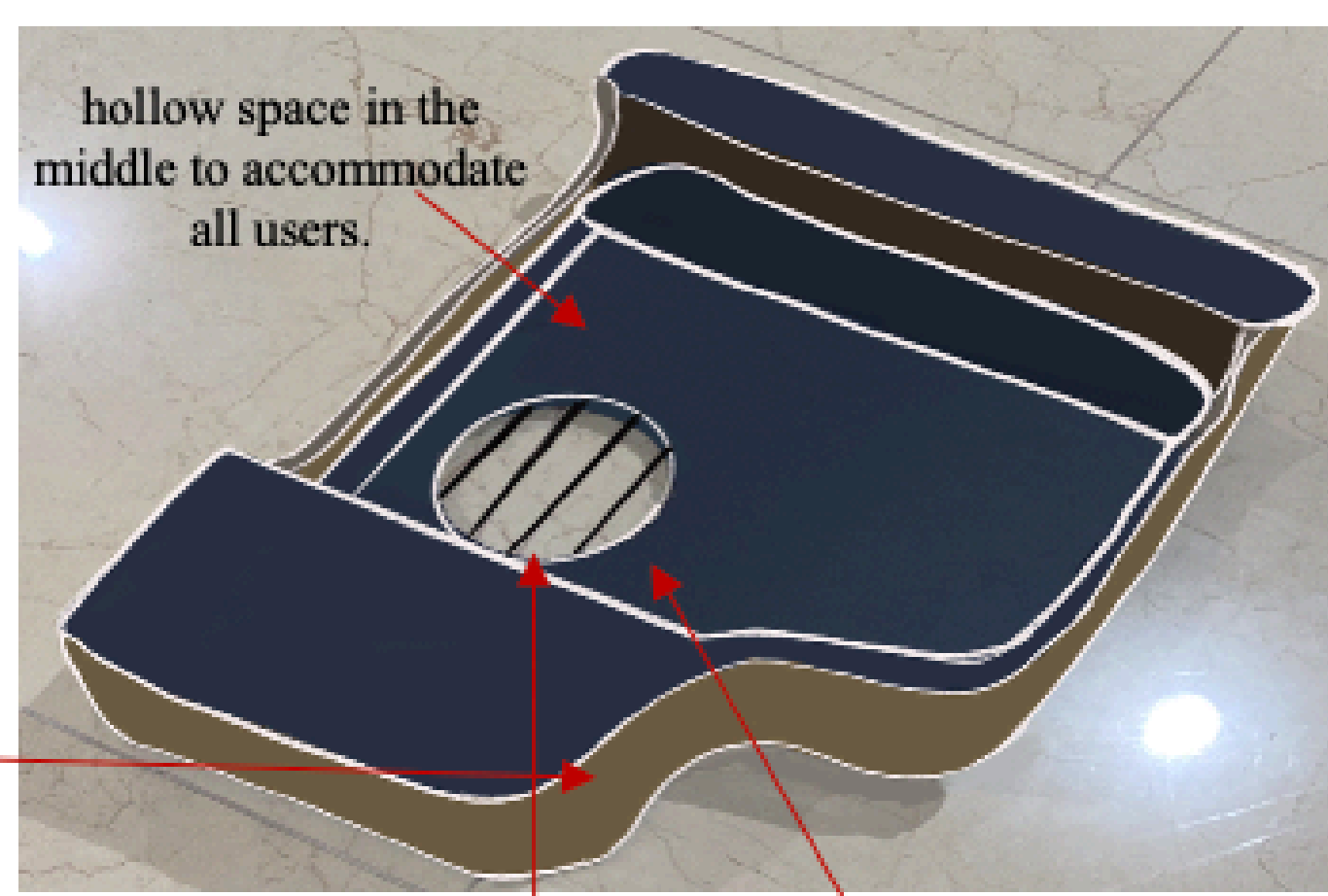


leg placement holes cut out using the 50th percentile

removal of curved attachment storage at the bottom of the guitar.



curves make it more ergonomically shaped and comfortable



hollow space in the middle to accommodate all users.

the bottom of guitar is open so sound hole is ineffective

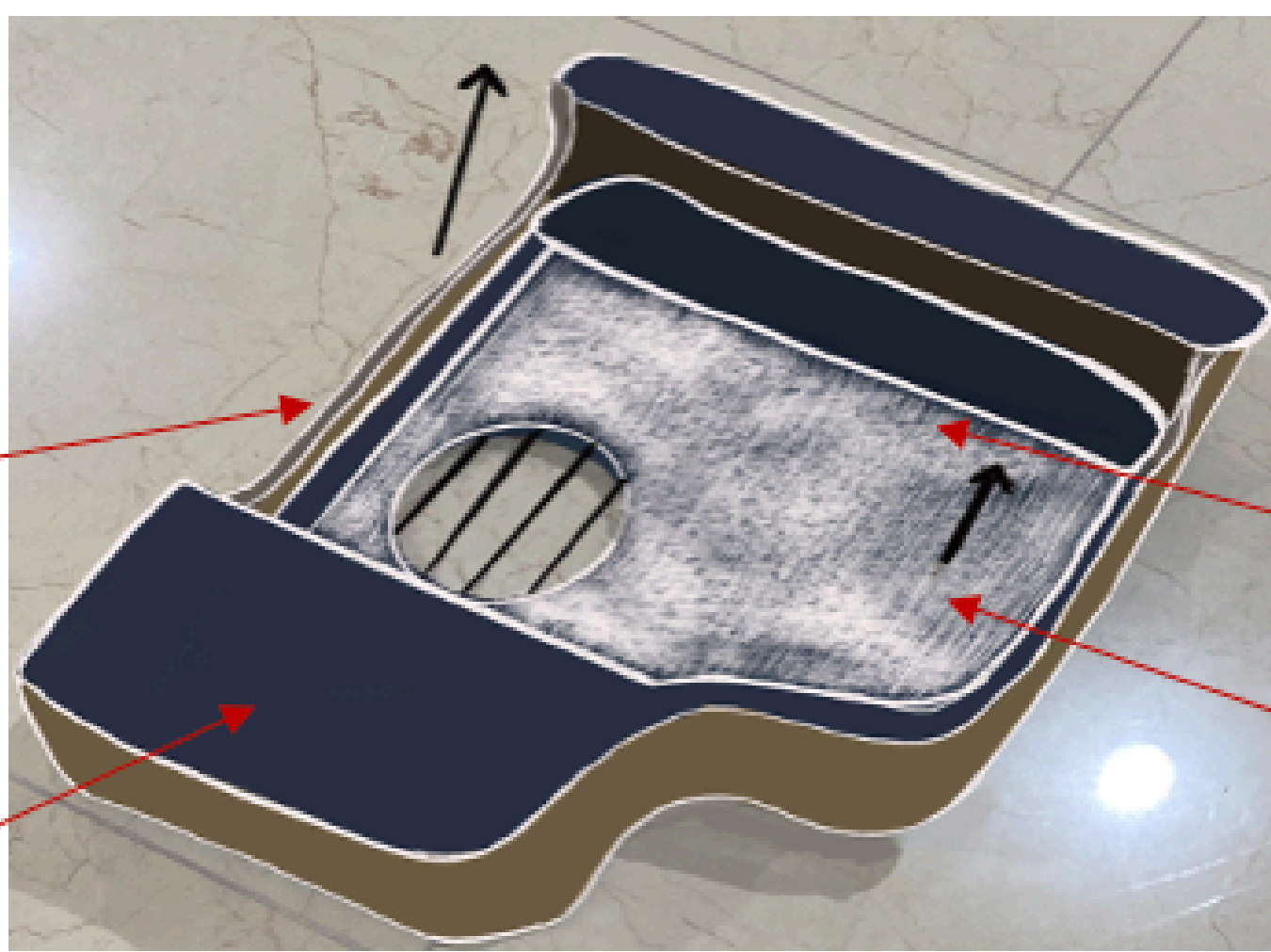
cannot resonate sound throughout the entire structure for better acoustics.

placing a wall/barrier so that there can be a closed area so sound can resonate

I will increase the height of the wall to allow for an enclosed space.

