Samuel D. Loveless

6 Strings and the Rest of the World

An installation for:
a custom-made six stringed instrument & the community

Contents:

Installation video:
https://drive.google.com/file/d/16BRlMaAHyNsl3ktldty5pQjqFvIAnOuD/view?usp=sharing

Installation soundscape:
https://drive.google.com/file/d/1Jcgp7slr4C8IDRuIYIZCwq_HDECIswWS/view?usp=sharing

WRITE UP

Pages: 4-10

6 Strings and the Rest of the World

6 Strings and the Rest of the World is a community focused installation, aiming to engage an intergenerational and diverse demographic audience, which invites participants to play, explore and create on a newly designed guitar-like instrument.

As music making is “an intrinsic and foundational part of human culture and society” (Higgins & Willingham 2017, p.3), I wanted to create something that allows people to co-create, enabling community cohesion and engagement, and be interesting, inspirational, accessible to all, placing “emphasis on conversation, negotiation, collaboration and cultural democracy” (Higgins & Willingham 2017, p.3). I have tried to create a space for “inclusive musical participation” (Higgins & Willingham 2017, p.1). *6 Strings and the Rest of the World* is designed to allow people to work together towards something new and exciting and be evermore connected from being an integral part of the creation of the piece/installation. Highlighting how together we can achieve something great. My focal points have been “people, places, participation, inclusion and diversity” (Higgins & Willingham 2017, p.4). I believe that if these five aspects are effectively embedded, then my aims for this installation will be effectively realised.

Sound juxtaposes contrasting human attitudes towards each other and our surroundings, both loving and destructive, to raise awareness about long-term responsibility for humankind. I am trying to “emphasise the importance of making connections among people, across issues and over time” (Higgins & Willingham 2017, p.4), in order to create a more cohesive society, focusing on the people around us as well as the long-now.

I wanted to create a workshop/installation that goes back to the origin and purpose of music - for it to be a fun interactive activity for all, where community cohesion and interaction is a cornerstone, presenting music as fun and accessible, giving “back to people the music that belongs to them” as Christopher Small (cited in Stevens, 1985) puts it.

Although most musical cultures and backgrounds are now, “available in almost any culturally diverse city in the world for the price of a bus ticket” (Schippers, 2010, p.14), I like Paton, believe it is important for musicians to, “facilitate access for those who are musically inactive” or “believe that music is not for them” (Björk, 2012). For myself, music is an (or even the only) exclusively accessible universal language. Anything we are able to do as musicians or facilitators (in any form) that enables even just two people to be able to communicate and interact with one another, then I believe we should. This may be in many ways, such as in the form of gigs and concerts, installations, or even online streaming services. All these ways (some more obviously than others) bring different cultures and ages together through the appropriation of music.

Community music has been substantially growing in the last decade, seeing, “a large increase in practices, courses, programmes and research as well as publications” (Higgins & Willingham 2017, p.1). This continuous path of community music is great. I hope that through my workshop and installation I am able to be a part of movement to help communities and beyond, as well as to get rid of the stigma that music is something which “either you have it or you have not” (Tillman 1976, p.5).

About the Instrument

When devising this instrument, I wanted to get rid any preconceptions about music and specific instruments, as well as the idea that to participate in or create music it is, “necessary to be thoroughly educated in music” before you “can even attempt to compose a tune” (Tillman, 1976, p.5). As, “music is one of the distinctive aspects of being human” (Higgins & Willingham 2017, p.4), Tillman (1976, p.5) asks “is it not possible that everyone is capable of some musical utterance?”. As a result, *6 Strings and the Rest of the World* is written for a newly designed guitar-like instrument - of alto & tenor pitch. To make this instrument, the essence of a guitar has been deconstructed and reconstructed, ensuring it has no preconceptions about it.

This instrument has the addition of taps suspended above it, allowing participants to tap/ press the taps, allowing water to fall onto the strings below. Attached to the tuning pegs are various motion sensors. These are designed and programmed to turn in various directions to various degrees, depending on the quantity and the whereabouts of the participants. This in turn creates musical contrast, interest and flow as well as enhancing the community effort of the installation (*see appendix for more information about the instrument itself).* The instrument has an adjustable height- to ensure it is appropriate and inviting to all (*Please see images & video for a visual description of the instrument).*

Aims

- to encourage people to work together to create something new and exciting underpinned by community cohesion

- be a catalyst for individual investment with cohesion within a community (and beyond)

- a steppingstone to long-term change

- create a situation where people step back from ‘the now’

Whilst reading Paton’s (2011) *Lifemusic: Connecting People to Time* I realised my aims have been perfectly summarised within this title alone. As part of time, together united in this. Björk (2012) writes that in this context “connecting people to time” is “getting involved and creating music together in the real, living, present here-and-now, instead of ‘fetishising’ absent historical composers and their works”, of course, which I believe has been achieved here.

Target Audience

The focus is on capturing and “inspiring a generation” (Olympics London, 2012) - as we heard so much about in the London 2012 Olympics. Millennials often have a big social media presence, which can strongly influence society. Throughout this project there is an aim to make changes now, so the next generation can easily continue with them. I want to inspire young people, so care for each other/individual unification is supremely important. Within this installation music-making has been presented as: “(1) it is natural, everyone can do it, (2) there are no wrong notes, (3) every sound is meaningful and revelatory, (4) it serves well- being and health for individuals and communities” (Björk, 2012, citing Paton, 2011). Of which Paton (2011) cited in Björk (2012) states this to be ‘Lifemusic’.

The Workshop

My workshop follows a passive leadership role from the facilitator (myself), rather than an active facilitation. I have gone so far as to say that myself as the facilitator should not even be in the vicinity - but myself as a participant can be. The whole intention of this workshop is for it to be a catalyst for people to interact and be a part of something together - and not necessarily to follow instructions from someone else. Facilitation is something that should enable “participants to harness the flow of their creative energy in order to develop and grow through pathways specific to them as individuals and the groups through which they are involved” (Higgins & Willingham 2017, p.68). Higgins (2012, p. 21) believes community music to be “a musical practice that is an active intervention between a music leader or facilitator and participants”. I agree with Higgins, but also think this definition can go further, that it doesn't have to be an 'active' interaction. Therefore, I believe community music to be "an interventionist approach between a music leader or facilitator and those participants who wish to be involved" (Higgins & Willingham 2017, p.3).

To achieve a true egalitarian, social participation in co-creating music, I chose signage and removed my active leadership in the activity. Björk (2012) cites Paton (2011) in saying that, "Paton makes a case against what he describes as hegemonies that are dependent on experts who create, control and mediate musical activity, reducing others to passive consumers".

My facilitation of the installations has been through social media event pages/publicity, posters, flyers, installation signage, accessibility of the instrument (and space) and directions. Through my submission I have tried to show its capabilities and possibilities of its uses within everyday life, being accessible to all anywhere and anytime.

A friend saw this instrument and asked if he might be able to run something with it, recognising the capabilities and potential of running an informed active workshop. He used this instrument in varying degrees of active leadership/facilitation to bring people closer together.

The point of the instrument is to facilitate cohesion and interaction within a community and beyond in whichever way is deemed appropriate. For this module it has mainly been shown through a passive workshop (and installation); also, as active workshop, showing this instrument is capable in varying degrees of informed and uninformed workshop/ installation formats.

This installation has been a long-term project for me (see appendix for Mark 1). I was awarded the Joe Brown Memorial Award for funding, and assistance from design engineering student David Hope at Imperial University, which without the electronics would have been unachievable (see appendix for Hope's full technological report). A challenge was people commenting on the dangerous nature, impossibility and impractically of using water on electronics, as well as the dangers and possible errors that come with creating a brand-new instrument. A multitude of testing have been taken to ensure safety. To ensure maximum control and safety, most elements of the installation have home-designed and built (see appendix for Hope's technological report).

I made a soundscape from all the different installations over the day. It directly shows how people who may never meet have come together (in the same as well as different locations). Making it into a soundscape encourages people to help others, due to being able to directly see the effects of working together.

Workshop (Installation) Environment

Ideally this installation would be held in various locations for long periods of time. Currently the installation is tailored for 2-10 active participants at any one time, bringing 100+ people an hour together. The installation has been displayed in three contrasting locations: Goldsmiths' Students' Union main space, Goldsmiths' Student Cafe and room RHB 167.

Evidence of Demand

In 2017-2018 the art group SUPERFLEX were commissioned to occupy the Tate Modern's Turbine Hall with their interactive installation 'One Two Three Swing!'. It invited the public to swing on swings and work as a team, seeing how "our collective energy resists gravity and challenges the laws of nature" (Tate), reinforcing that together something new and profound is achievable. This also shows that institutes and companies are keen to get involved in and be a part of community cohesion, endeavouring to make change.

Evidence of need

The motivation of installation is partly driven to facilitate teamwork skills and develop empathy within the community to tackle social and ecological issues; such as the isolation mental health illnesses bring. In the UK 1 in 4 people experience mental health problems each year. Ecologically, "the planet's average surface temperature has risen about 0.9 degrees Celsius since the late 19th century… through Glacial Retreat… Ocean Acidification… Sea level rises" and more (NASA).

Influences

6 Strings and the Rest of the World was inspired by John Cage's *4'33"*, Maria Chavez's sound art installation 'String Room' and Danish artists' collective SUPERFLEX's *One Two Three Swing!* Henry Dagg, Tim Murray-Browne, Bill Fontana, Tacita Dean and Felix Gonzalez-Torres to name a few.

Cage questions our preconceptions of what music is and should be, and introduces us to life rather than to art. Instead of introducing life, I have tried to introduce the idea that music can be made up of the work and cohesion of people within everyday society and that it doesn't need to be composed by one person sitting at a piano. Music can be an interactive activity which brings people and communities together.

I was also greatly inspired by Maria Chavez's *String Room*, as this, like *6 Strings and the Rest of the World* asks the question what is music, and what should it be. She does this excellently through creating a fun interactive medium for the public to explore music, whilst at the same time creating something quite random yet beautiful.

Evaluation

All events successfully created a space in which people from all walks of life could come together to create something new and exciting. the video affirmers to me that *6 Strings and the Rest of the World* is doing its job in many ways, being the catalyst for them interacting, talking and laughing together. A huge array of different interactions with the instrument (and surroundings) are evident.

People I know and don't know who attended the installations have commented to me on the long-term thinking aspect of the installation in a positive and engaging way. I was also encouraged to take this installation further afield (to other social spaces)

I have a lot of visions and hope for this project, and realise that to effectively aim the installations, site specific modifications and even instruments/installations will need to be created. No two people are the same let all two different communities across London and beyond (see appendix for description of future plans).

Please Note: The video contains audio from the soundscape (comprised of the participations from the various displays), as well as the live installation audio.

References:

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Schippers, H. (2010). *Facing the music: Shaping music education from a global perspective*. Oxford: Oxford University Press.

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APPENDIX

Pages: 12-40

Additional Installation Information

Tuning

Each string (tuning peg) has been assigned to a sensor on the opposite side of the instrument - ensuring that teamwork is essential to make the installation work effectively. Each peg is able to be tuned to two tones from its resting position. This has been split up into semi-tone differentials - thus there are four points of tonal transition. As mentioned before, the strings are tuned according to the amount and proximity of the participants to the sensors. It works roughly so if one person is watching from a short distance, the string will be tuned up by one semi-tone from the resting pitch. If they are closer, or there are two people, then it will get tuned up two semi-tones from the resting pitch. This process also occurs for the third and fourth semi-tones from resting position, with the fourth semi-tone from the resting position being when someone is up close to the instrument / actively participating with the taps of the instrument. The tuning of the strings to each of the different gages takes a short while. This enables the participants not to get lost and be more accessible to all demographics of participants. The installation is set up in a way that encourages support and teamwork by the participants in a fun and easy way. The resting notes of the 6 strings are: E, A, D, G, B, E (the same as conventional tuning on a guitar). I deliberated for some time as to what I wanted the pitches to be. I experimented with a variety of tunings including more conventional alternative tunings and less conventional ones. In the end, conventional tuning proved to be most effective for the desired outcome. These pitches really enable the participants to easily make some nice, melodies and sonorous harmonies, whilst passing through some less pleasing chords and clusters. It is this aspect of the installation that I guess makes it a character of itself. The note and tuning choices directly comment on how things can look ok and fine from the outside or at a quick glance - seen through the open spread rest chord (notes). Once you delve deeper or don’t think about what is actually going on, it can all be quite messy and disjointed - commenting on the dissonant chords. But finally, when the participants finally get the hang of the instrument, they will be able to create such beautiful and even complex chords - showing that when we work together, we truly can create something nice. Here the message is extremely simple. It asks the participants to simply think about one another before jumping to conclusions. Everything may look fine with that person, but when you actually ask, they may have had the worst day life could throw at them. If we all took that time to listen or try and help, then eventually we will achieve that beautiful sonorities that are able to be heard within this installation.

