Guitar Assisted String Pressing Device

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Initial Research and Observations

Background

Instrumental playing often takes a long time to learn so that the limbs can master the way to play.
However, this is often a challenge for some people with physical disabilities.
In my initial research, I found that there are already a number of organisations concerned about this issue, and YouthMusic published a report in 2022 that illustrates the difficulties that many players with physical limitations, or who want to learn to play an instrument, encounter in practice. And it's often much more difficult for people with physical limitations to learn an instrument than for the average person. [1]

Field research and online research.

63% of retailers said they were unaware of the existence of disabled instruments. I visited two offline musical instrument shops in Glasgow and it is also true that there were no relevant instruments in the shops.

These online organisations offer a number of bespoke instruments to people with physical limitations. These assistive instruments can be categorised as：[2]

Bespoke instrument

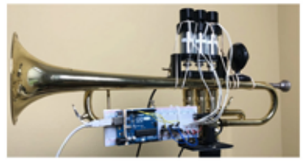
Accessories

Modified instrument

YOUTH MUSIC

DRAKE MUSIC

OHMI
Music-Making for People with Physical Disabilities



Focused Issues - Guitar left-hand string pressing problems


[3]

Design Insight

In the course of my online interview, an older person suggested that due to age, he did not have enough strength in his left hand to press the strings. I researched this and found it to be a very common problem.

Problem Overview

In my research, many elderly people lose strength in their fingers as they get older and do not have enough strength in their left hand to press the strings. Likewise, there are many patients, for example after a stroke or if they have injured their fingers, who also lose strength in their fingers and suffer the same problem. And at the same time, many beginners, due to their lack of finger strength, are prevented from continuing to learn the guitar.

So, in summary, left-handed string pressing is a problem worth solving.

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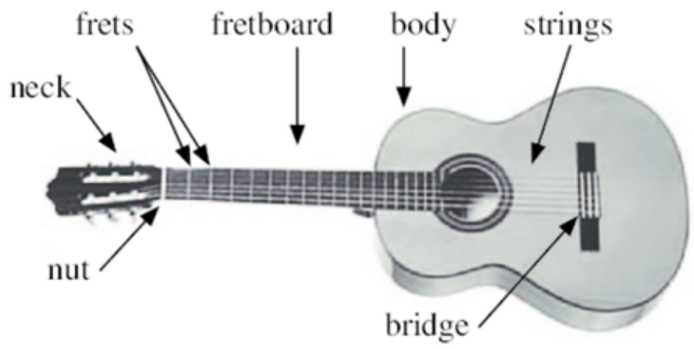
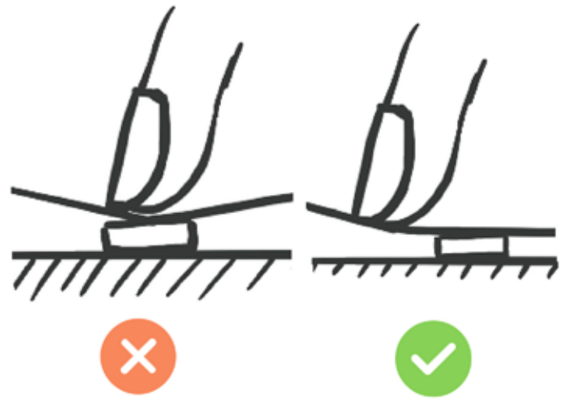
Reflection: During the initial research of the problem, the broad issues were not fleshed out in a timely manner. A lot of research time was wasted. The scope of the design problem should have been narrowed down more efficiently afterwards.

Further Research

Introduction to Classic Guitar



The structure of the guitar is shown in the diagram. [4]
The right hand is used to sweep and pluck the strings, while **the left hand** is used to press the strings to play the chords.
This design is based **on the classical guitar**.



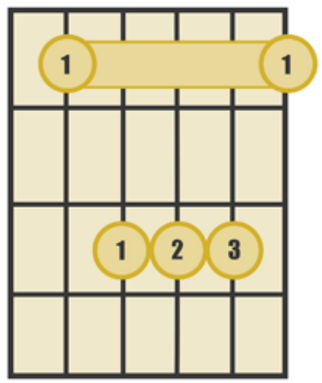
The correct way to press guitar strings with your left hand is to press your finger on the string **one finger's distance** from the fret. **Keeping your finger close to the fret** will save the force needed to press the string. But **you should not press your finger on the fret.**

WHY It's difficult to for the left hand

After my research, there are various reasons why pressing the strings with the left hand can cause difficulties.