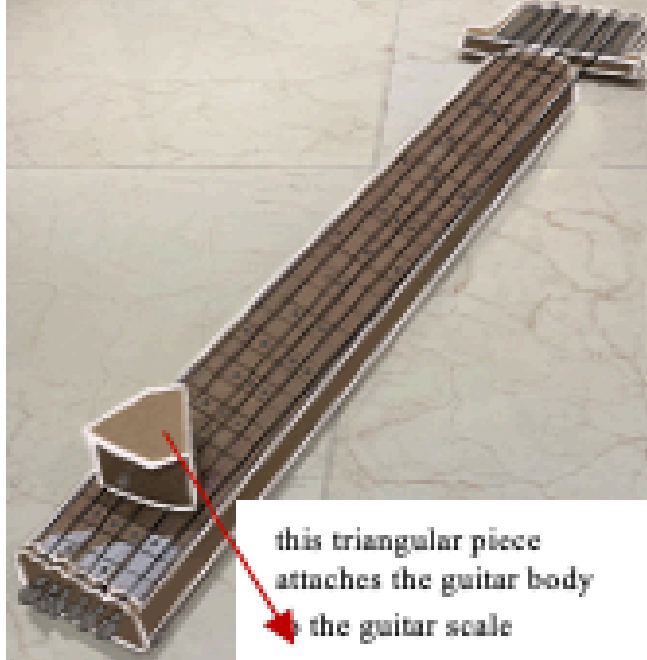
leg placement was still too small so middle barrier was removed.

users can play the guitar on their lap comfortably, without worrying about the sizing.

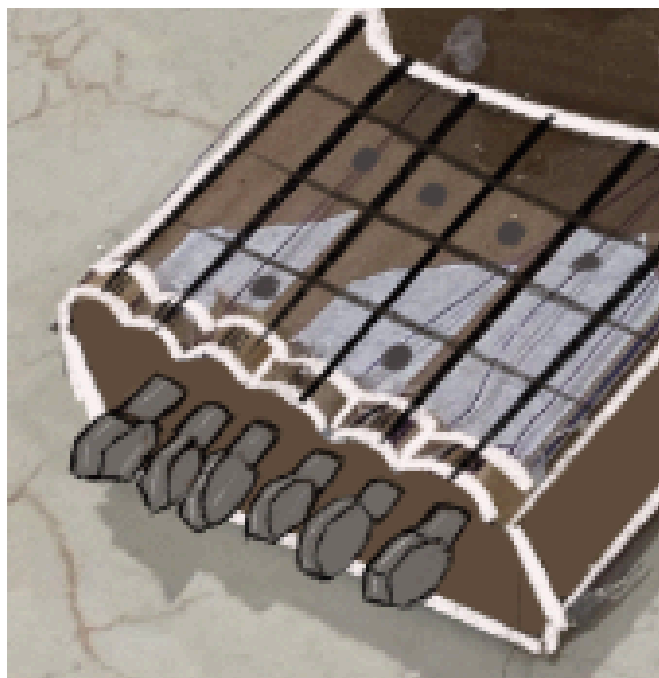




For my first physical model
101.6cm X 38.1cm-
measurements



The guitar scale measurements
90cm X 15cm,
which was too wide



added tuning pegs to the scale
length component attached to the
strings. (was on guitar frame)



Did not overlap correctly,
measurements of scale length
were too large.



Rods were placed to connect
the two structures.



sound hole added, narrower,
slanted, tapered scale length



bottom of the scale length made
into a rectangular shape for
sliding mechanism.



second half is curved and
hollow for easier curvature of
fingers



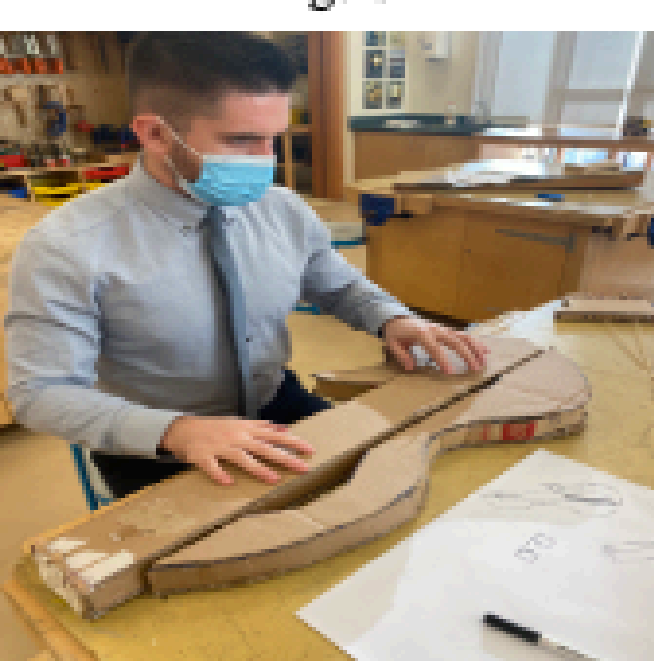
easier to hold and place into
the guitar frame



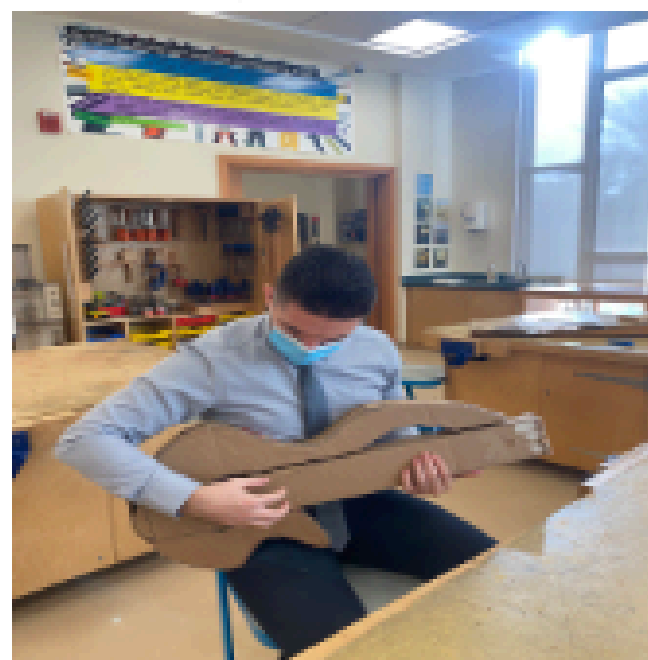
removed unnecesasy curves in
the guitar to make the scale
length accessible.