Looking to the future

6 Strings and the Rest of the World will be part of a wider project called *Catharanthus Rosea*. *Catharanthus Rosea* is comprised of four interactive sound art installations, drawing on the origins of music as a fun and meaningful interaction, which is both created by passion and inspires it. Each entitled accordingly: *6 Strings and the Rest of the World*, *A Thought in the Wind*, *The World's Rhythm* and *There's Hope Yet*.

Catharanthus Rosea is a project designed with community-centred activity at its heart, so a project best operated within the public sector. The installations ideally need to be shown in a space that brings the community together, accessible to an intergenerational and diverse demographic. Therefore, in clear and easily accessible areas for all to reach - accommodating sight, hearing, mobility, additional needs and costs.

I think that for *6 Strings and the Rest of the World* to be better realised, multiple instruments (of the same type, but different pitches) need to present. As a result, the instrument in both a soprano and bass pitch are in the pipe line; with David Hope already designing and running tests on various parts for the instruments.

From this installation I have already started on working on ways to develop ones experience (in a controlled space). With the inclusion of multiple variables: proximity to the instrument, floor pressure sensors and hight sensors. Each of these will control a different aspect of the instrument. Proximity - string pitch | Floor pressure - tone/sound manipulation (tone, reverb, eq, delay) | hight - effects (overdrive, octave doubling, phase shifter). I am also going to include the inclusion of several fish tanks (each having a 1- a few fish in). This will make it more inclusive for everybody and get people more interested in the installation. These fish tanks will have two types of sensors: 1. going through the tanks (beam like) and will. Activating drones when crossed. 2. Will be a proximity sensor. I think these sensors will control the movement of the instruments (on wheels). When the fish move in one direction so does the instrument. All these elements with a more tactile and inclusive instrument should result in a much more convincing message and soundscape.

Inspired by Paton (2011) cited in Björk (2012), I also hope and believe the use, inclusion and presence of (community-)music where it is not currently evident will 'contribute to greater interpersonal trust'. I think this to be the case whether in a community, school, board room and beyond. This is why I hope to take this project to: Biennales and festivals (e.g. Ealing Summer Festival and Womad), galleries (Tate Modern), community centres and public spaces like train stations, bus stops, parks/playgrounds, shopping centres, at receptions or communal spaces in schools, Universities, big corporate companies and more. Trying to create a presence of music, community and positive interaction at every chance available.

Furthermore, to raise awareness and profile, I would like to bring the installations (or recordings from them) into both the pop genre (e.g. Henry Dagg's partnership with Björk) and classical world (for the compositions/installations to be listened to in a more formal setting - e.g. John Cage's 4'33"). To make my vision of community music, interaction and cohesion even more evident, I am aiming to have multiple displays up (both permanent and portable) at the same time, with live audio streams linking them. Initially this will take place within various points in London, enabling people of all walks of life, ages and demographics to actively participate in a piece created together. I am working on this idea to make it full proof, and work on a way that the participants (both active and passive) and beyond can listen to and download the time portion of the piece which they, with others across (various locations of) London have directly created together.

Technical/Resource Requirements

Location: An open space (indoors or outdoors), with accessible power source or portable power supply.

Equipment:

Ideal set up: Instrument, hydrophone microphone x1, PA system [speakers x2, mixing desk (only 2 channels needed)], DI box x1, 1/4 inch jacks x 2, reverb pedal, extension chord x1, gaffer tape, cable ties/masking tape, water. *For outdoors: portable power supply.*

Simple set up: Instrument, hydrophone microphone x1, guitar amp x1, extension chord x1, gaffer tape, cable ties/masking tape, water. *For outdoors: portable power supply.*

Minimal set up: Instrument, hydrophone microphone x1, portable speaker (e.g. minirig), water. *For outdoors: portable power supply.*

Accessibility arrangements: Clear bold posters with the inclusion of braille text, clear signage, clear installation information and instructions, wheelchair accessible, and appropriate seating for those less able to stand.

Process & Development

Mark 1 of this piece was shown at Goldsmiths University and was called *Two Guitars and The Rest Of The World* [video link: _4AF793B2-9427-4453-8DF2-51FC7A8042FC_HQ.mp4].

Two Guitars and the Rest of the World (Mark 1) consisted of two guitars being tuned to each of the different 12 tones (with the notes spanning across two octaves). These guitars are amplified and are laid down flat with pipettes suspended above each of the six strings of the guitars. The installation has been placed in a public area - in this case at the front desk at university, with the intention that the public would come, tap and squeeze the pipettes, making water fall onto the strings and occasionally body of the guitar. As it is interactive it is left to each person to decide which pipettes to tap/squeeze and how long to squeeze them for. Thus creating unpredictability and a sense of aleatory. To ensure greater interest and interactive fun, five guitar pedals are attached to the guitars and have been laid out with brief instructions on them (seen below) as to what the participating public should do. Thus the sound of the guitars will be ever changing, as different people will turn the dials to a greater degree than others. This adds to the organic and aleatoric nature of this piece and also brings a greater variety of interest to it, as well as adding some direction to the piece. Furthermore, to add greater textural contrast, a loop pedal has been used at various intervals to create thick and thin textures.

Pedal Instructions:

Digital Delay - Twist dial as you wish if you are right handed || Press pad if left handed

Over Drive - Twist dial as you wish if you are not an undergraduate at Goldsmith's || Press pad if you are an undergraduate at Goldsmith's

Phase Shifter - Twist dial as you wish if you have brown eyes || Press pad if you do not have brown eyes

Super Octave - Twist dial as you wish if you have a piercing(s) || Press pad if you do not have a piercing(s)

Cry Baby (amplifier/instrument) - Push down if you are smaller than 5’9” || Pull up if you are 5’9” or are taller

As shown above, *6 strings and the Rest of the World* has been developed and changed in a multitude of ways from Mark 1. *6 strings and the Rest of the World* has been tailored more to the participants’ ease and accessibility. This can be seen through the absent pedals. In Mark 1, I found that having pedals simply created another variable that made the installation as a whole a bit overwhelming to the participants. However, a more viable and less overwhelming variable that was added was the motion sensors. The new setup in *6 strings and the Rest of the World* really enables the participants to work together, whilst clearly hearing the change of effects in the tuning. Although the taking away of the pedals might create less musical interest, I do believe overall it enhances the desired effect of the installation.

6 Strings and the Rest of the World

Thursday 2nd May 2019

2-4pm at Goldsmiths
Students'
Union main space

4-6pm at Goldsmiths
Students'
Union Cafe

6-8pm at Goldsmiths
RHB 279

6 Strings and the Rest of the World

Thursday 2nd May 2019

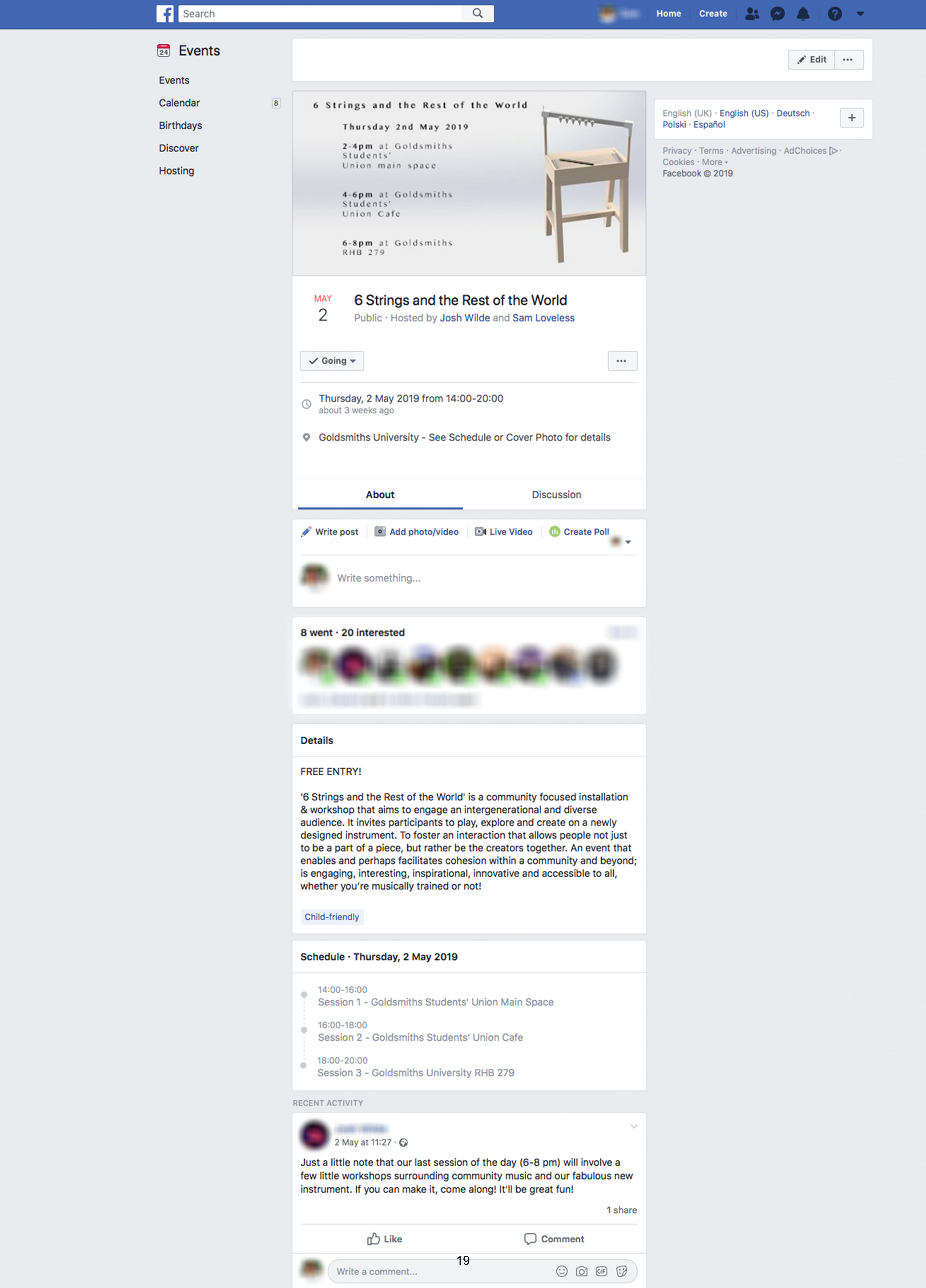
2-4pm at Goldsmiths Students' Union main space

4-6pm at Goldsmiths Students' Union Cafe

6-8pm at Goldsmiths RHB 279

A community led installtion and workshop using a newly invented instrument to come try!

6 Strings and the Rest of the World is a community focused installation & workshop that aims to engage an intergenerational and diverse audience. It invites participants to play, explore and create on a newly designed instrument. To foster an interaction that allows people not just to be a part of a piece, but rather be the creators together. An event that enables and perhaps facilitates cohesion within a community and beyond; is engaging, interesting, inspirational, innovative and accessible to all, whether you're musically trained or not!


