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Faculté de génie
Faculty of Engineering

GNG 1103 - Deliverable D: Conceptual Design

Group F5

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Abstract

This document outlines 3 conceptual designs that each team member produced. Out of the 18 total conceptual designs, a final three contenders were formulated. Through the use of metrics and a matrix, the most suitable concept was determined to be the *Proximity Design*. This design utilizes the pre-existing ultrasonic sensors from the Equilibrium art installation along with speakers placed along the railing of the stairs. Moving forward, a prototype shall be developed from this design.

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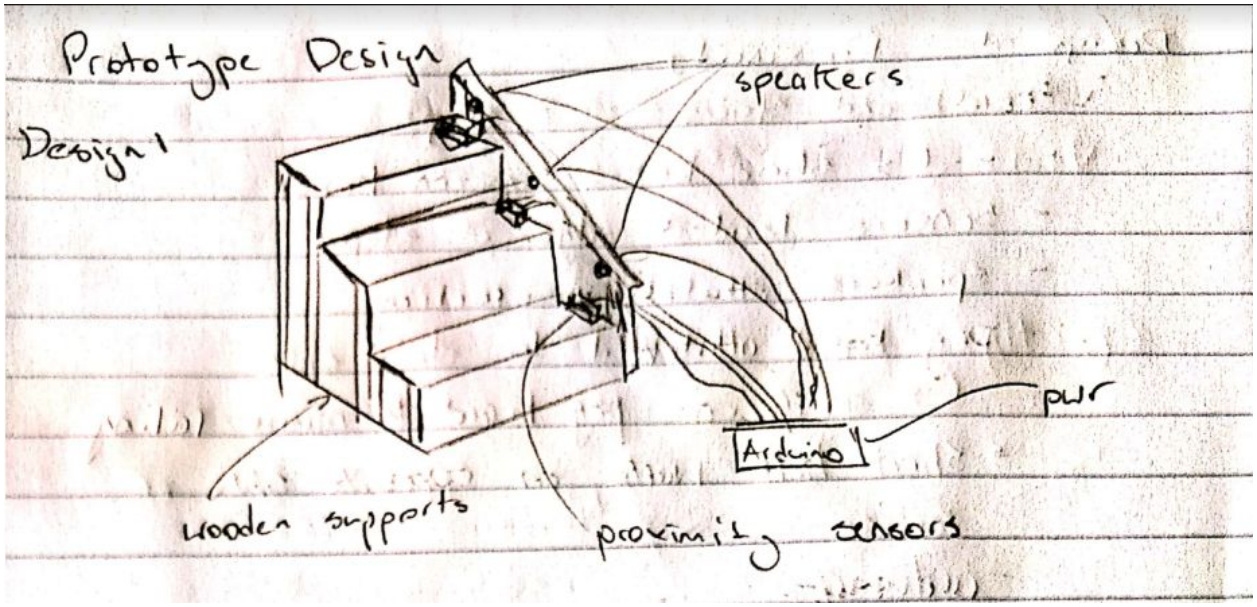
Introduction

This document outlines 18 initial design concepts as improvements for the Equilibrium art installation. Each of the 18 design concepts contains a sketch and a brief description. Three final concepts are chosen or formed based upon the best aspects of the 18 design concepts. These final three designs are explored in further detail. The final three designs will be compared to the design criteria and metrics and from this one design will be chosen to pursue.