1. Lack of strength
Lack of strength is the main problem in pressing the strings.

2. Finger posture
3. Pressing more than one string at a time



The reason for 2 and 3 is mostly due to the fact that playing chords often requires several fingers to press the strings at the same time.
The diagram shows a **B chord**, which is one of the most **difficult** chords to press on the guitar. As you can see, **four fingers need to be used at the same time, and one finger needs to hold down five strings at once**. I had a beginner guitarist try this and it did not work.

Interviews

My grandfather used to be a guitar player but gave up playing the guitar when he got too old and couldn't press the strings with his left hand anymore.

Pressing the strings with my left hand was a struggle for me and I gave up learning the guitar as I never had enough strength to press the strings.

I was once in recovery from an illness when I lost the strength in the fingers of my left hand to be able to press the strings. This bothered me for a while, but thankfully I recovered in the end.

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Reflection: In my further research I continued to explore the causes of this problem and interviewed a number of user groups. This gave me a deeper understanding of what was causing the problem.

Further Research

Relevent Products In The Market

Product to help press the chord [5]

It is a **purely mechanical construction** that allows the player to press all the strings required for a chord together by pressing a single button.

Disadvantages

As a single button requires multiple string presses, **more force is required for a single press.** Also, during my research, guitar players indicated that they did not like this product because **it would make playing less fun.**

Product to help build strength[6]

This product, which can be used to **increase the strength of the finger muscles**, is often used as a tool for beginners to build up their finger strength.

Disadvantages

It is **not the solution for some players who are not able to recover** due to non-rehabilitation, or temporary non-rehabilitation.

Conclusion

There are **no products on the market** that can be used to reduce the force of pressing the strings.

Refining the problem

User Requirements

User Group

The user group includes, but is not limited to:

1. **Older guitar players** who have lost strength in old age
2. **Patients** who have suffered from finger injuries
3. **Beginners** with congenital weakness of the fingers

It helps the user to **reduce the force required** to press the strings. This is also the main need.

As the guitar is played on a stand or handheld, the product **should not be overly heavy**.

Try to **keep the guitar the way it was originally played**.
In the course of my research, as the users are basically former players and people who want to learn the guitar, they generally expressed a desire to be allowed to keep their original playing style as much as possible.

Ergonomically, the product is designed with reference to the body dimensions of **5% to 95% of the population**.

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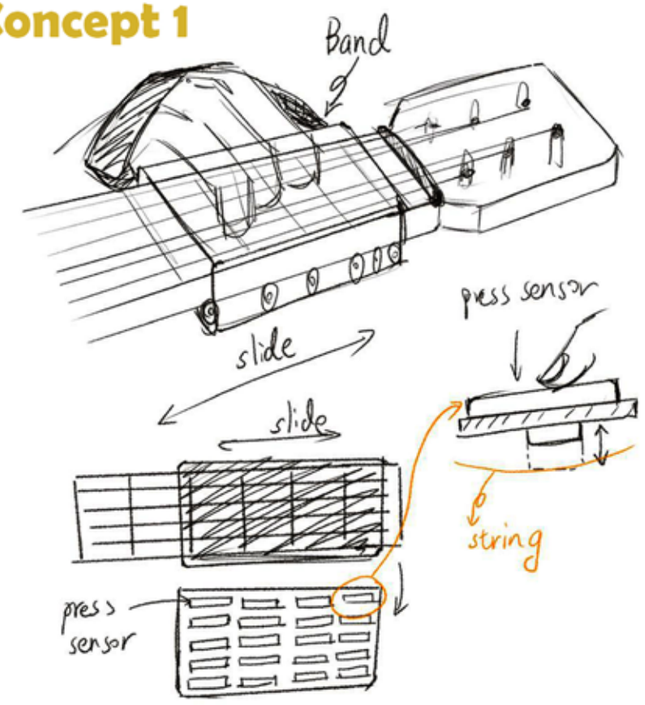
Reflection: After competitive research and refinement of the questions, it became clearer to me what the user needs were for pressing the string issue.