scale length was now easy to
slide in and were the correct
dimensions



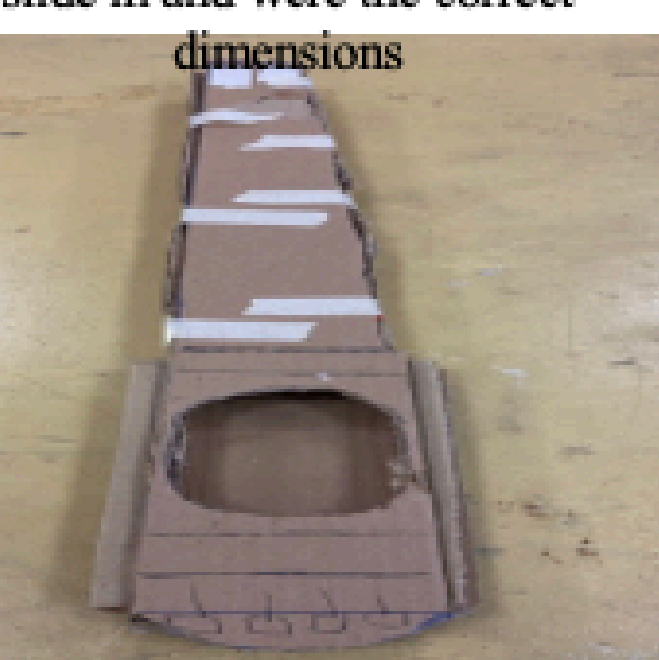
user testing showed that the
scale length did not have a
sleek aesthetic.



user has to wrap their fingers
tightly around the scale
length.



overall developed guitar frame
and scale length is more
aesthetically pleasing.



ridges added on the side on the
scale length for the sliding
mechanism.



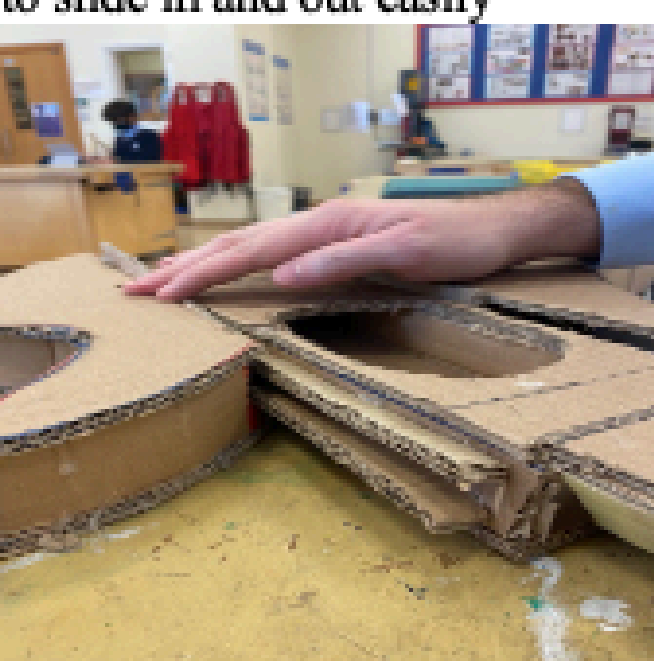
slots made on each side of the
guitar to allow the scalle length
to slide in and out easily



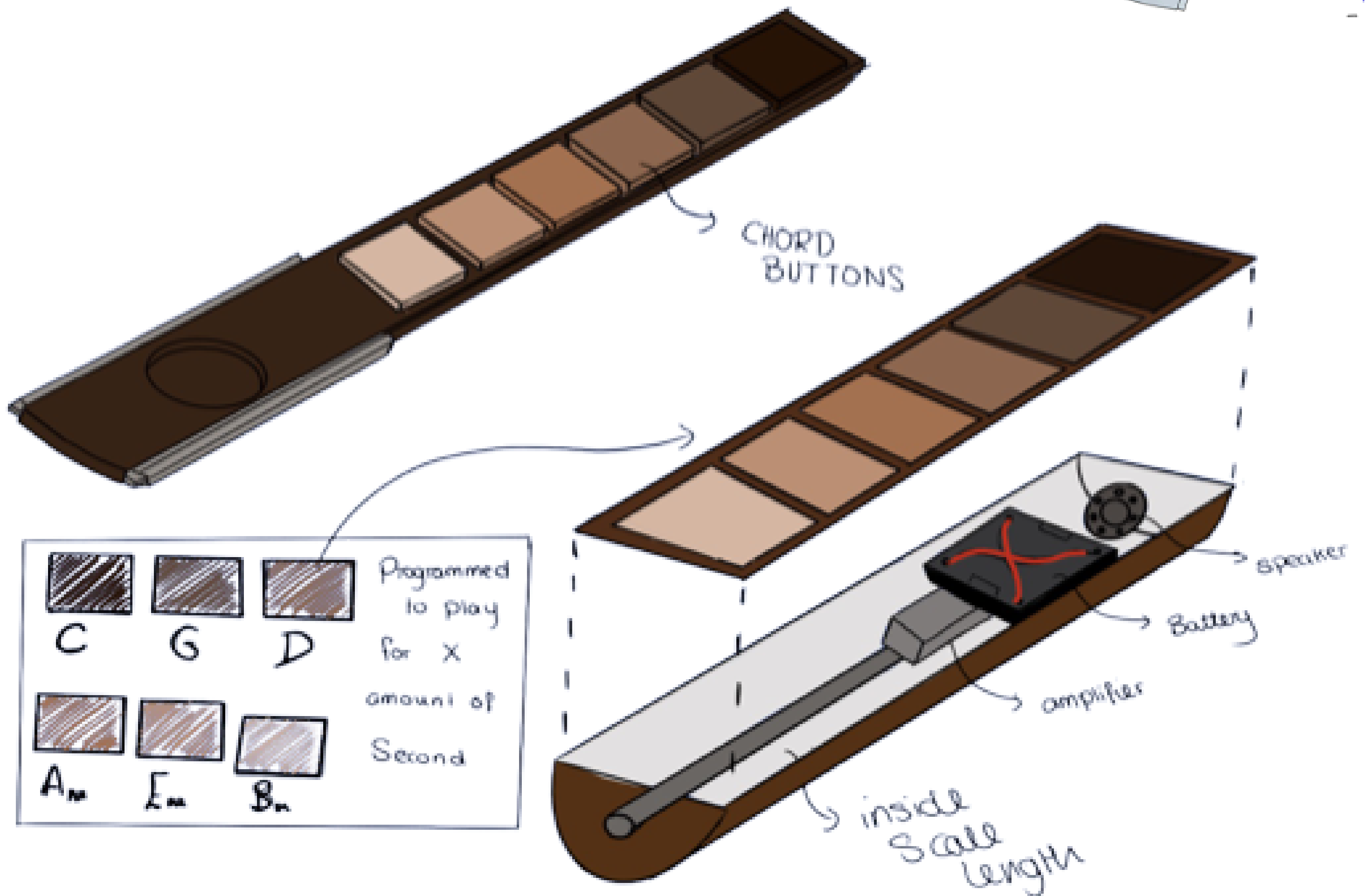
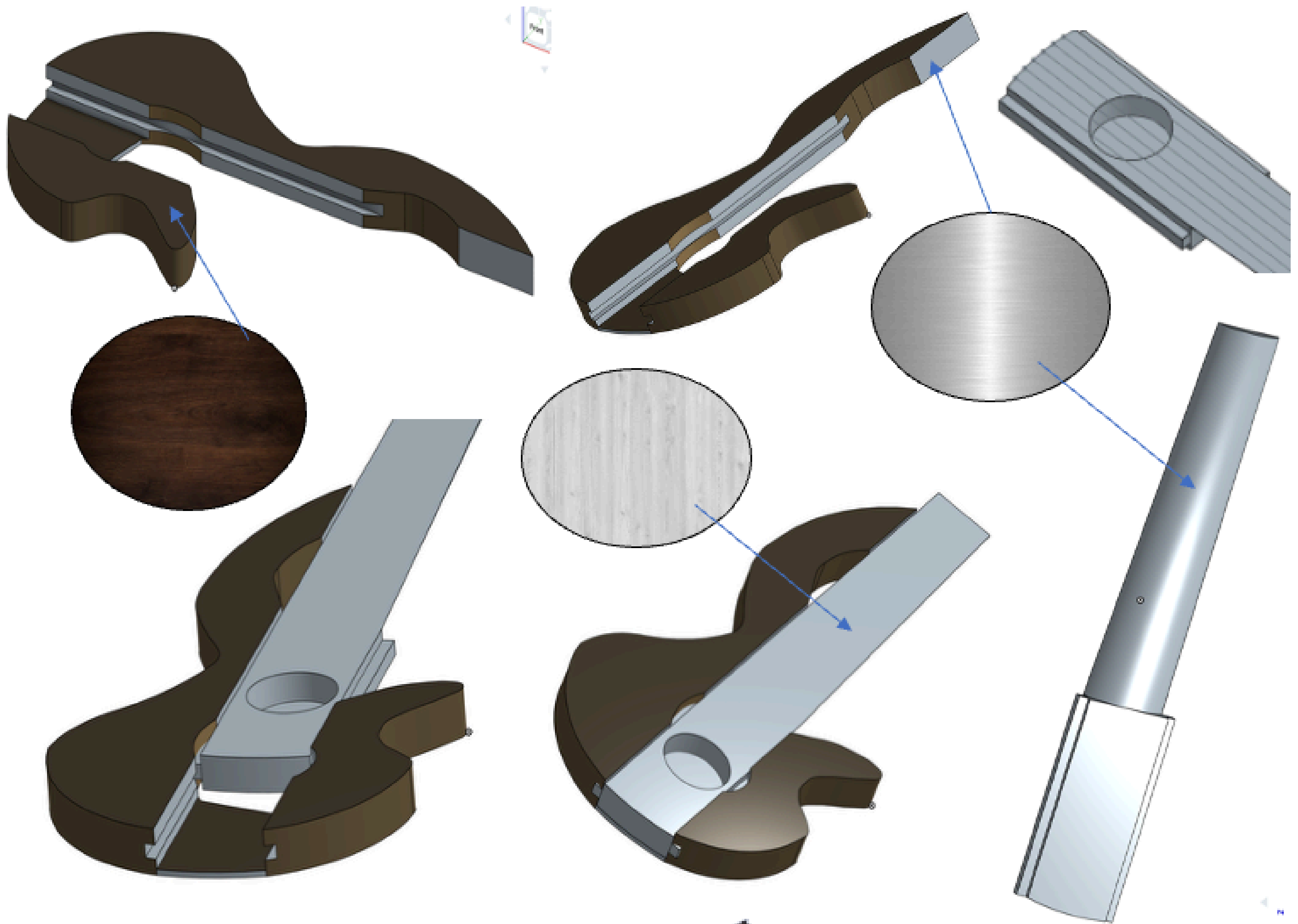
ridges on the side of scale length
is slotted into these slots.