Search
Home
Create
Events
Events
Calendar
8
Birthdays
Discover
Hosting
Edit
6 Strings and the Rest of the World
Thursday 2nd May 2019
2-4pm at Goldsmiths Students' Union main space
4-6pm at Goldsmiths Students' Union Cafe
6-8pm at Goldsmiths RHB 279
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MAY
2
6 Strings and the Rest of the World
Public · Hosted by Josh Wilde and Sam Loveless
Going
Thursday, 2 May 2019 from 14:00-20:00
about 3 weeks ago
Goldsmiths University - See Schedule or Cover Photo for details
About
Discussion
Write post
Add photo/video
Live Video
Create Poll
Write something...
8 went · 20 interested
Details
FREE ENTRY!
'6 Strings and the Rest of the World' is a community focused installation & workshop that aims to engage an intergenerational and diverse audience. It invites participants to play, explore and create on a newly designed instrument. To foster an interaction that allows people not just to be a part of a piece, but rather be the creators together. An event that enables and perhaps facilitates cohesion within a community and beyond; is engaging, interesting, inspirational, innovative and accessible to all, whether you're musically trained or not!
Child-friendly
Schedule · Thursday, 2 May 2019
14:00-16:00
Session 1 - Goldsmiths Students' Union Main Space
16:00-18:00
Session 2 - Goldsmiths Students' Union Cafe
18:00-20:00
Session 3 - Goldsmiths University RHB 279
RECENT ACTIVITY
2 May at 11:27 ·
Just a little note that our last session of the day (6-8 pm) will involve a few little workshops surrounding community music and our fabulous new instrument. If you can make it, come along! It'll be great fun!
1 share
Like
Comment
Write a comment...

Come inside and experience

6 Strings and the Rest of the World

A brand new interactive installation

6 Strings and the Rest of the World

A community focused interactive installation that aims to engage an intergenerational and diverse demographic audience.

This experience enables participants to not just be a part of a piece, but rather be co-creators together, enabling cohesion within a community and beyond.

The participants will for evermore be connected as a result of them being an integral part of the creation of the piece. It highlights how, together, we are able to achieve something great.

Within this installation, sound is used to highlight the juxtaposition of human attitudes towards each other and our surroundings, both loving and destructive.

Your interaction from today will be combined with the other displays from across the week resulting in a soundscape with an estimated 100-200 participants from all demographics and generations, creating something innovative and inspiring. I hope that by making this project into a soundscape, it will encourage people to think more about one another and our responsibility to towards mankind, as through this installation we are able to directly see the effects of working together.

Please freely interact with the instrument

If you would like a copy of the soundscape you have co-created, please leave your email address on the sheet as you leave.

6 Strings and the Rest of the World

Why not….

Try walking around the instrument

Try walking closer to the instrument

Try walking away from the instrument

Press a tap and see what happens

Try and play a duo with another participant

See what happy and sad sounds you can make together

Take a seat to watch and listen

See what cool sounds you can make with as many people as possible

See what cool tunes you can make

Try walking around the instrument

Try walking closer to the instrument

Try walking away from the instrument

Press a tap and see what happens

Try and play a duo with another participant

See what happy and sad sounds you can make together

Take a seat to watch and listen

See what cool sounds you can make with as many people as possible

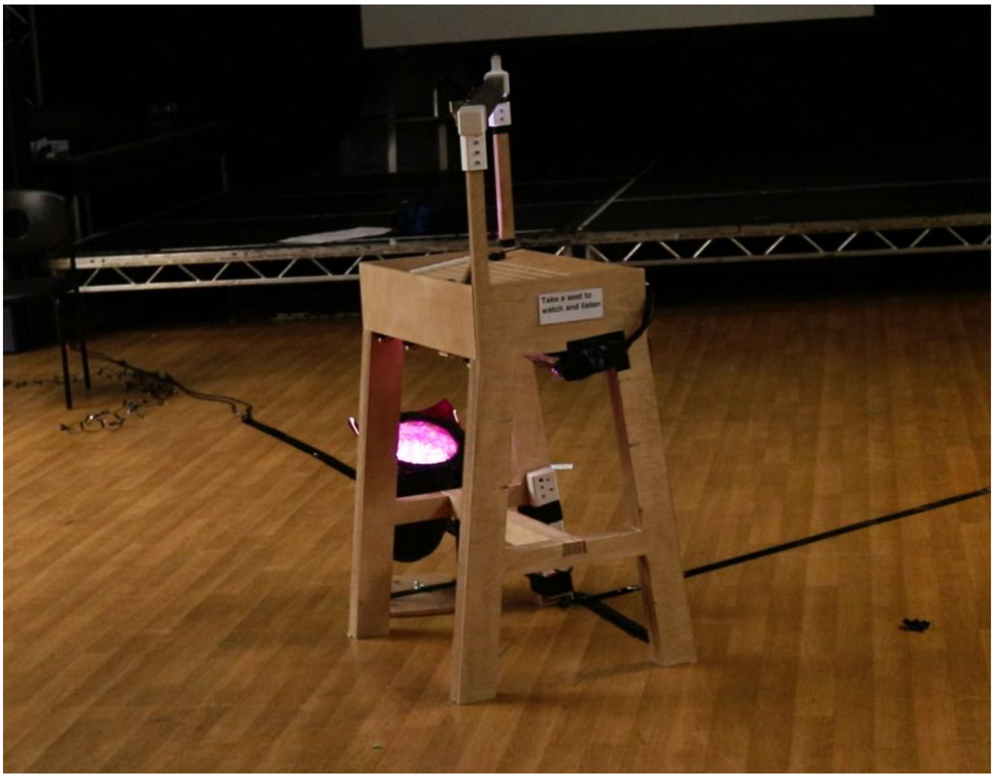
See what cool tunes you can make

6 Strings and the Rest of the World

For a copy of the soundscape you please leave your email address below:

Please see link to David Hope's website for a visual journey through our processes of making this instrument:

https://www.davidpriorhope.com/en/current-projects#/water/



Contents

// BRIEF

The assignment was to create an interaction. The interaction had to have a mechanical element, code and electronics. The machine needed to be elegant and well constructed.

// IDEA (SUMMARY)

The idea was to create a new kind of instrument. A stringed machine that could be actuated using water. The instrument would be unique in that each performance would be unreproducible – the instruments strings would tune to the audience's behaviour (their location around the machine). Although not clear to spectators, they play a part in the sound they hear.

// APPROACH

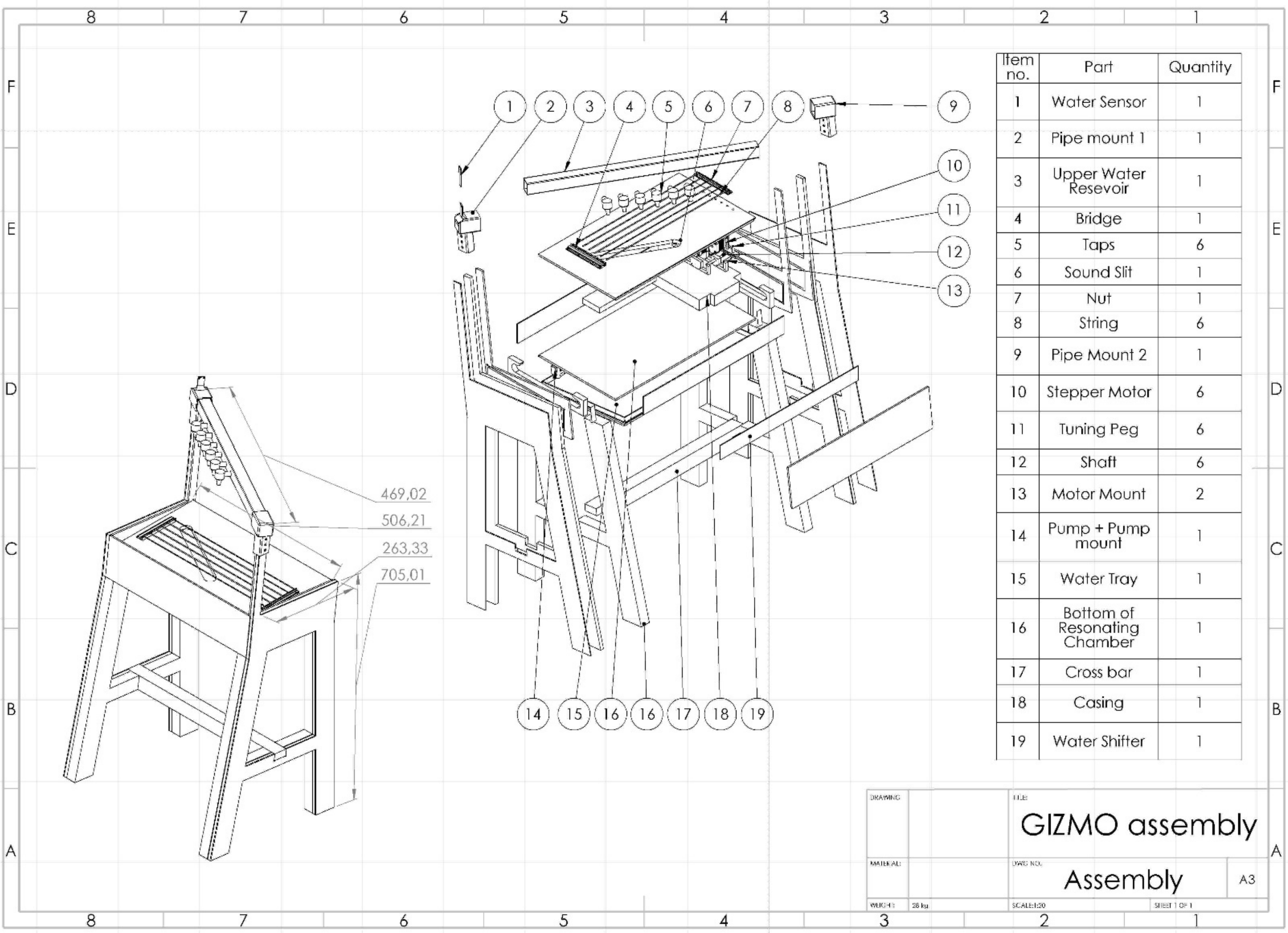
The Gizmo had to be ambitious, novel and beautiful. To begin, the aesthetic nature of the machine was explored. Once this was defined, the technical requirements were calculated through approximations (both practical and theoretical). The manufacture was done in parallel to the technical calculations and tests; a CAD model was used to accurately manufacture the parts for the machine.

The machine was then assembled and failed to function. This was due to a faulty wire connection. The electronics have since been soldered and redesigned. The machine (V2) is almost fully functioning.

The process was not as straight forwards as above - 10 TMC2100 Stepper motor drivers; 2 Arduino Megas; 1 Sharp IR Sensor Cable were destroyed in the R&D of the Gizmo.