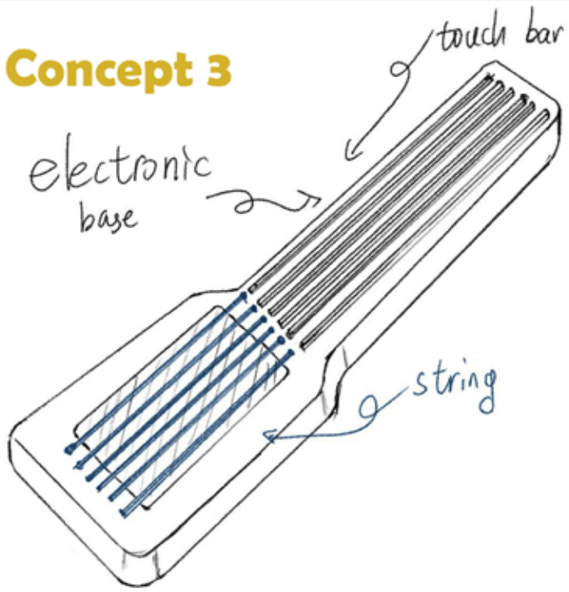
Concept Evaluation

Concept 1



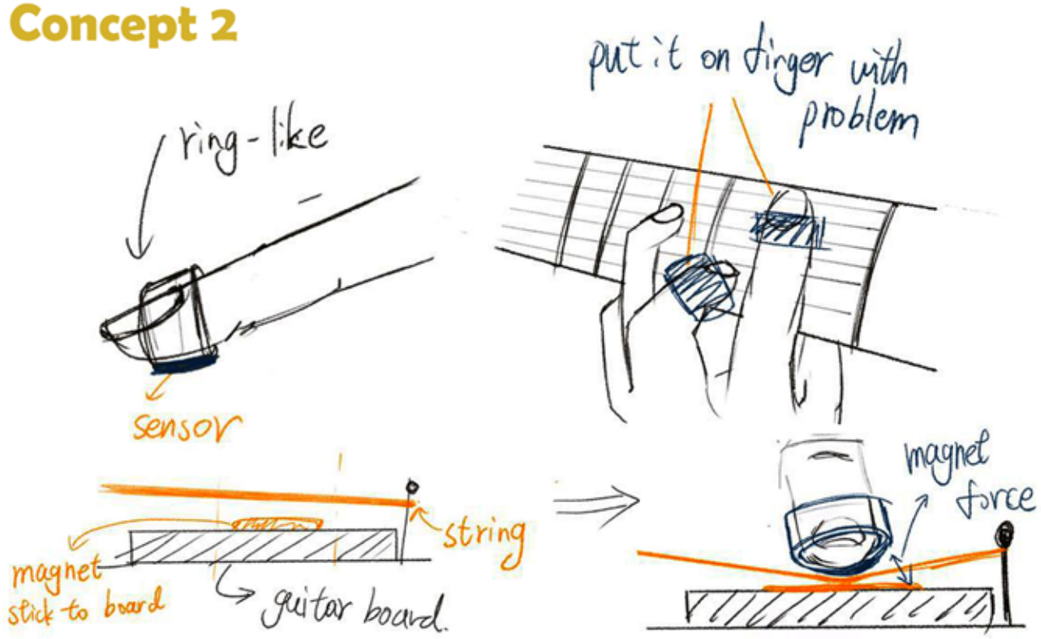
A touch sensor and an **electrically connected mechanism** are placed above the part of each string to be pressed, which when touched by the finger, triggers a downward pressure mechanism to help the user press the string.

Concept 3



Concept 3 **ditches the original guitar** straight away and uses a circuit to simulate a small guitar with **a touch section** on top to simulate the strings that need to be pressed. The lower part simulates the strings used for sweeping and plucking.

Concept 2



Put **a ring-like product** on the finger. A magnetic piece is attached to the guitar plate. The magnet on the guitar plate provides a downward suction to the finger as it presses down, assisting the finger to press down on the string. At the same time, when the finger is lifted, the signal is sensed and the pressure is released, allowing the finger to play smoothly.

	Concept 1	Concept 2	Concept 3
Technical difficulty	3	1	2
Retain playing style	2	3	1
Costs	3	2	1
	8	6	4

By comparing the three options, we can see that option 1 is the most suitable one. So **the final result** is:

Concept 1

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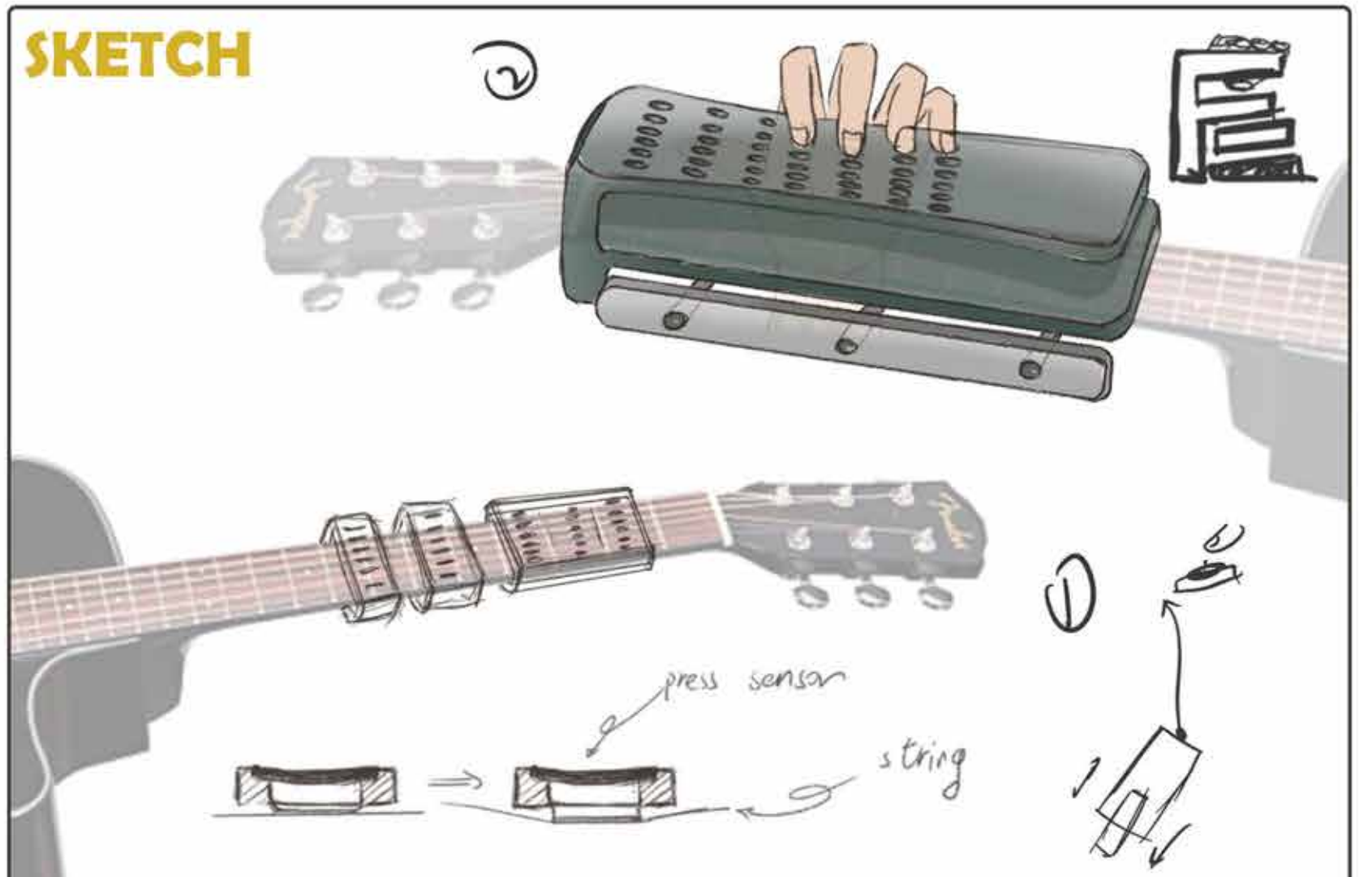
Reflection: Exploration of solutions to problems through rapid concept mapping. The comparison of characteristics allowed me to discover the most suitable solution.

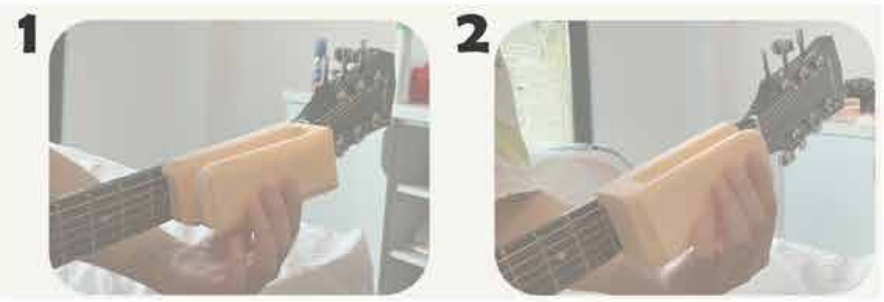
Concept Development



Two types of grip have been designed based on the chosen concept.