This allows the scale to be inserted
and removed easily and quickly.



CAD DEVELOPMENT



DESIGN JUSTIFICATION



This inclusive guitar will allow users with physical disabilities to play music confidently and comfortably in public with the same functionality as a traditional instrument (3.1). My main design consists of 2 primary components, consisting of a scale length (74.63cm) and a rounded guitar body frame (68.9cm) mainly there for aesthetics (1.5), these measurements allow components to be proportional and accessible to users (3.2, 4.3). User feedback has revealed that those with dexterity limitations find it difficult to perform complex tasks such as curving fingers around the scale length and fretting notes. Therefore, I developed the frets and strings on the scale length into chord buttons that play the 6 main chords of a guitar (C, G, D Am, Em, Bm) on one half and 6 strings on the bottom half allowing pitches in low and high ranges to be played along with tuning pegs for tuning. The chords can adjust to any song/piece desired thus allowing users to play with ease and satisfaction (3.1, 3.3). The addition of more refined suction cups at the bottom ameliorates aesthetics and allows the guitar to be played on a flat surface (1.4, 6.4). The removal of unnecessary curves and edges (1.6) allows for a sliding mechanism to be introduced by the addition of ridges. This ensures transportability and versatility since users decide on how they play it, depending on their physical pain and their environment (3.4, 6.4). Furthermore, the addition of a metal clasp at the bottom of the guitar frame will keep the scale length in place. A narrow slanted and curved scale length improves ergonomics and allows for embellished design aesthetics (1.1 4.4). The guitar will be made from spruce which has a significant effect on the acoustics, is durable, and scratch-resistant (5.2). The sound-hole on the scale length has 1 inch that is hollow on each side which allows sound to resonate through the structure (3.1, 4.1). The use of dark brown, grey, and black paints allows users to feel less degraded in the industry and allows for a luxurious and sophisticated aesthetic (1.1,1.3,1.7) therefore, reflecting its price point of \$500-\$1000 dollars (4.6). Lastly, the use of an Epoxy surface finish ensures an elegant glossy aesthetic and allows it to resist wear and fatigue (5.4, 5.6).

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|------------------|------------------------|-------------|
| 1. Aesthetics | 4. Product Constraints | 7. Quantity |
| 2. Target Market | 5. Material selection | |
| 3. Function | 6. Size | |