The process has been documented here: https://www.davidpriorhope.com/en/current-projects#/elements/

// TECHNICAL TERMS & DRAWINGS



Item no.	Part	Quantity
1	Water Sensor	1
2	Pipe mount 1	1
3	Upper Water Resevoir	1
4	Bridge	1
5	Taps	6
6	Sound Slit	1
7	Nut	1
8	String	6
9	Pipe Mount 2	1
10	Stepper Motor	6
11	Tuning Peg	6
12	Shaft	6
13	Motor Mount	2
14	Pump + Pump mount	1
15	Water Tray	1
16	Bottom of Resonating Chamber	1
17	Cross bar	1
18	Casing	1
19	Water Shifter	1

FIGURE 1: Technical Drawing of Assembly

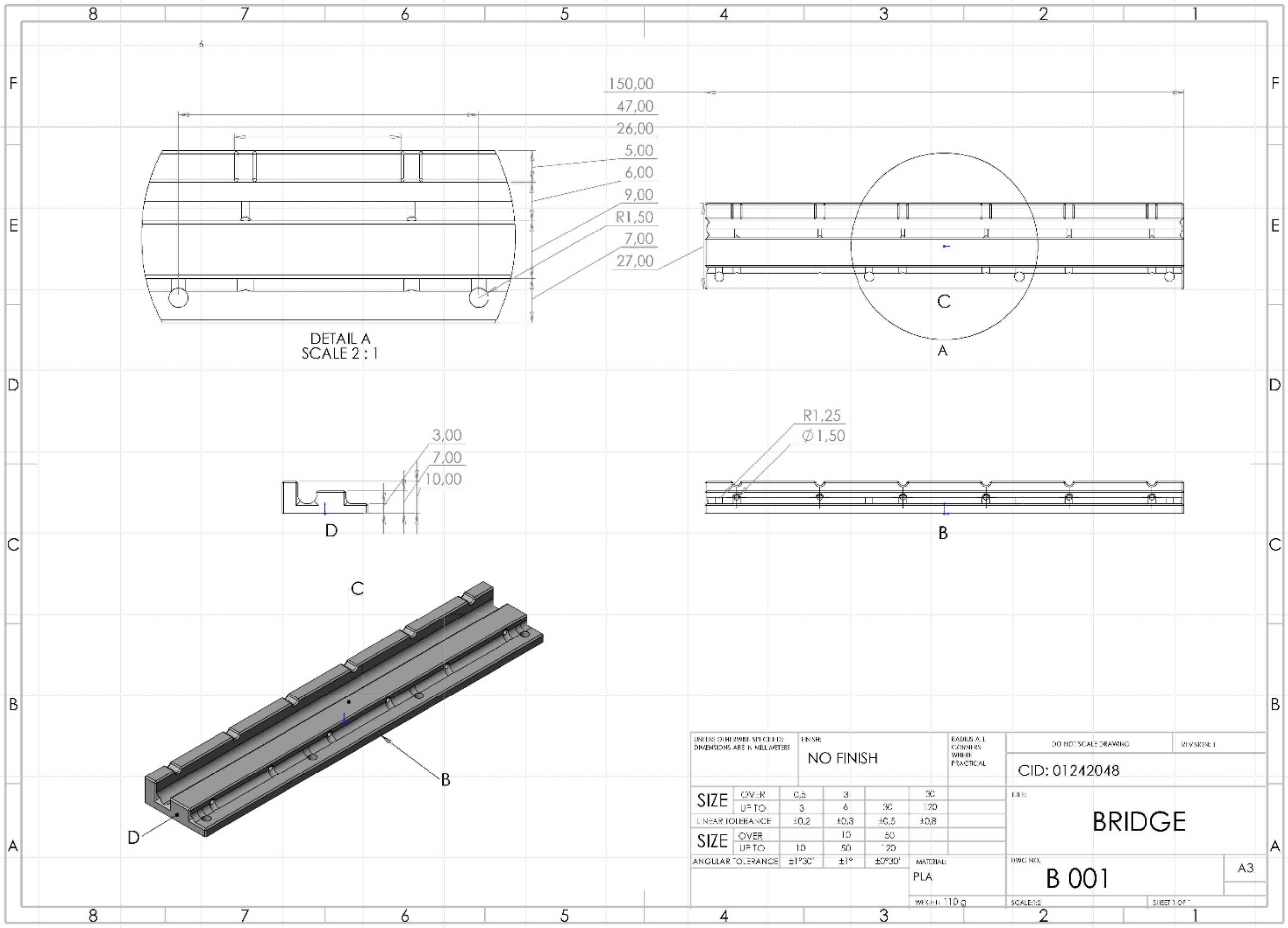


FIGURE 2: Technical Drawing of Bridge

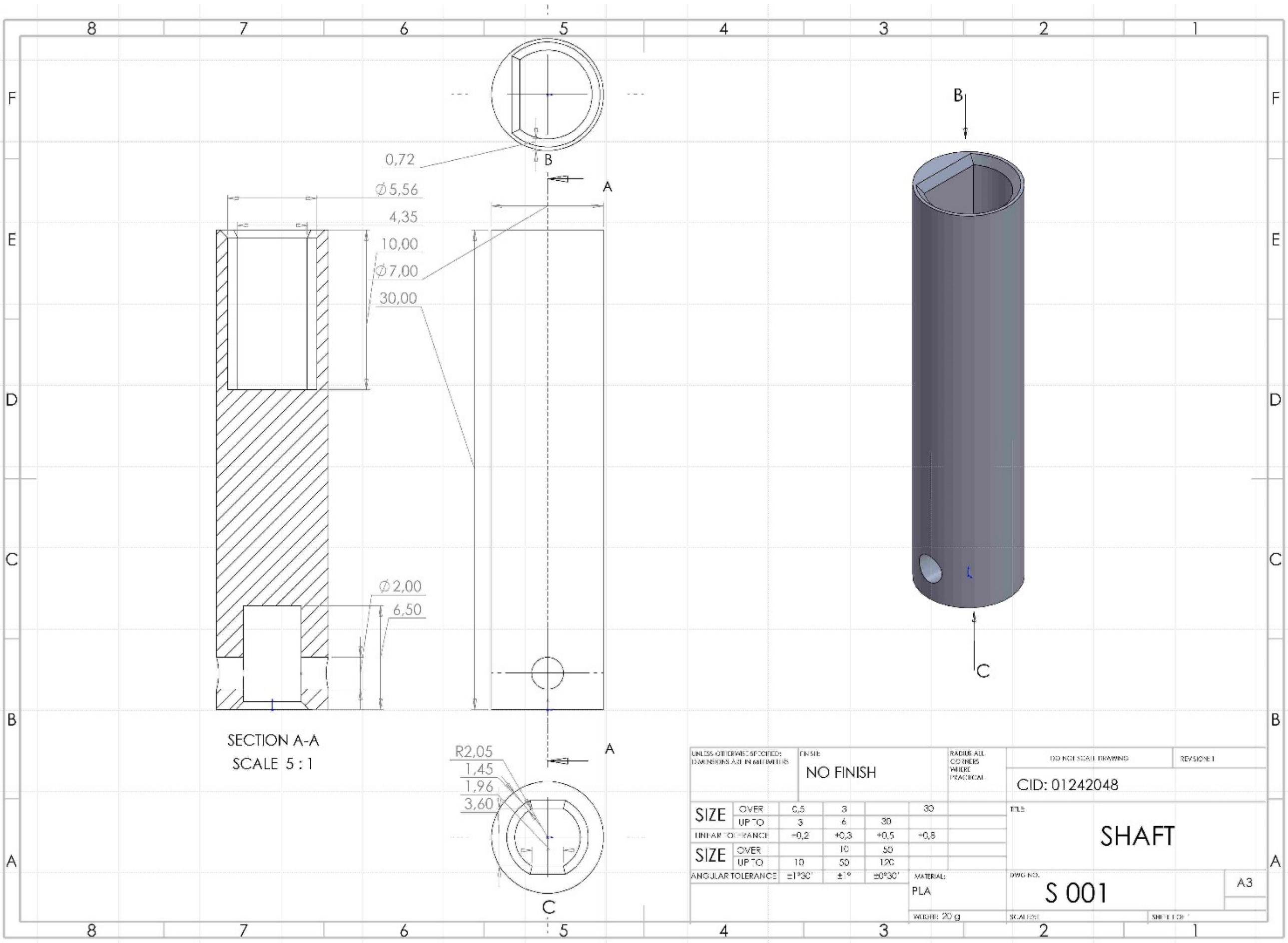


FIGURE 3: Technical Drawing of Shaft

// AESTHETIC DEVELOPMENT

A series of 1:5 cardboard prototypes were created. These served also to explore ergonomics. The form was visually and geometrically simplified and refined – the form selected is both ergonomic, minimal and neatly accommodates for mechanisms and electronics. Throughout the process I sketched potential ideas and forms.

FIGURE 4: prototype 1 (1:1) & improvements

FIGURE 5: prototype 2 (1:5) & improvements

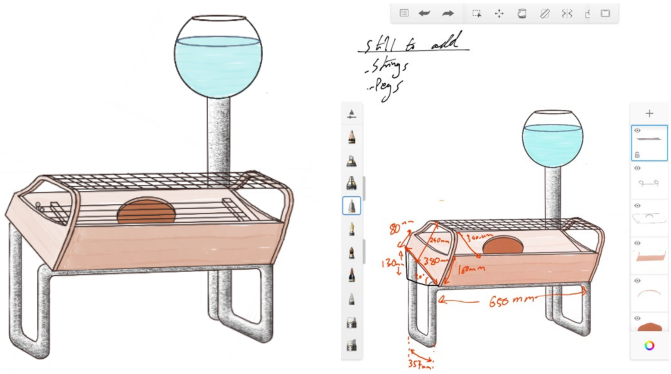


FIGURE 6: sketch 1 & dimensions

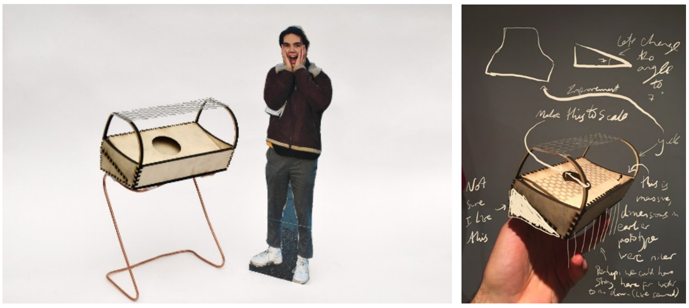


FIGURE 7: prototype 3 (1:5) & improvements

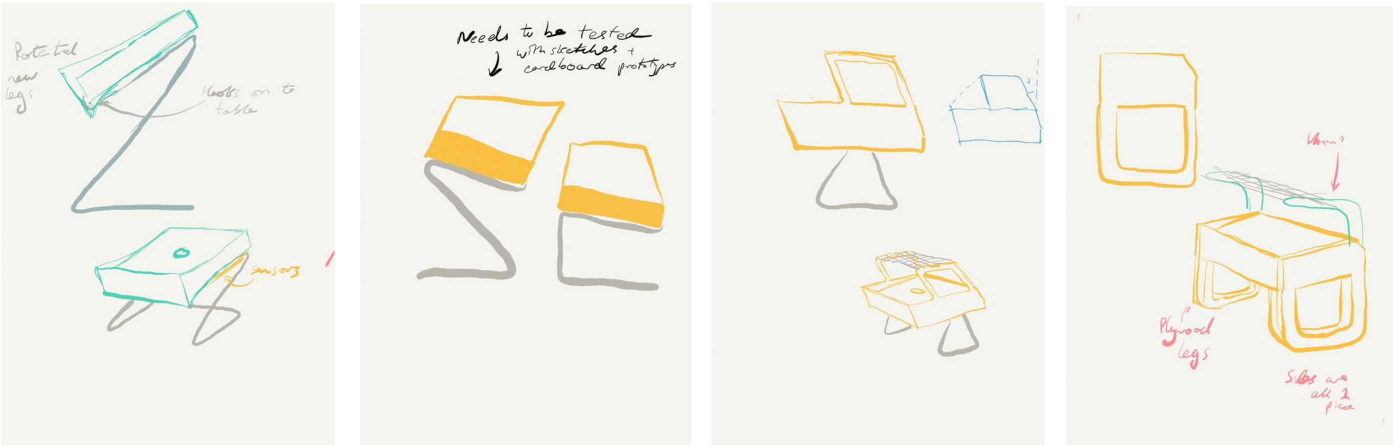


FIGURE 8: sketches between prototype 3 & 4

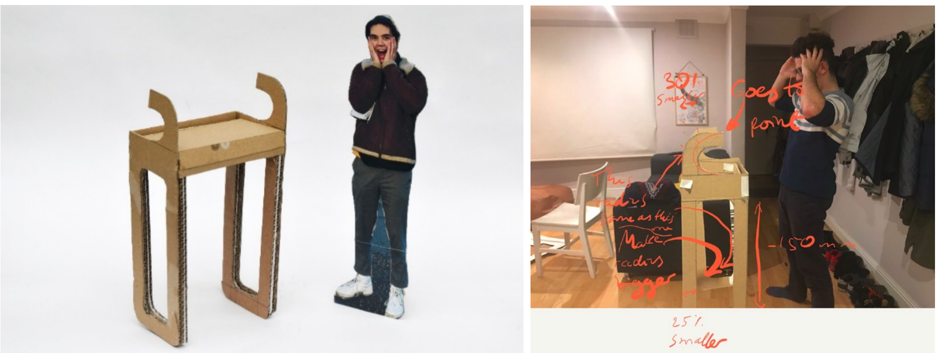


FIGURE 9: prototype 4 (1:5) & improvements

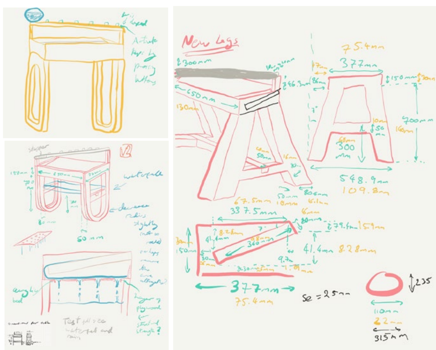


FIGURE 10: ideas and sketches between prototype 4 & 5

I was trying to simplify my design. I felt there were unnecessary curves - I wanted to give the design a sense of continuity and simplicity. A lot of my aesthetic design was guided by calculations – I had a rough idea of dimensions of components and wanted the volume of the resonating chamber to be the same of that of a normal guitar.