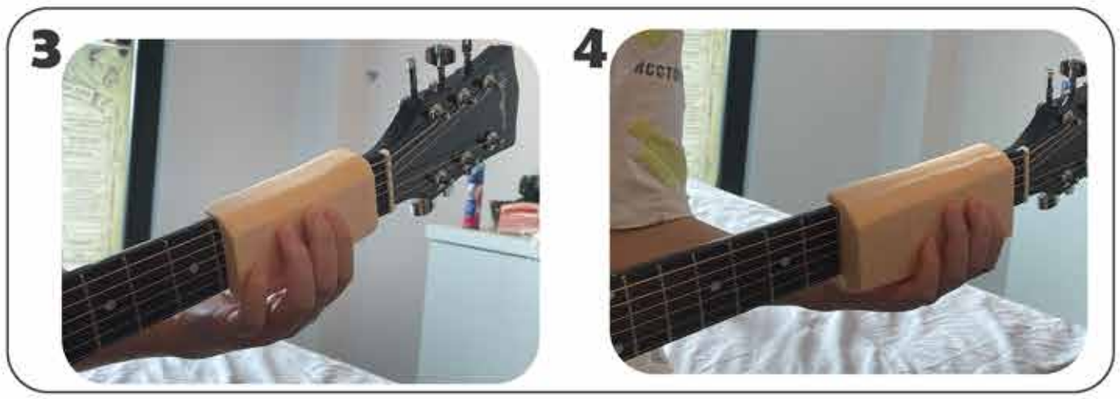
Prototyping

I made four different sized models based on the two gripping styles for testing.



Conclusion

I tested **4 players** and they were **not comfortable when gripping models 1 and 2** due to the **excessive angle** of bend required in the wrist. And **models 3 and 4** are two sizes of one solution. I found out that since **the player no longer has to apply pressure to press the strings**, the thumb page no longer has to be placed behind the instrument. So much so that **the thicker model does not cause discomfort** either. So the exact size can be determined by the internal components.



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Reflection: The model made of foam allowed me to test the way it was used and to know which option was more comfortable. But more models could be made here.

Technology Development

Having established the general logic and appearance of the product, I started to think about how to implement its functionality.

Morphological Table

After defining the functions to be performed by this product, it **was broken down into different modules** to explore **how these functions could be achieved**.

Function	Solution 1	Solution 2	Solution 3
Energy Source	Replacement battery	Rechargeable Battery	Use Plug
Sensing the touch of a finger	Touch sensor 	Press sensor 	Button 
Pressing down on the strings + Loosen the strings	Use magnet force+ spring 	Use solenoid 	
Feedback to users	Light	Vibration	Sound
Heat Dissipation	Cooling fans 	Heat sinks 	

Reasons for selection

As traditional guitars are not plugged in for use, they take rechargeable batteries. It can be used without the hassle of wires and is more environmentally friendly than replacement batteries.

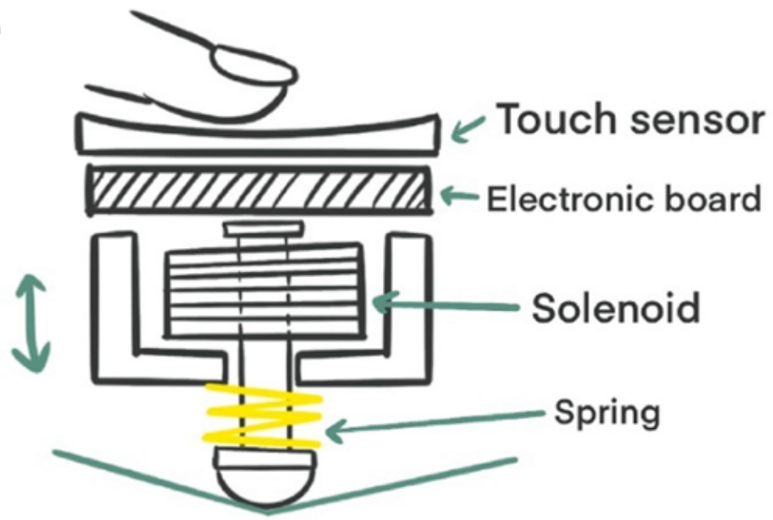
The touch sensor, in contrast to the other two options, only requires a simple touch to send a signal.

The use of magnetic suction and springs requires more complex components than the Solenoid. This is why the Solenoid is more concentrated.

As the product is used in the playing of the guitar. The vibrations affect the hand movements and the sound affects the music played.

Fans can be noisy, so a heatsink is more appropriate.

After a selection process, the **Geometric Layout of the scheme** is shown below



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Reflection: Using the Morphological Table allowed me to logically develop the possibilities of the internal structure in a clearer way. This ultimately helped me to choose the internal structure that I could implement.

Arduino Simulation [7] [8]