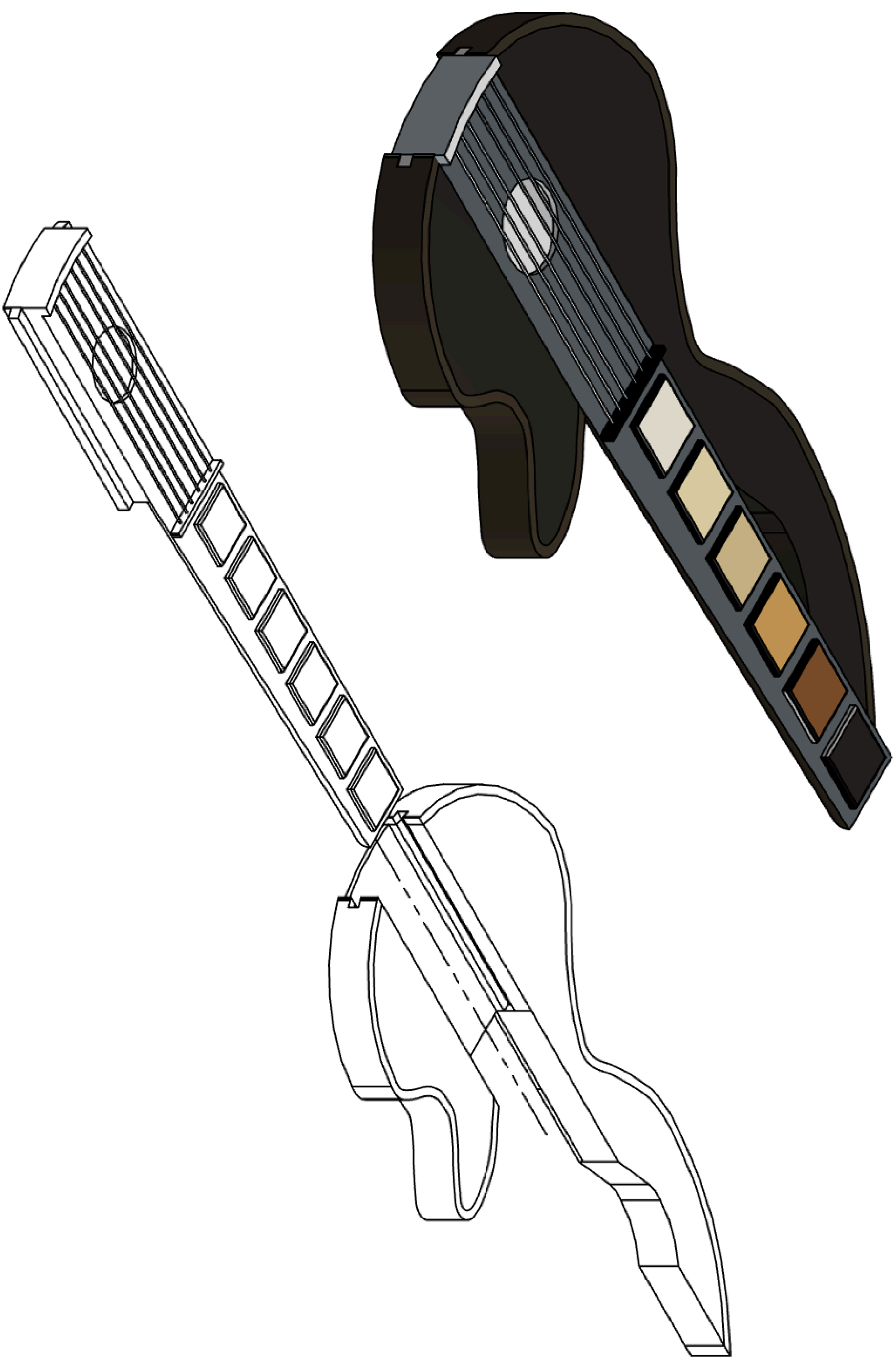
MATERIAL JUSTIFICATION

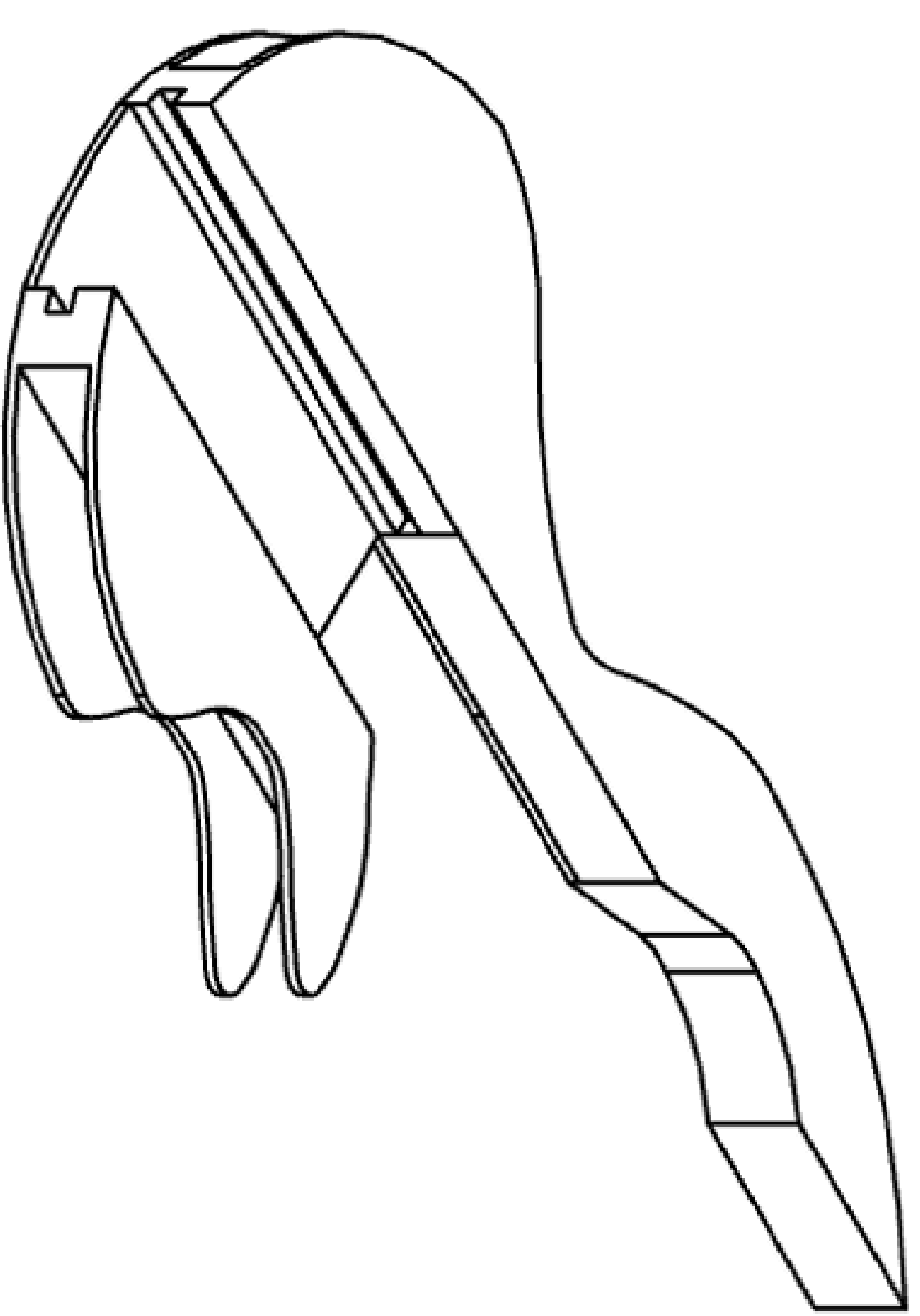
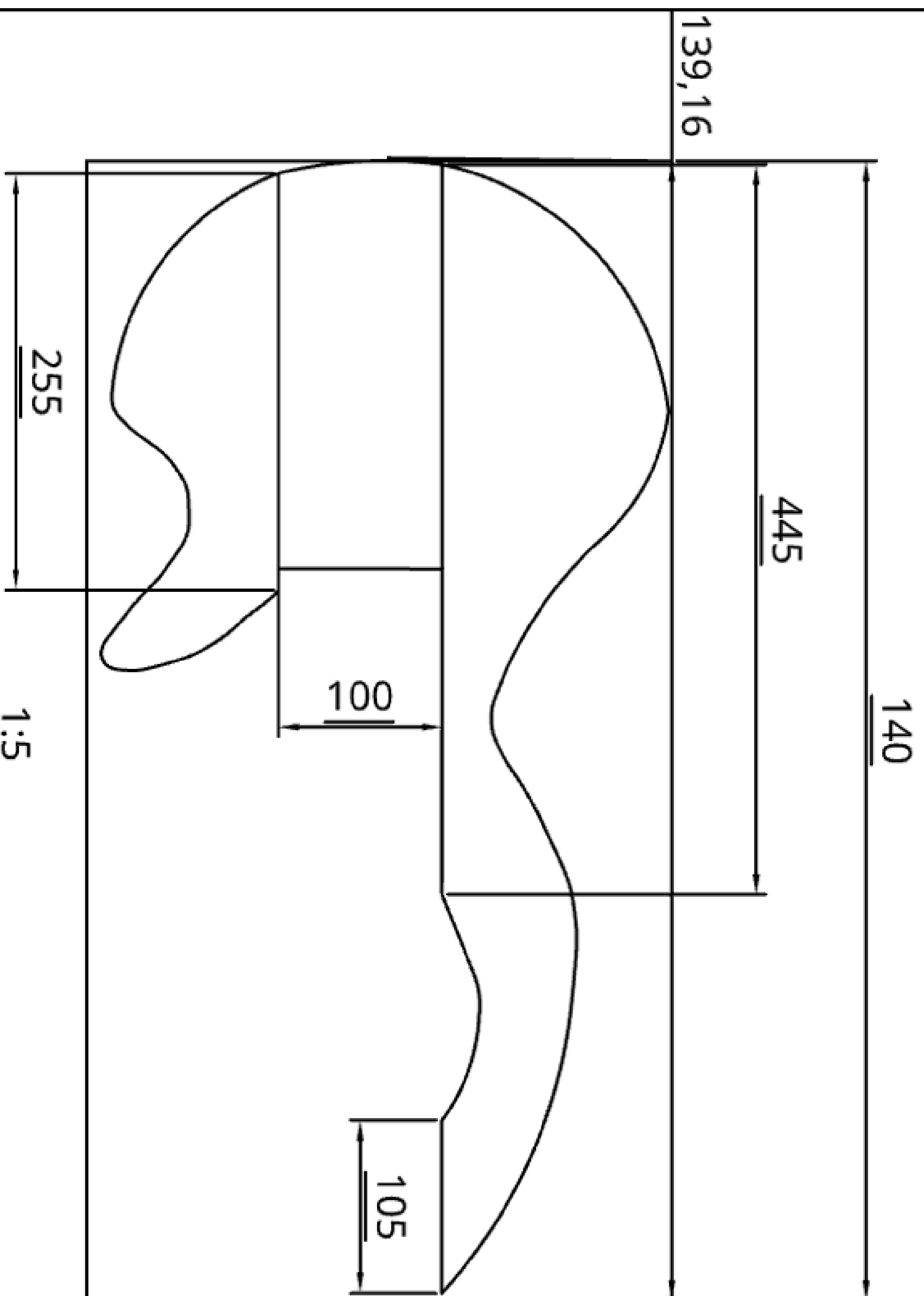
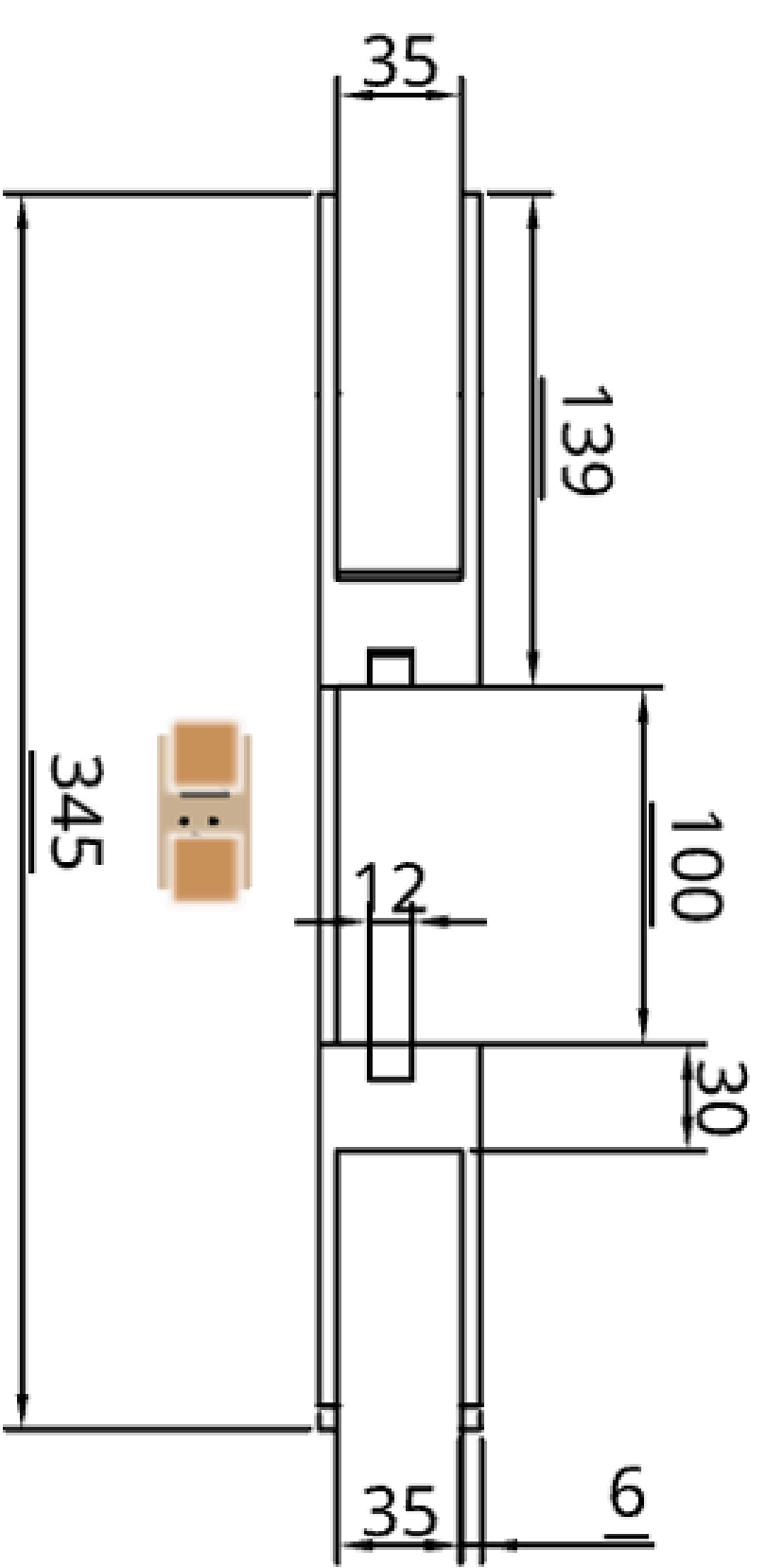
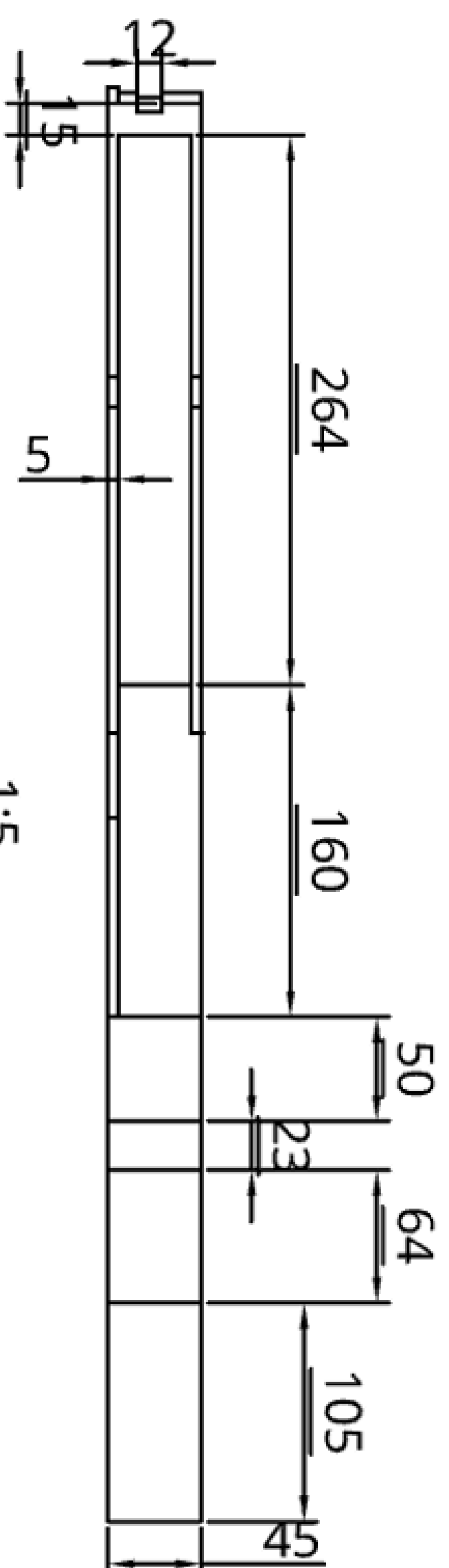
Components	Materials Chosen	Justification
Guitar Scale length	Spruce (softwood)	• Spruce is a sustainable softwood that grows a lot faster than hardwood, (renewable/readily available) • Spruce is ideal for the the soundboard of a guitar due to its stiffness/ hardness which prevents permanent indentation/damage/scratches/abrasion. • High density but lightweight, maximising the comfort and efficiency for users. Its high density amplifies the resonance produced by the strings.
Scale length guitar strings	First three strings is made from phospher bronze	• Thicker strings allows for a full and warm sound produced and this material is known for its balance and consistency.
	80/20 bronze	• Brighter overall tone produced and provides clearer treble response.
Guitar frame (front)	2.5-5mm spruce panels.	• High stiffness to weight ratio, ensures comfort/transportability. • The combination of spruce and rosewood produces a versatile tonal palette. • Fast and accurate to lasercutt reducing mistakes and waste of materials.
Guitar frame (back)	2.5-5mm indian rosewood panels.	• Pairing of the warm/rich can expand the sound from mid range to high and low end tones by producing deep bass and bright treble notes. • Rich overtones have a high response rate allowing the sound to resonate throughout the structure effectively. • Thin panels of wood is used to enable the wood to vibrate along with the strings and amplify sound.
Cables/wires	Copper strands	• Copper strands conducts electricity with high flexibility/ little resistance allowing electricity to flow through guitar/chord buttons.
Chord buttons	5cmx5cm Cedar	• 5cmx5cm square blocks of cedar with a thickness of 3cm will be used for the chord buttons (lightweight/less dense to press) • Readily accepts stains so colors can be used to diffrentiate chord buttons.
Suction cups	PVC plastic	• PVC has good mechanical strength and toughness so sticks to flate surfaces easily. • It is light in weight eliminating excess weight to the instrument. • PVC can be cut and welded easily therefore can be shaped into the elegant suction cups designed.