Initial Designs

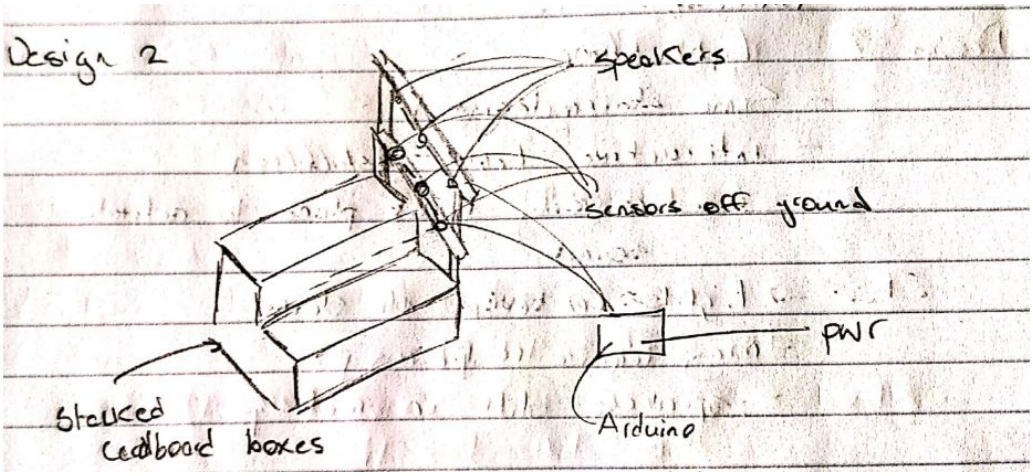
Below are 18 different design concepts that will be under consideration for further development, the entire design may be considered, or only specific attributes.

Design 1:



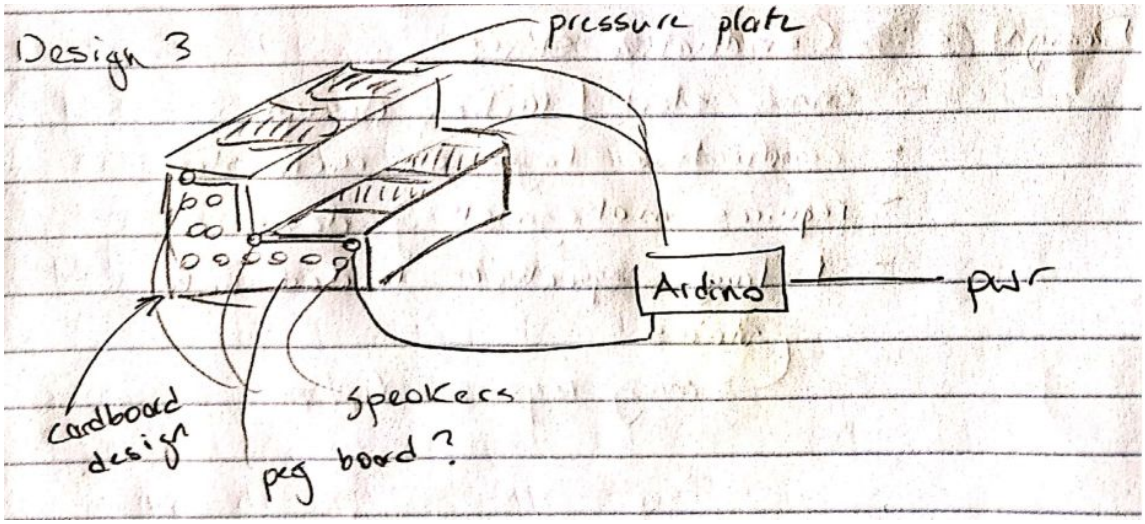
The design was used as a starting point and was created with idea of using basic components and prioritizing functionality. Wood supports were used for the supports for the stairs, with a basic wooden railing down the right side of the steps. Speakers were mounted on the underside of the railing, and the proximity sensor (Ultrasonic sensor) was simply placed on the edge of the steps. All components were connected to an arduino device.