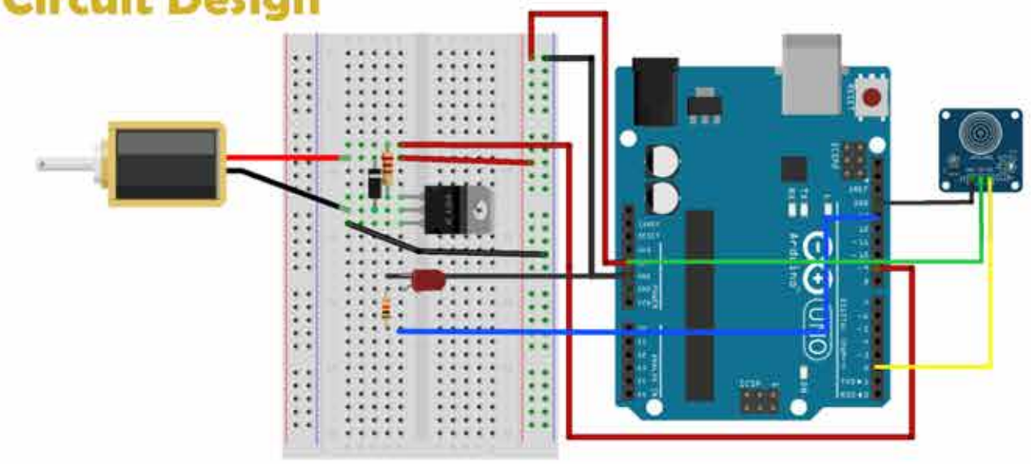
Having identified the basic electronic components, the choice was made to use Arduino to simulate the circuit logic of the device's internal modules.

Arduino Code

Arduino_code

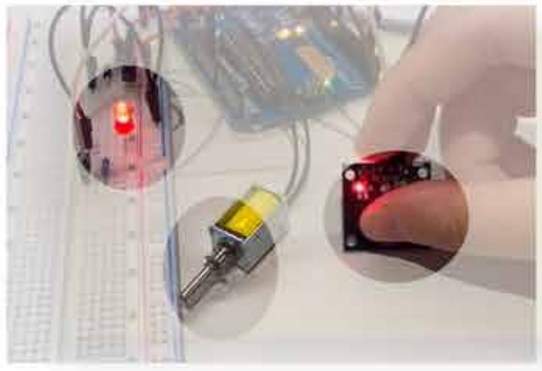
```
int solenoidPin = 9;      //This is the output pin on the Arduino
int touchPin = 2; // pin for the touch sensor
int ledPin = 13; // pin for the LED

void setup()
{
  Serial.begin(9600);
  pinMode(ledPin, OUTPUT);  // set the Led Pin to output
  pinMode(touchPin, INPUT); // set the Touch Pin to input
  pinMode(solenoidPin, OUTPUT);          //Sets that pin as an output
}

void loop()
{
  int touchValue = digitalRead(touchPin); // read the Touch Pin
  if (touchValue == HIGH) { //check if the sensor is touched
    digitalWrite(ledPin, HIGH);
    digitalWrite(solenoidPin, LOW);
    Serial.println("TOUCHED");
  }
  else {
    digitalWrite(ledPin, LOW);
    digitalWrite(solenoidPin, HIGH);
    Serial.println("not touched");
  }
  delay(100);
}
```

Circuit Design

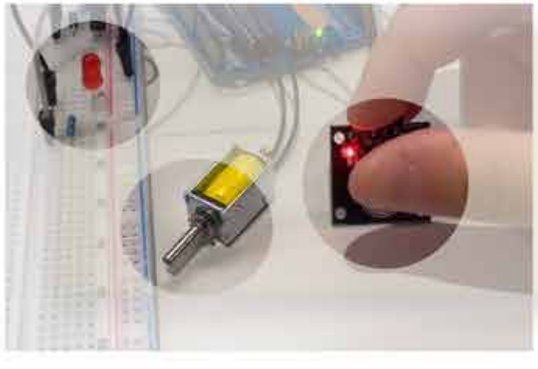


Result

When the circuit is correctly connected and the code is run on the computer, the following results can be seen:



When **the finger touches the touch sensor**, the **Solenoid pops** outwards and presses the string. A **light comes on** to tell the user that the position has been pressed.



When the finger **is lifted from the touch sensor**, the **Solenoid retracts inwards** and the string is released. The **light goes out**.

Reflection: Simulation of the internal circuitry via Arduino allows me to test whether the logic of the circuit can be implemented.

Selection and Calculation

1 Testing the force required to press the string

Based on the results of the test, the force required to press the string was determined to be:

$$F = 0.3kg = 0.3 \times 9.8 = 2.94\ N$$

2 Select Solenoid [9]

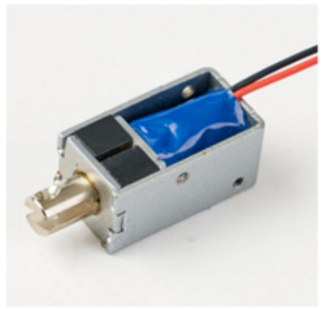
The criteria for selecting Solenoid were:

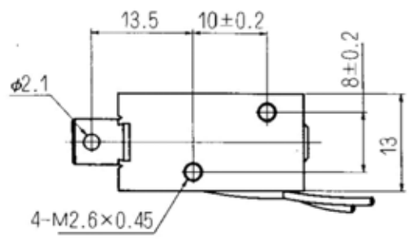
Minimize the size + Achieve the target thrust