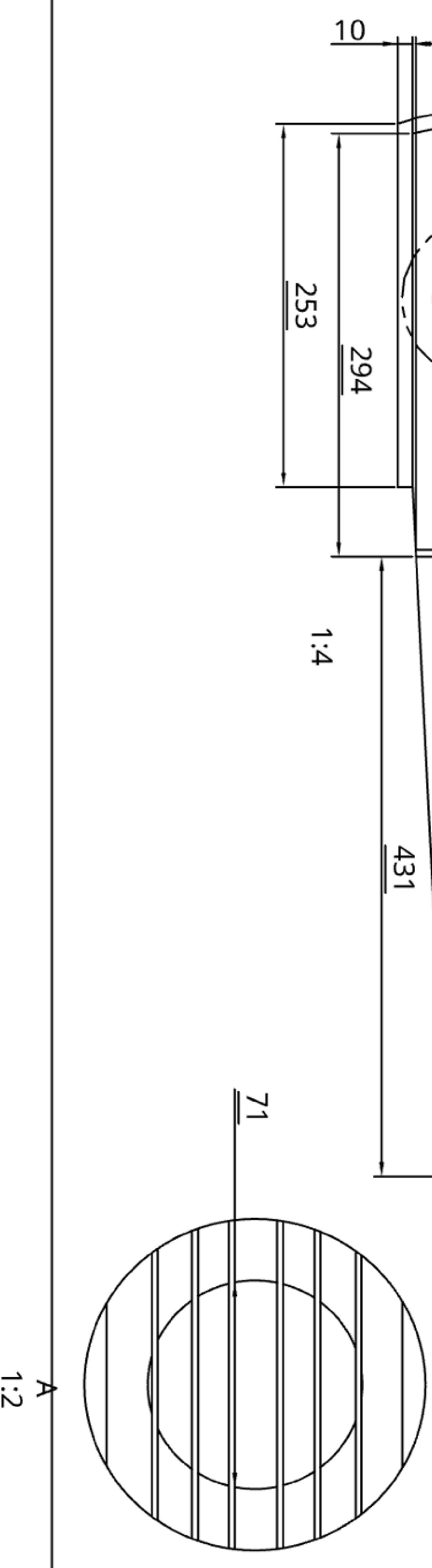
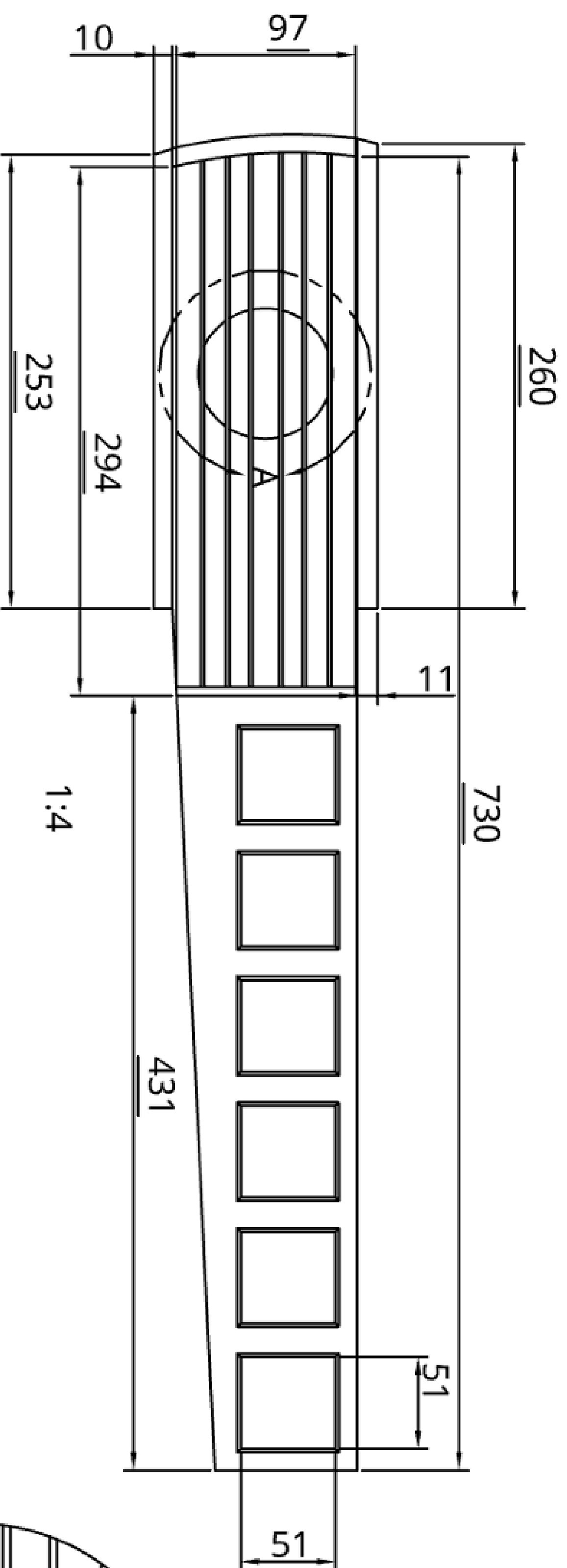
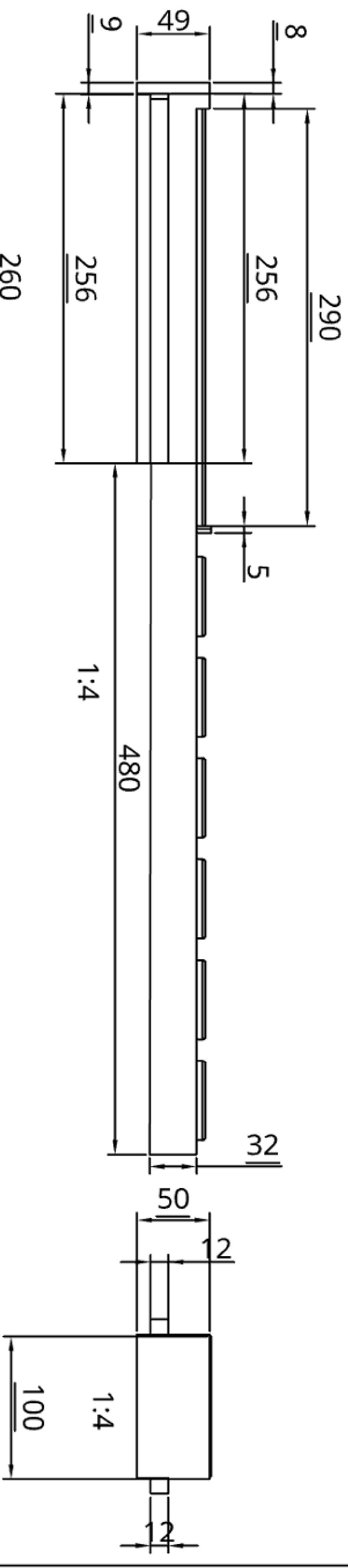
Component	Manufacturing technique	Justification for manufacturing technique
Guitar frame top	- Lazer cut using DXF files taken from cad models. - Bracing the inside of the guitar frame.	- Precise way of producing the necessary dimensions (time efficient/less waste) - Bracing allows a strong structure. - clamp straightes the curved pieces and the glue keeps them in place.
Guitar frame bottom	Clamping and gluing the bracing on the top of the guitar frame.	
Sides of the guitar frame	- Cut out less than 2mm thickness of wood for the sides - create a bending fixture made of scrap pieces of wood or high-density foam. - forming technique/bag press for the body of the guitar. - Side bracing glued onto the rest of the guitar frame using Aliphatic resin glue	- Less thick so easier to bend. - Acts as a mould for curved sides of guitar. - Easy and fast to produce accurate curved shapes. - strong adhesive that is waterproof.
Scale length top/bottom	Planning/shaping rectangular pieces of wood.	To give a tapered shape at the top for embelished aesthetics.
Sound hole	Use a lazer cutter for the required dimensions.	Accurate and precise dimensions for soundhole.