FIGURE 11: Final 1:5 prototype

FIGURE 12: 1:1 Cardboard Prototype

This was the prototype I was most happy with. I feel it accommodates all the components in a spacious and simple way. The form is simple and feels natural. The cross bar at the bottom balances the instrument visually and offers structural support. To validate I was satisfied with the design I created a 1:1 cardboard model (Figure 12).

FIGURE 13: Treated Plywood

I am obsessed with plywood. I love the layers – for their unique appearance but also for the high performance of the material. My structure is made from plywood cut on a CNC router. When designing the CAD for my files, it was important to consider the radius of the endmill. I opted for grooves to slot the parts into as opposed to finger joints. I think these joints look good and are strong. The sheets have been glued using wood glue (PVA) and sealed from water using watertight silicone.

I treated the wood using beeswax, this gave a darker finish and made the surface hydrophobic.

The upper water reservoir was made from stainless steel square pipe (40mm x 40mm) cut on a bandsaw.

// TECHNICAL DIMENSIONS

Deciding dimensions was challenging and hectic. To make the decisions easier to understand I have described my process linearly.

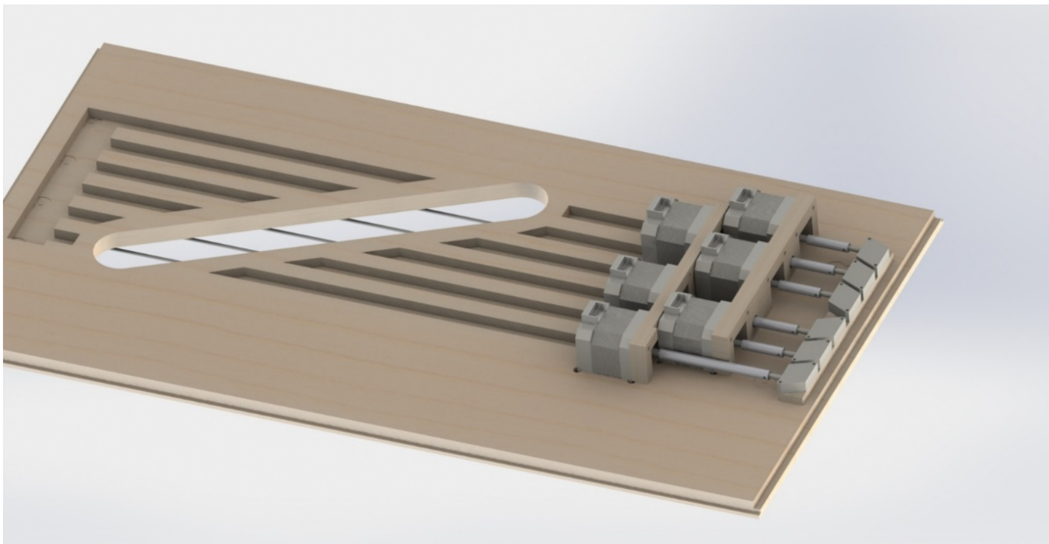


FIGURE 14: Top Face of instrument (upside-down)

Figure 14 shows the top face of my instrument as cut on the CNC router. The motors sit inside the top face. This acts to restrain the motors in the horizontal plane. The pocket also serves to allow the axis of the stepper motor shaft to be coincident with the axis of the shaft of the tuning peg. The pockets underneath each string make the material thinner thus improving the transfer of sound into the resonating chamber. The sound slit is parallel to the upper water reservoir this is so that water droplets would not contact the top face as this would overpower the soft sound of the strings being struck by the water. The strings and sound slit are off centred; this is due to the taps (which protrude from the upper water reservoir) – if the strings were centred then the sound slit and nut would be overlapping.

As can be seen from Figure 14 each motor shaft needs to be approximately 50 mm apart due to the dimensions of the motors. The separation of the motors was the same as the separation of the strings (Se). This influenced the design of my custom nut and bridge.

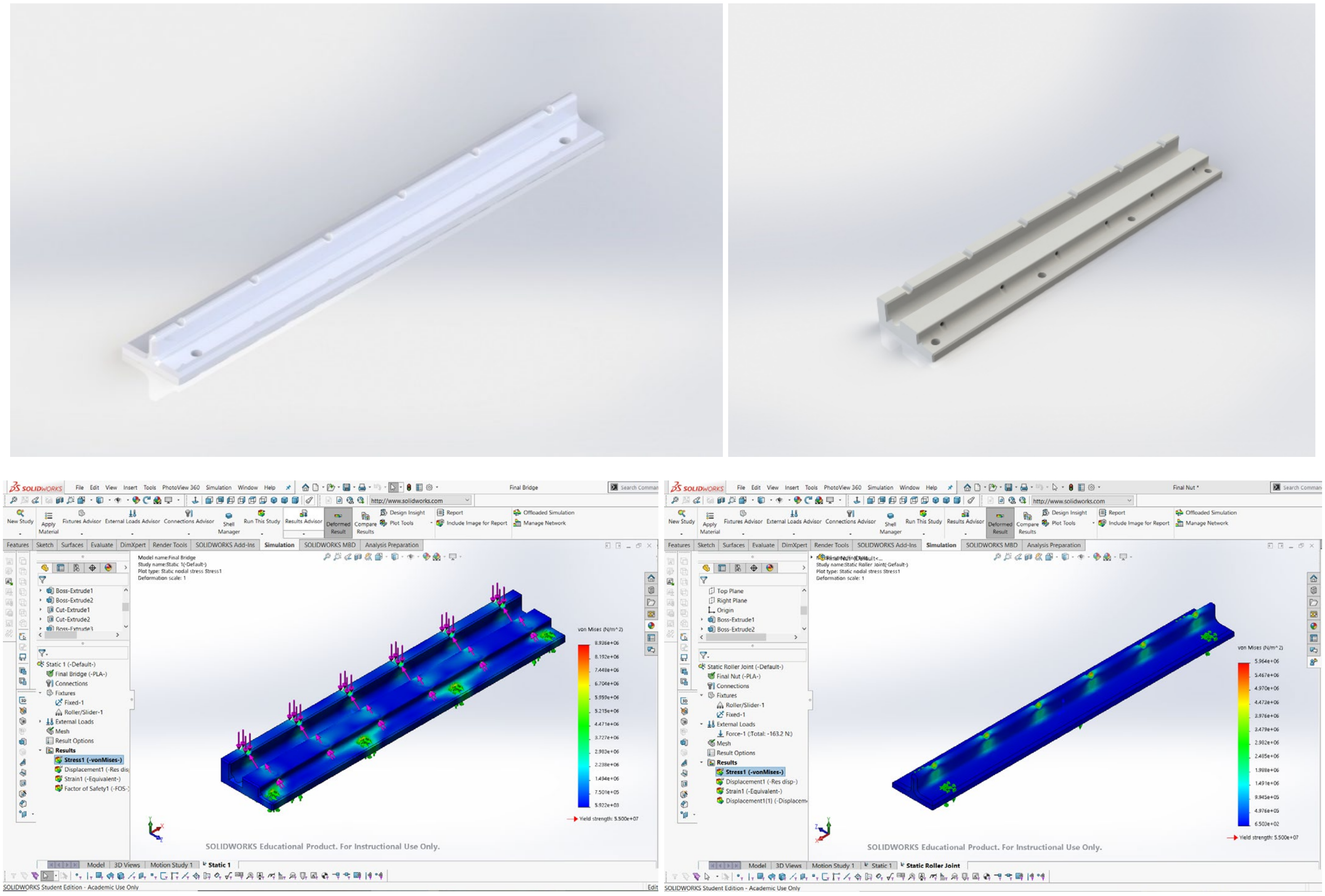


FIGURE 15: Custom Nut and Bridge & FEA analysis

These parts have been 3D printed on a Prusa i3 MK2.5 (due to the high accuracy of the printer: 50 um layer height) with 100% infill PLA - this is so that the vibrations transfer into the wood better. The parts have also been designed to be easy to 3D print (lack of overhangs, fillets, etc...). The final nut and bridge come after some iteration. Figure 15 also shows FEA analysis on the bridge and nut – I have assumed the maximum tension per string to be 80 N and have assumed the points where the string will rub due to tuning/untuning to be roller joints. The bridge and nut had a safety factor of 6.2 and 9.3 respectively.

Aligning the taps with the strings was initially done through calculations.

Using similar triangles:

$$Sxy = Se \times \frac{\sqrt{630^2 + 347^2}}{347}$$

Se = 26 mm

Sxy = 53.89 mm

Using trigonometry:

$$Sabz = \frac{Sxy}{\cos(3.68)}$$

Sabz = 54.0 mm

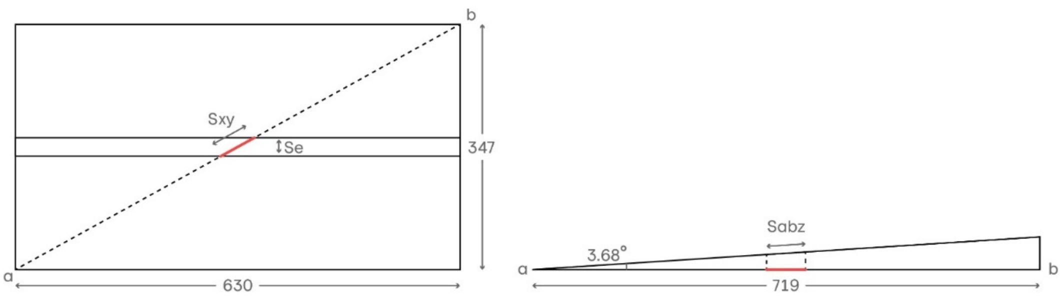


FIGURE 16: Alignment along XY plane and abZ plane respectively

This measurement was slightly inaccurate due to the slant of the strings (7 degrees to the XY plane). Due to the number of inclinations in different planes and the accuracy required, I chose to align the taps using reference geometries in my CAD model; the actual value of Sabz = 53.6 mm. To get the accuracy required a metal milling machine accurate to 0.01 mm was used to create the perforations in the square pipe.