I consulted the datasheet of solenoid and the model I finally chose was:

SDK-0625L-6

Turns	520
Volt DC	6V
Resistance(20℃)	6.8Ω
Weight	25.5g
Life Expectancy	Standard Life 500,000 cycles minimum
Operating Temperature Range:	-20℃ ~ +40 ℃



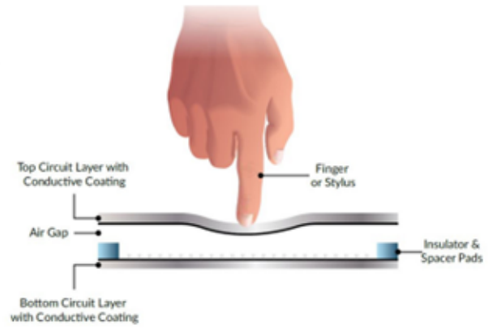


3 Select Touch Sensor [10]

The resistive touch sensor was chosen as the principle for the contact sensor.

The advantages are:

1. Resistive touch sensors require a tiny amount of pressure to activate and **are well protected against touch**.
2. **Cheap** to build.
3. The **shape** of the touch pad can be changed.



4 Select Battery [11]

The primary work done by the Solenoid pressing the string is：

$$W_0 = F \times \hbar = 2.94 \times 0.004 = 0.01176J$$

A rough estimate of the work done by the product in a fully charged state is:

$$W = 0.01176 \times 200000 = 2352W$$

$$\mathrm{W} = 3600 \times \mathrm{V} \times \mathrm{Ih}$$

The battery capacity can be calculated as:

$$\text{Battery Capacity} = \frac{2352}{3600 \times 6} = 0.11\text{Ah}$$

Take:

$$Battery\ Capacity = 330\ mAh$$

the battery type selected is:

6V 330mAH Ni-MH battery

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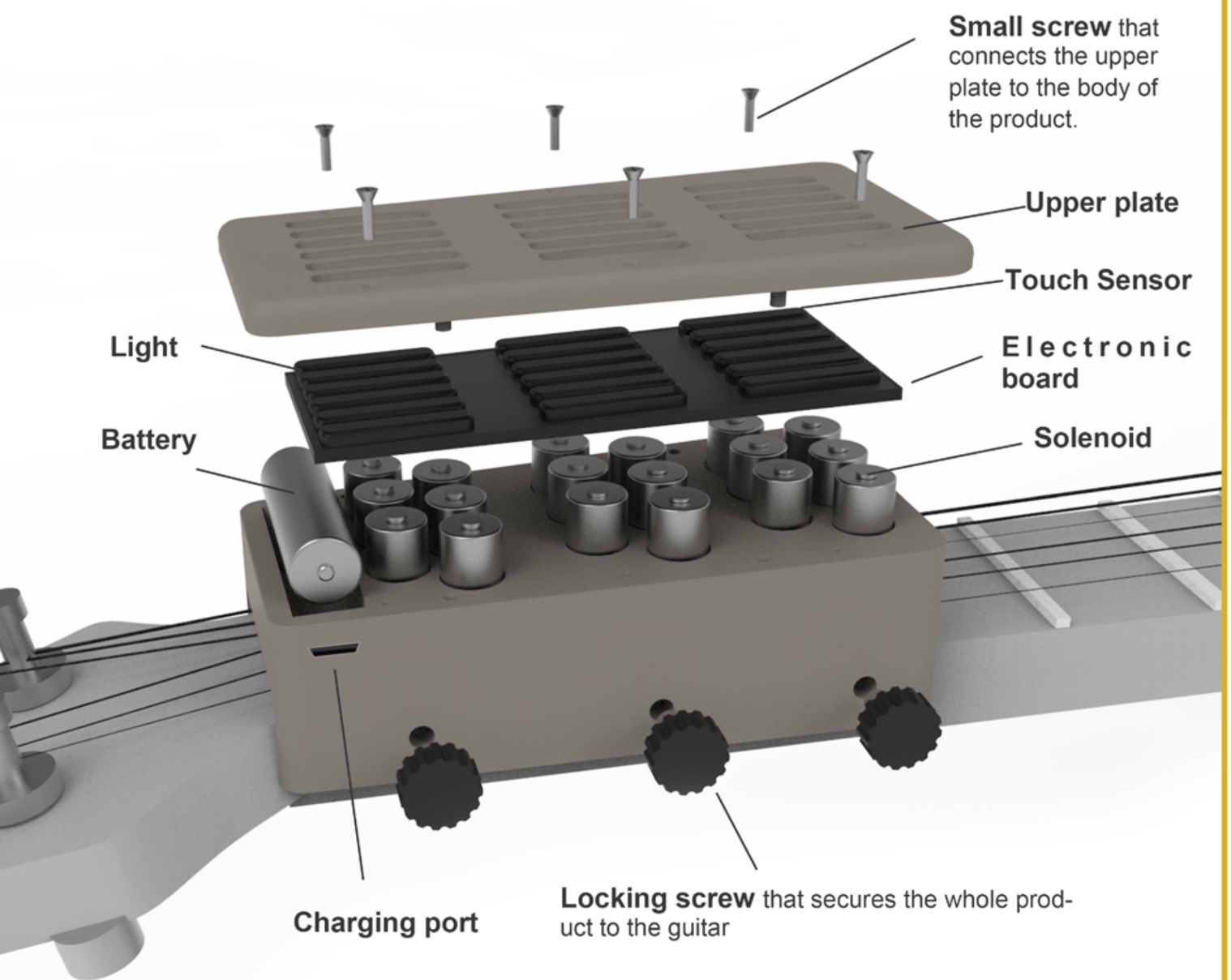
Reflection: Once the circuit logic and circuit components had been determined, I started to calculate the components I needed from the actual data. This helps me to determine the dimensions that I should need for my product.