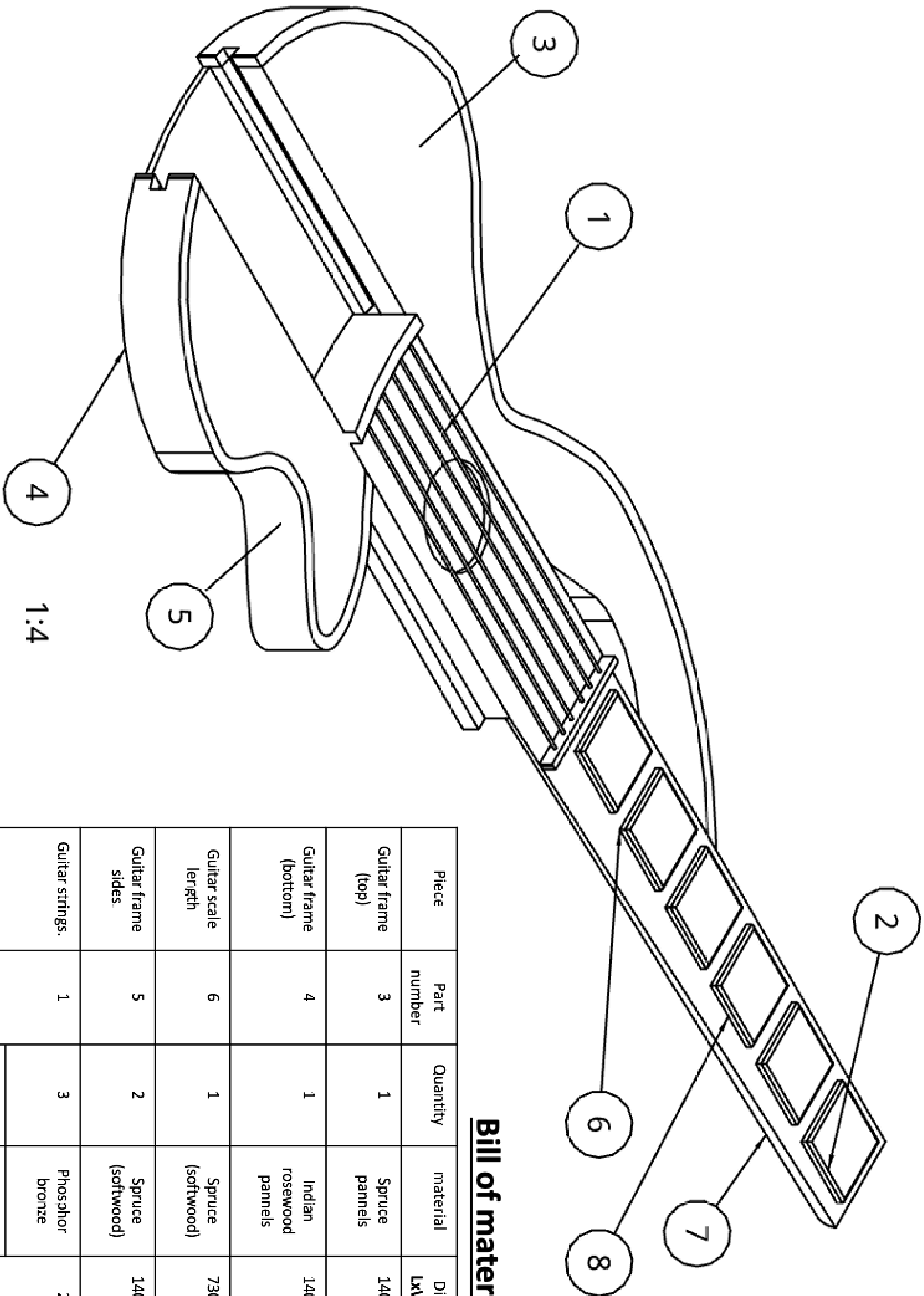
FINAL DESIGN











Bill of materials.

Piece	Part number	Quantity	material	Dimensions LxWxH (mm)	Finish	Unit cost	Total cost
Guitar frame (top)	3	1	Spruce pannels	140 X 68 X 35	Epoxy surface finish		
Guitar frame (bottom)	4	1	Indian rosewood pannels	140 X 68 X 35	Epozy surface finish		
Guitar scale length	6	1	Spruce (softwood)	730 X 97 X 50	Epoxy surface finish		
Guitar frame sides.	5	2	Spruce (softwood)	140 X 68 X 35	Epoxy surface finish		
			Phosphor bronze	297 X 71	NA		
Guitar strings.	1	3	80/20 bronze				
		3					
Chord Buttons	2	6	Cedar	51 X 51 X 6	NA		
Suction cups	7	1	PVC plastic	W20 X H11	NA		
Cables/wires	8	1	Copper strands	NA	NA		