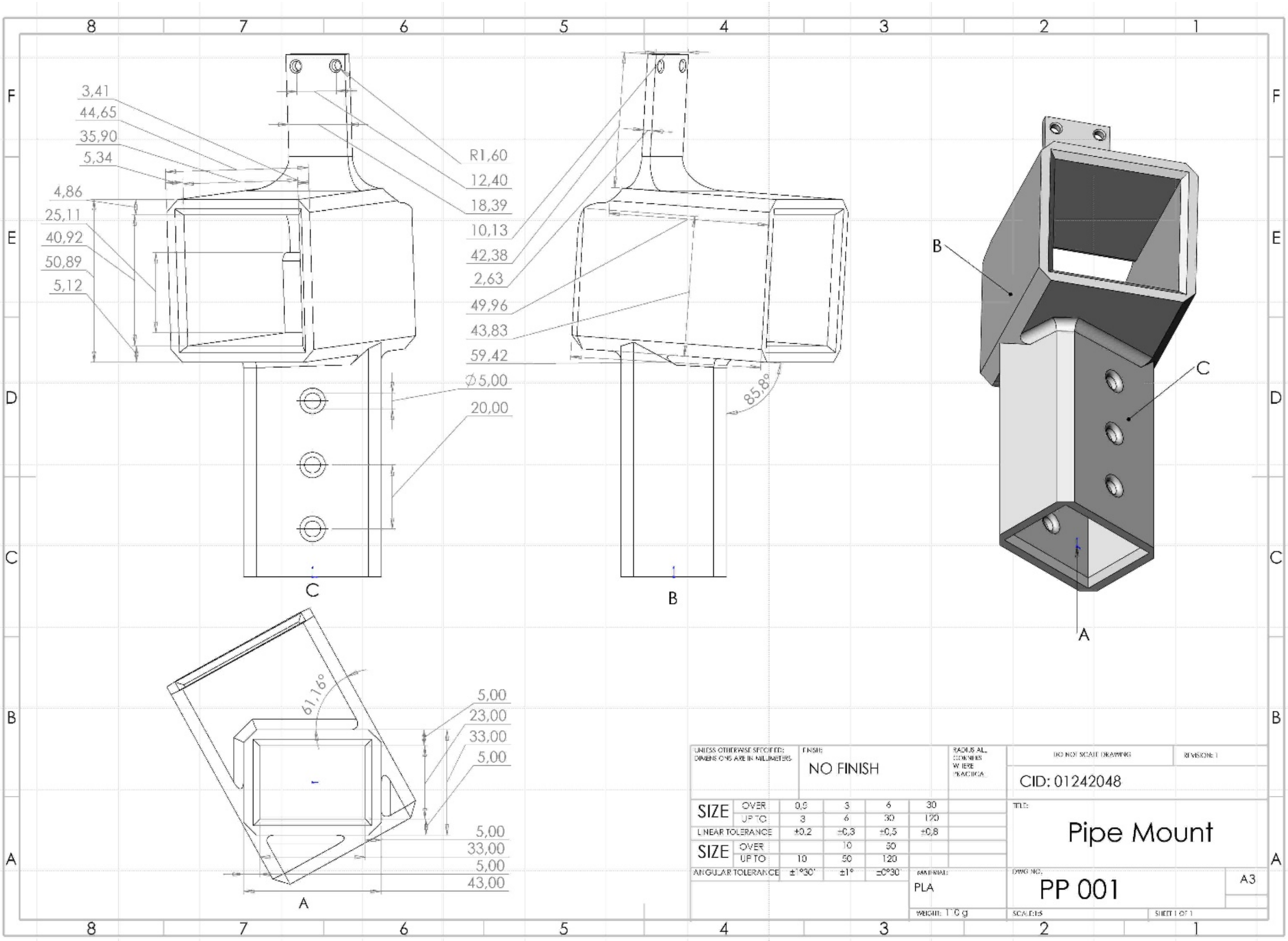


FIGURE 17: Pipe mount

2 pipe mounts were printed on the Prusa i3 MK2.5. Both pipe mounts were different since the upper water reservoir was angled to allow water to flow to all taps whilst preventing overflow from the open end. The pipe mount on top was printed with an integrated water sensor mount – this dropped the water sensor to the correct height into the upper water reservoir to allow a flow of water to the highest tap without overflowing. The pipe mounts were secured to the structure using nuts and bolts and secured to the upper water reservoir using watertight silicone sealant.

// SYSTEM 1 - INPUT: DISTANCE; OUTPUT: TUNE

To change the pitch of each string, stepper motors were selected. Stepper motors are accurate (to 1.8°), have high torque and can perform unlimited 360° rotations.

Stepper motors are generally noisy; it was important for my motors to be as quiet as possible since the motors are integrated into the resonating chamber (where sound is amplified). To silence the motors, I used Trimanic Silent Stepper Drivers (TMC2100). These stepper drivers micro-step the motor, splitting each step into an extra 16 steps. This decreases the speed of the stepper motor, however for my cause that was unimportant. The drivers Vref (reference voltage) had to be adjusted so that they would supply the correct current to the motor (too much would cause heating). The Vref was measured by placing two probes of a multi-meter between the Enable and Ground Pin on the stepper motor driver.

$$Vref = Irms \times 2.5/1.77$$

The reference voltage could then be adjusted by turning the potentiometer on the driver.

To estimate the torque required from my stepper motor I did some calculations using 2 methods:

Method 1:

Approx. torque from hand on tuning peg= ***3 Nm***

Diameter of tuning peg (handle) = 17.5 mm

Energy = Force x distance

Energy for 1 turn = $\frac{3}{0.5 \times 17.5 \times 10^{-3}} \times 17.5\pi \times 10^{-3}$

= 6π J

For a rotation that would last 3 s, 2π *W would be required. Using a safety factor of 4 (accounting for inefficiencies in the motor, etc…) the actual power requirement would be approximately* ***25.2 W.***

Method 2:

Max tension in guitar string = 80 N

Radius of tuning peg (string) = 3 mm

Torque applied by string = 80 x 0.003 = 0.24 Nm

A worm gear in the tuning peg is used to reduce the input torque. These have a ratio of approximately 1:20.

Input torque = 0.24/20 = ***0.012 Nm***

Energy for one rotation = Torque x 2 π *= 0.024* π *J*

Time for one rotation = 3 s

Power = 0.025 W

Actual power (with safety factor) = ***0.1 W***

Given that both results produced completely different results I chose to conduct a practical investigation.

FIGURE 18: Getting hands-on with torque

In the crude setup above, a friend and I investigated the reaction force of the tuning peg for the A string (has the largest tension) just before moving. The scales gives a mass, which can be converted to weight by multiplying by 9.81.

Radius of tuning peg handle = 10 mm

Mass just before movement ≈ 3 kg

Torque = 3 x 9.81 x 0.01

Torque = **0.29 Nm**

Energy = Torque x *2* π *= 1.85 J*

Time allowed for one rotation = 8 s

Power = 0.23 W

Power with safety factor = **0.93 W**

I chose to use the values from my experiment since they were calculated from real data.

FIGURE 19: V1 waterproofing of internal electronics in resonating chamber

The selected motor was a 12 V Nema 17 Stepper Motor with 40 Ncm of torque and maximum operating current at 0.4 A. This means the motor had a power of approximately 12 x 0.4 = 4.8 W (P=VI), achieving a rotation in about 1.6 s with the load measured above. I chose to use a 12 V stepper motor as this is not only cheaper than 5 V motors with similar torque but also 12 V uses a smaller current for a given power. Since the current is smaller in a 12 V motor this reduces the heating effect in the circuit and motor. As I would be using 6 of these motors (one for each string) and would need to protect these motors from water using a vacuum formed HIPS enclosure, the motors had to be cool (to avoid deforming the enclosure).

To confirm the Nema 17 and TMC 2100s were adequate I created a test rig, the width of the wood was a sixth the width of the intended width of the instrument, this was to observe the deforming effect of one string.

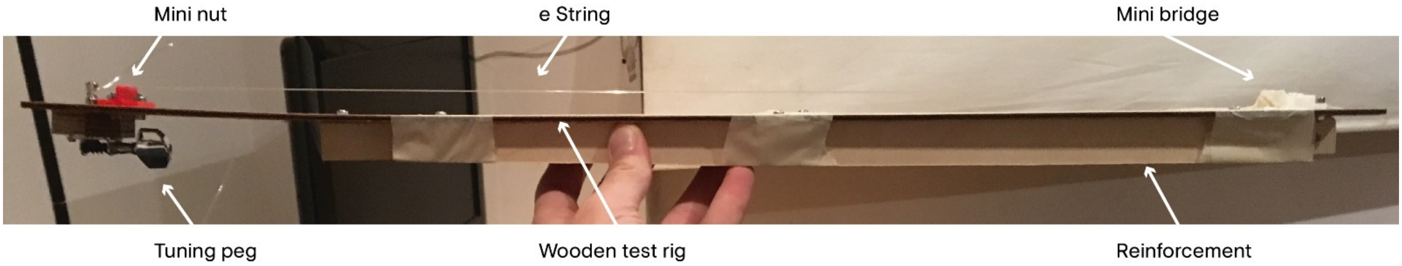


FIGURE 20: Test Rig (no motor attached)

I connected my Nema 17 motor directly to the tuning peg using a custom shaft printed in ABS on a FDM 3D printer. The test indeed confirmed the motor could tighten/loosen the string and was silent. I learnt from my experiment that 3 mm plywood would be unable to withstand the bending moment.

I chose to use a shaft as opposed to gears due to the space limitations inside the resonating chamber. Although in my test rig the shaft performed well, a shaft plastically deformed in a subsequent test – I decided to print my shaft on the MarkForged MK2, this prints in a Carbon-nylon composite. This new material has a higher fatigue strength (being more durable) and higher Young's Modulus. Simulations in Figure 20 suggest the part will be capable of withstanding over 1100 cycles (loaded forwards and backwards) before failure. Although this is suitable for a few exhibitions, upon failure a milled steel shaft with a pin to secure axially would be a better solution.

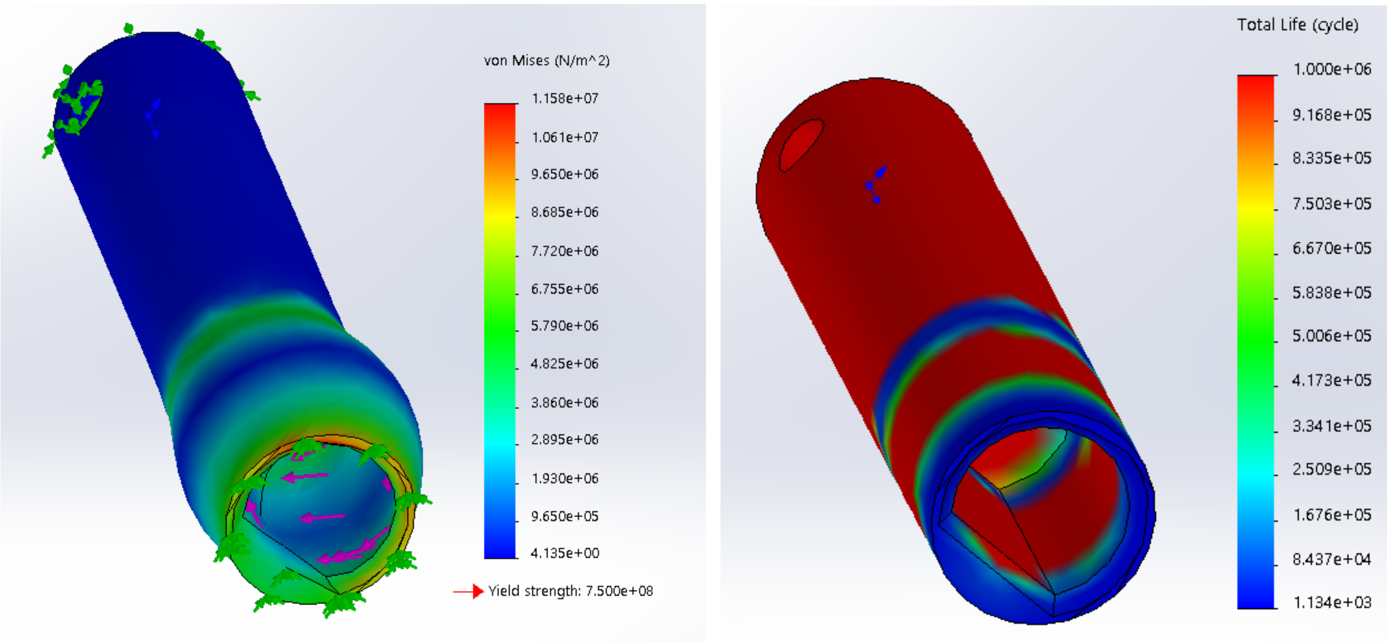


FIGURE 21: FEA analysis of shaft

To detect proximity of performers/audience SHARP IR sensors have been chosen. This is as they can detect objects up to 800 mm away. As the tuning varies based on the sensors values, they were connected to the analogue input pins. I created a variable "max_dist", beyond this value any readings do not tighten the strings.