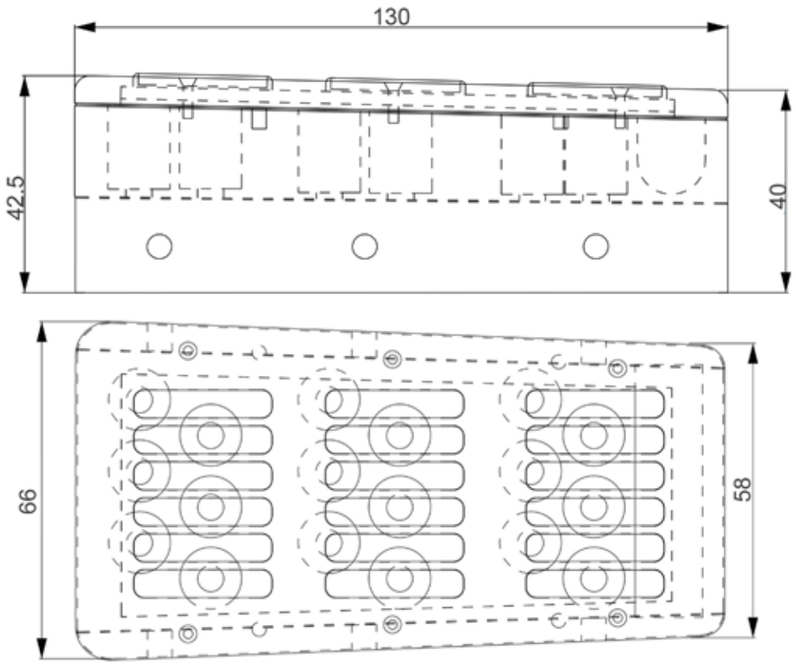
Assembly and Size Testing

Exploded view



Size Test

The 3D printed model is used to test whether the models are comfortable to use in terms of size. [12]



Unit: mm

Reflection: Once you have confirmed the dimensions of the parts, you can start to determine the internal structure and the actual dimensions of the product based on them

Final Design

1-3 Frets | **4-7 Frets** | **8-12 Frets**

Dividing the product into **different modules**, the user can fit the different modules on top of their guitar according to their needs. **A light** will flash in the pressed position to provide feedback.

Material Selection

ABS or Acrylonitrile butadiene styrene

Reason:

1. Can take injection moulding
2. Has good impact resistance and strength

1. The **middle** of the touch block is a touch sensor made of **film and glass**.

2. The **surrounding translucent plastic** allows light to shine through so that the user can be aware of which place is pressed.

The buttom of the Solenoid that comes into contact with the strings needs to **be wrapped in a layer of silicone** at the front in order to prevent damage to the strings. **It simulates the texture of the skin.**

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Reflection: The choice of materials for the products could have been more detailed, for example by exploring their strength to determine. However, as this project was not one where a very strong product was used, this step was not undertaken.

Discussion

For this project I have combined the design process with engineering knowledge. The design process ensures that my design is user-centred and meets the most realistic needs of the user. And engineering knowledge ensures that my product is achievable and not just a pipe dream.
Of course, I also had many shortcomings, such as not being efficient enough in identifying problems, which led me to struggle with this project for a while. Also not exploring exactly how the user can install the different modules into different positions on the guitar, which is something that deserves to be continued and improved upon.

Reference

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