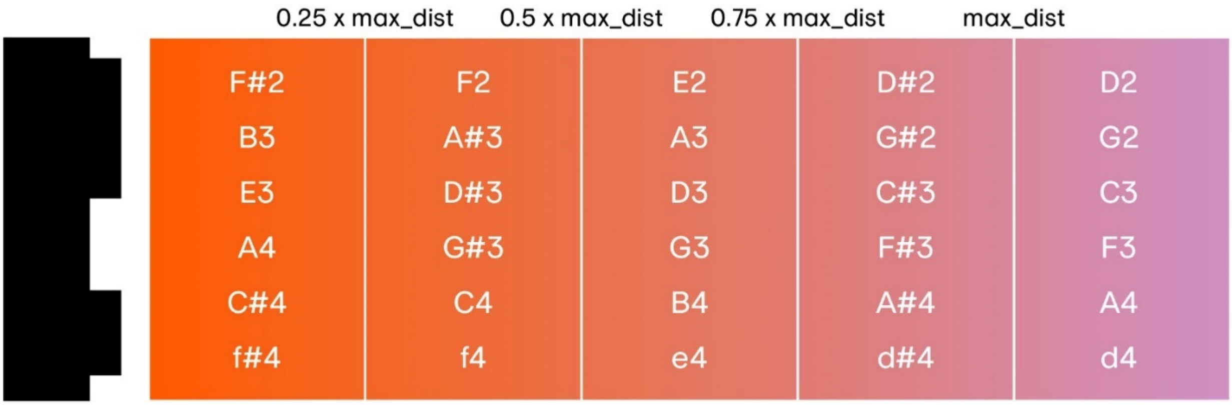


FIGURE 22: Note v Distance

Figure 22 maps the target tune of each string in each band. For example, if a sensor detects a distance between band 0.75 x max_dist and max_dist the strings will tighten/loosen to a target tuning of D# G# C# F# A# d#.

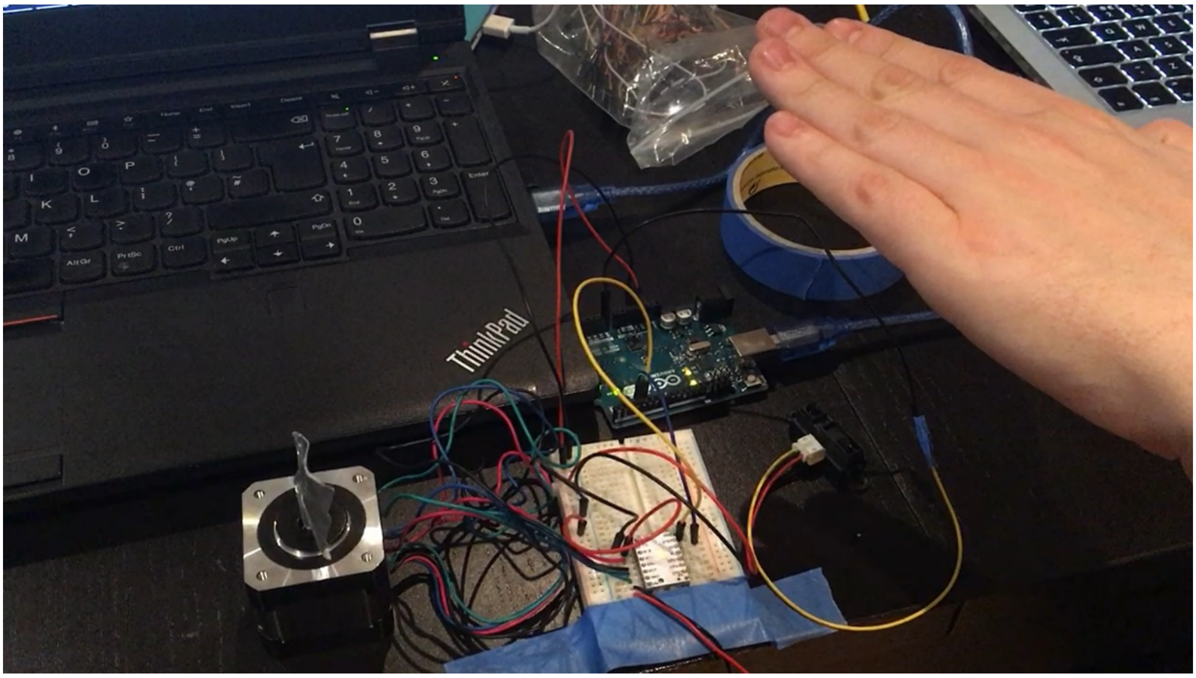


FIGURE 23: Turning stepper motor by waving

```
//TOP e string
int e_DtoDsharp = 2956;    /
int e_Dsharptoe = 6027;    /
int e_etoF = 3881;    //spec
int e_FtoFsharp = 3511;    /
int counte = 0;

//B STRING
int B_AtoAsharp = 2215;
int B_AsharptoB = 3048;
int B_BtoC = 4533;
int B_CtoCsharp = 8547;
int countB = 0;

//G STRING
int G_FtoFsharp = 2857;
int G_FsharptoG = 1321;
int G_GtoGsharp = 4343;
int G_GsharptoA = 3263;
int countG = 0;

//D STRING
int D_CtoCsharp = 3692;
int D_CsharptoD = 4295;
int D_DtoDsharp = 5826;
int D_DsharptoE = 5658;
int countD = 0;


//A STRING
int A_GtoGsharp = 5264;
int A_GsharptoA = 6190;
int A_AtoAsharp = 6834;
int A_AsharptoB = 6904;
int countA = 0;

//E STRING
int E_DtoDsharp = 1437;
int E_DsharptoE = 2839;
int E_EtoF = 1751;
int E_FtoFsharp = 2173;
int countE = 0;
```

FIGURE 24: Steps for tuning

Although the standard guitar tuning is EADGBe, I have tuned each string a tone lower (DGCFAd) this is to reduce the average tension in the strings thus increasing the lifetime of the strings.

To tune each string to a different note I measured the number of steps required by the stepper motor to get from one note to another (data on right).

$$Step, s \ \propto Tuning\ peg\ angle, \theta$$
$$\theta \propto Tension, T$$
$$T \propto Note, n$$
$$\therefore s \propto n$$

The data was collected by using a tuning app on my iPhone and counting the number of steps by printing to the serial.

// SYSTEM 2 - INPUT: WATER LEVEL; OUPUT: PUMP ON/OFF

To reload water into the upper water reservoir a quiet (to not be picked up by the contact mic) 5V pump and water sensor were used. As discussed above the water sensor was attached to a pipe mount to drop the sensor to the appropriate height.

The pump selected had a flow rate of 100 L/h and the rubber tube had an inner diameter of 5 mm.

$$Power\ of\ Motor, Pm = 5V \times 0.2A = 1W$$
$$Flow\ Rate, Q = 100Lh^{-1} = 2.78 \times 10^{-5}m^3s^{-1}$$
$$Inner\ diamerter\ of\ rubber\ tube, d = 5mm$$
$$fluid\ velocity, v = \frac{Q}{A}$$
$$v = \frac{2.78 \times 10^{-5}}{\left(\frac{\pi \times (5 \times 10^{-3})^2}{4}\right)}$$
$$v = 1.42\ ms^{-1}$$
$$Reynold's\ Number, Re = \frac{density, \rho\ \times v\ \times d}{viscosity, \mu}$$
$$Re = \frac{997 \times 1.42 \times 0.005}{0.00089}$$

$$Re = 7953.6 \ \therefore turbulent\ flow$$
$$Roughness\ of\ rubber\ tube, \varepsilon = 0.0016\ mm$$
$$\frac{\varepsilon}{d} = \frac{0.0016}{5} = 3.2 \times 10^{-4}$$
$$Using\ Moody\ Chart: friction\ factor, f = 0.035$$
$$head\ loss, \Delta h = f \times \frac{length, l}{d} \times \frac{v^2}{2g}$$
$$\Delta h = 0.035 \times \frac{0.5}{0.005} \times \frac{1.42^2}{2 \times 9.81}$$
$$\Delta h = 0.36\ m$$
$$Required\ hydraulic\ power, Ph = \frac{Q \times \rho \times 9.81 \times (\Delta h + l)}{3.6 \times 10^3}$$
$$Ph = \frac{2.78 \times 10^{-5} \times 3600 \times 997 \times 9.81 \times (0.36 + 0.5)}{3.6 \times 10^3}$$
$$Ph = 0.234\ W$$
$$with\ a\ safety\ factor\ of\ 4, required\ pump\ power, PM = 4 \times Ph = 0.94\ W$$
$$\therefore ordered\ pump\ can\ raise\ fluid\ desired\ the\ height$$

The above value was verified by conducting a simple test gradually lifting a hose and measuring the height at which the flow stopped. The experiments results suggested the calculations gave reliable results.

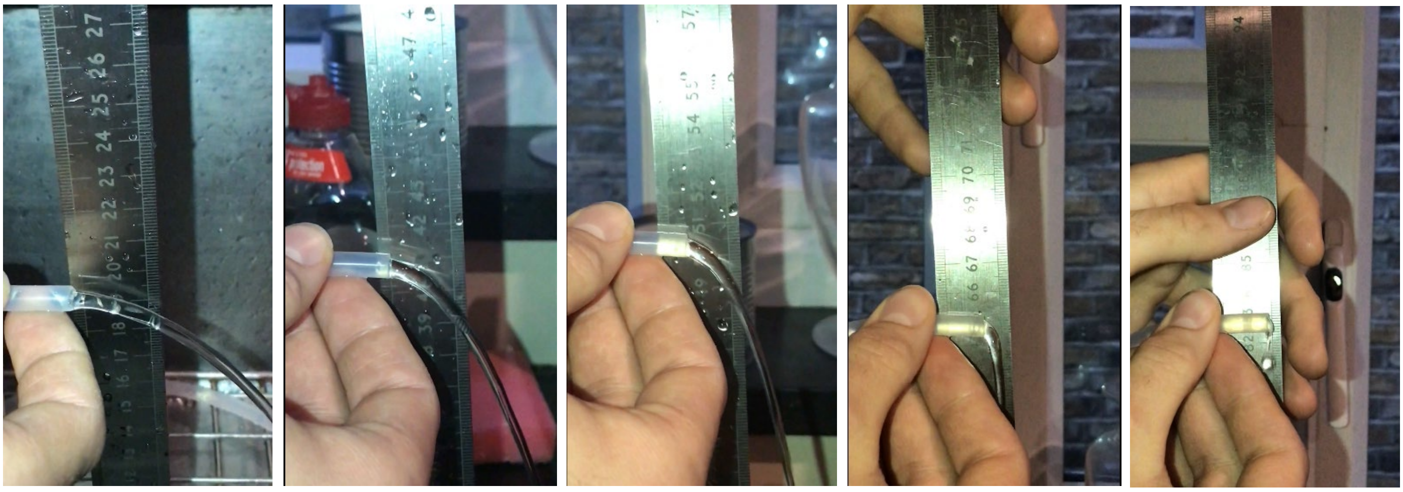


FIGURE 25: Practical test to observe effects of head loss

It was important that the flow rate from each tap would be less than a sixth of the flow rate of the pump (this is in order to assure a state of equilibrium in the upper reservoir – prevents undersupply). I struggled to find a method of calculating the flow rate through the taps so I decided to conduct a practical investigation. I filled a water bottle and weighed it; I then pushed the tap onto the opening of the bottle and released water through the tap. I recorded this and kept a stopwatch in the background. Once the supply of water reduced I stopped the flow. I then weighed the bottle at the end of the experiment. The change in mass of the bottle was proportional to the change in

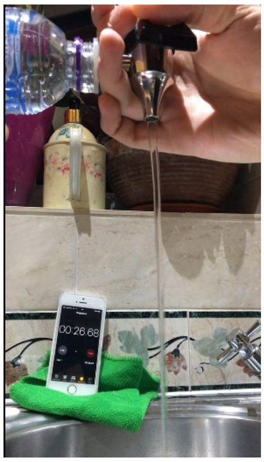


FIGURE 26: Flow

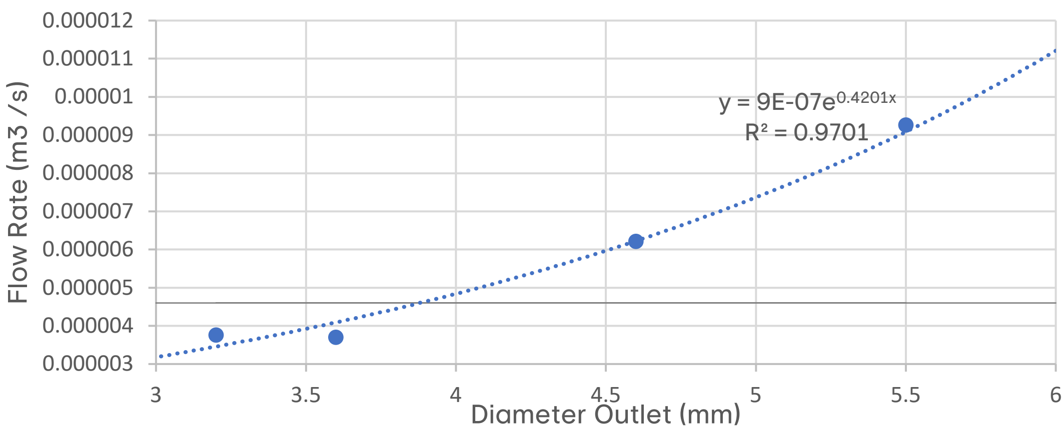


FIGURE 27: Flow rate through tap v diameter

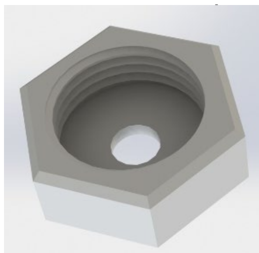


FIGURE 28: Flow limiting nut

volume. Using this and the time elapsed, I could calculate the flow rate. I found the flow rate from the taps was too much – I designed a screw attachment to print and screw into the end of the tap (figure 26); I found that a much simpler solution was to laser cut some cylinders from acrylic and press fit them into the ends of the tap (figure 27). Varying the internal diameter changed the flow rate from the taps (figure 25).

As the data in figure 25 suggests, an inner diameter of less than about 3.8 mm was appropriate (the solid line indicates one sixth of the pumps flow rate).

I tested the pump and water sensor mechanism. Initially I powered the pump through an Arduino digital pin – in a test with all my electronics the Arduino Mega (mega was chosen as an UNO did not have enough pins) caught fire. I avoided this problem by using a transistor, diode and supplying power through a 5V supply (external to the Arduino).

FIGURE 29: Laser cut flow limiter

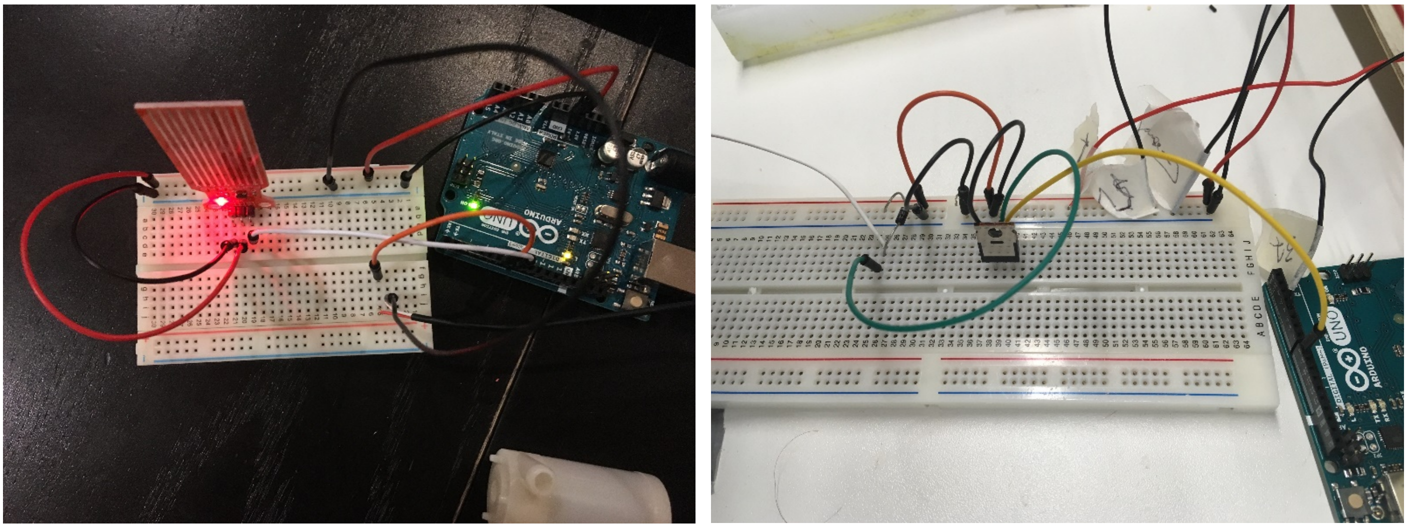


FIGURE 30: First test combining water sensor with pump (left) and inclusion of MOSFET (right)

// POWER AUDIT

TABLE 1: Power Audit

NO.	COMPONENT	OPERATING VOLTAGE (V)	MAXIMUM CURRENT DRAW (A)	MAXIMUM POWER DRAW (W)
1	Arduino Mega	7-12	1	12
6	Stepper Motors	12	0.4	28.8
6	SHARP IR Sensors	5	0.05	1.5
1	DC Pump	5	0.2	1
1	Water Sensor	5	0.02	0.1
TOTAL				**43.4**

To output the required power, I selected a 12V 5A power supply (max power = 60W).

// MANUAL TUNING

At the end of use the instrument will have a completely different tuning than the given tuning. At the end of use, each string will need to be manually tuned to the correct pitch. To do this I have included a “Manual Tuning Mode” this can be accessed (in V2) through flicking the integrated toggle switch protruding from the electronics box. 3 buttons allow the strings to be tuned, 2 push buttons are used to increase/decrease the pitch, whilst another button acts to switch between strings.

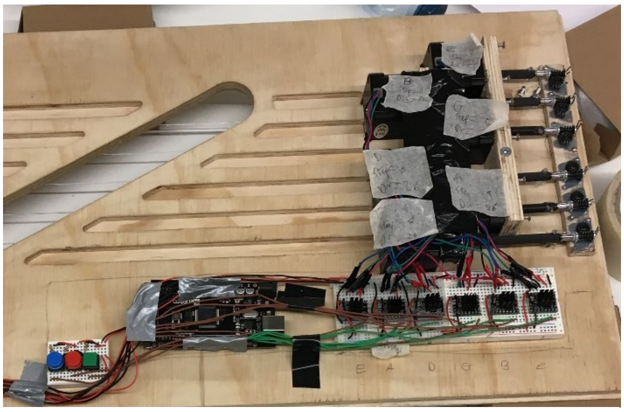


FIGURE 31: Manual tuning testing (buttons left)

// ASSEMBLY 1

Following the first assembly of the instrument it failed to work for several reasons.

TABLE 2: Faults and Fixes

FAULT	CAUSE	DIAGNOSIS
Water droplets failed to consistently land on guitar strings	Meniscus effect	Cotton string attached to nozzle to accurately direct water
System fluctuating between ON/OFF	SHARP IR Sensors drawing bursts of power in phase superior to the maximum power output of the Arduino. Initial power supply used was 12V 3A (too little)	Use a larger power supply . Do not power the IR sensors directly from the Arduino but rather a 12V to 5V converter
Water droplets very noisy when landing on wood	Large drop distance; no padding. Sound echoing in resonating chamber	Sponge to absorb impact of water droplets
Cables everywhere	Poor cable management	Electronics box designed to fit major electronic components & connections
Required disassembly after each use for manual tuning	Poor design	Flick switch integrated into electronics box. Flick to change code running on machine from performance to manual tuning and vice-versa

FIGURE 32: V1 Assembly

I was satisfied with the finish of my Gizmo, the quality could have improved with better cable management. All the parts fitted well.

// V2

V2 is still a work in progress. I have done a number of changes which are discussed below.

The cotton string (Figure 33) in the tap effectively removed the unwanted meniscus effect.

Figure 34 shows a test verifying the switch can be used to switch modes states. This simplifies the process of resetting the string tunes following performances.

The new (Figure 35) wiring reduces the power draw from the Arduino, making the system more stable. I have also powered the Arduino through with 9V instead of 12V being a safer voltage (recommended input of 7-12V).

The revised wiring works without fluctuating between on/off. The inclusion of a flick switch also allowed for ease of switching between modes. As can be seen in Figure 36, the stepper motor drivers are mounted on header pins and the Arduino Mega is fixed to a ProtoShield, this allows them to be easily replaced should they choose to fry.

I have designed my second version of my Gizmo having learnt from the flaws of the first attempt, with continued testing and refinement the Gizmo will be operational.

FIGURE 33: Before and after addition of cotton string

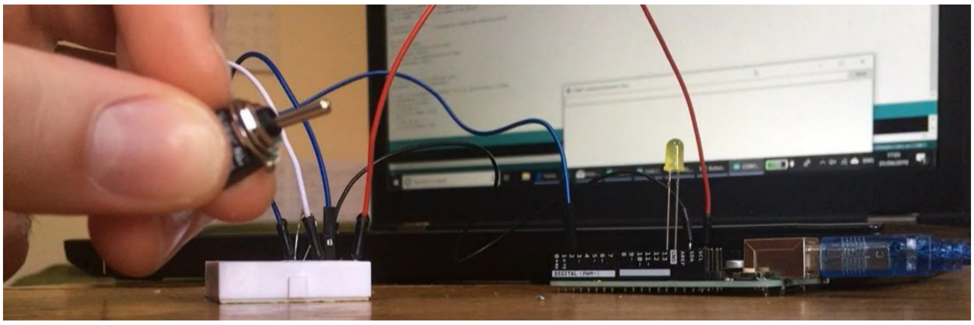


FIGURE 34: Testing flick switch

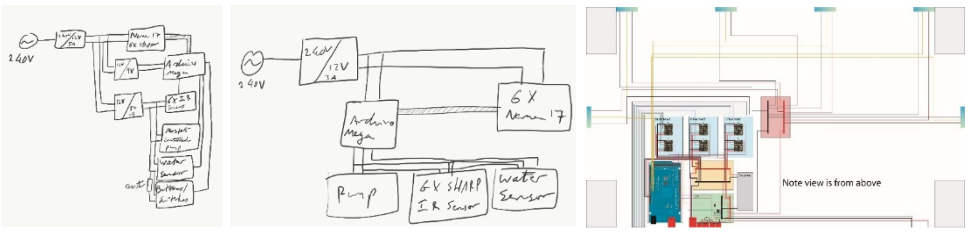


FIGURE 35: Block diagram before (left) and after (middle); wire schematic

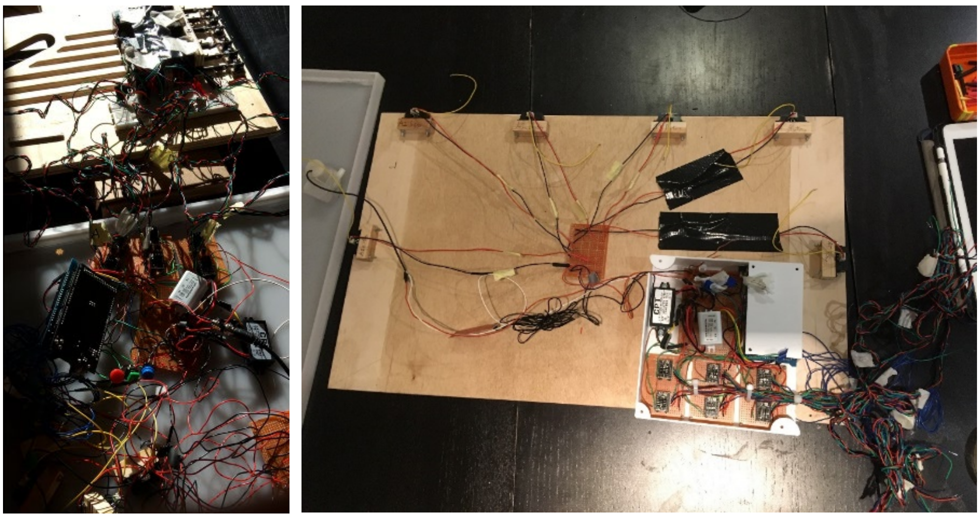


FIGURE 36: Wiring before and after fitting into electronics box

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