Design 2:



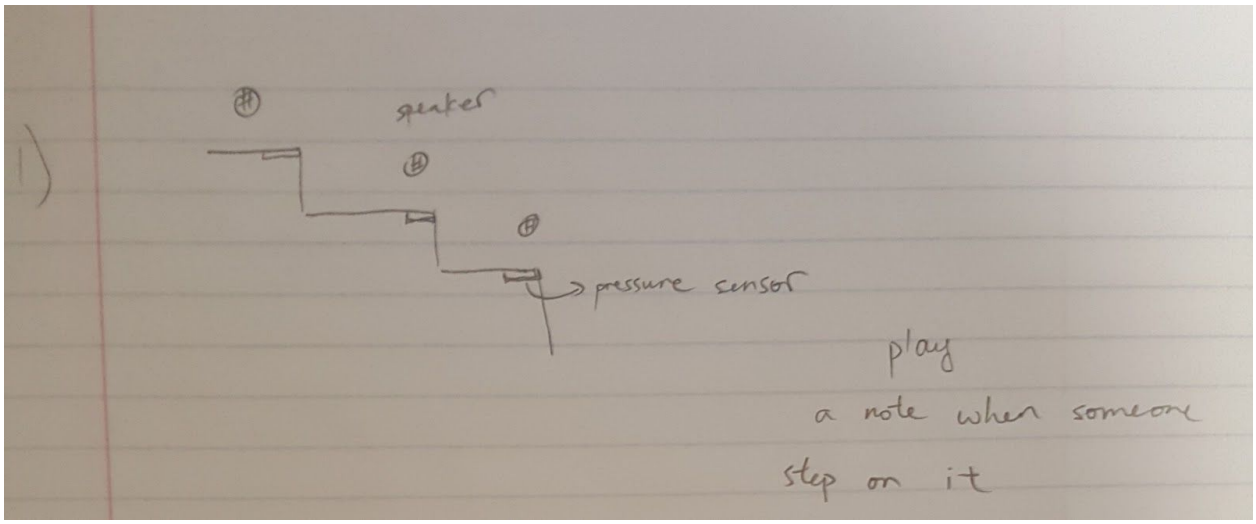
The second design attempted to replicate the stairs found the STEM building with more accuracy. Here, the railing has secondary lower bar running parallel to the main railing, this represents the track found in the STEM building that currently houses the sensors. The same speakers and sensors are used as design 1. The stairs are built using stacked cardboard boxes which would reduce cost and simplify the build. The arduino remains the same.

Design 3:



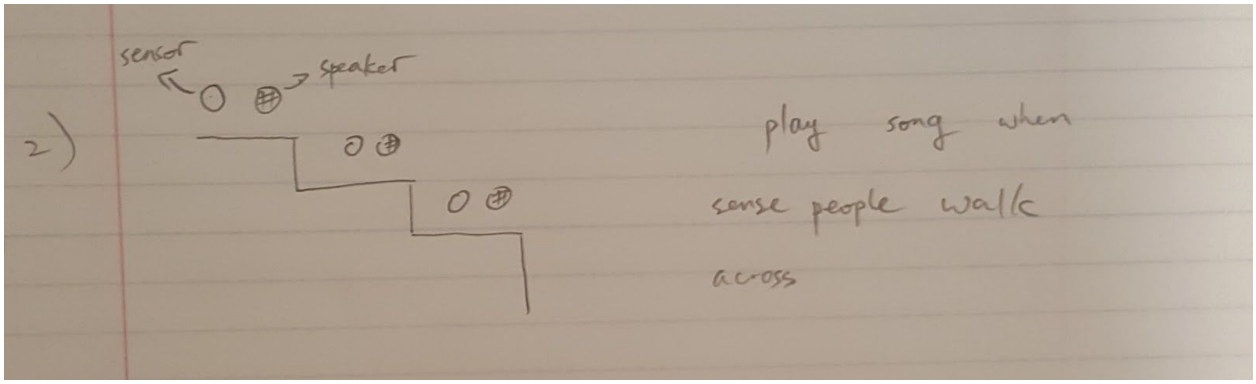
Design 3 attempts to employ a different detection method that Designs 1 and 2. Here a type of pressure plate or weight sensor is placed on each step, which would trigger based upon a certain pressure or weight. This design uses a similar cardboard step design but has a peg board attached to the side of the steps which could be used to mount the speakers on the edge of the steps.

Design 4:



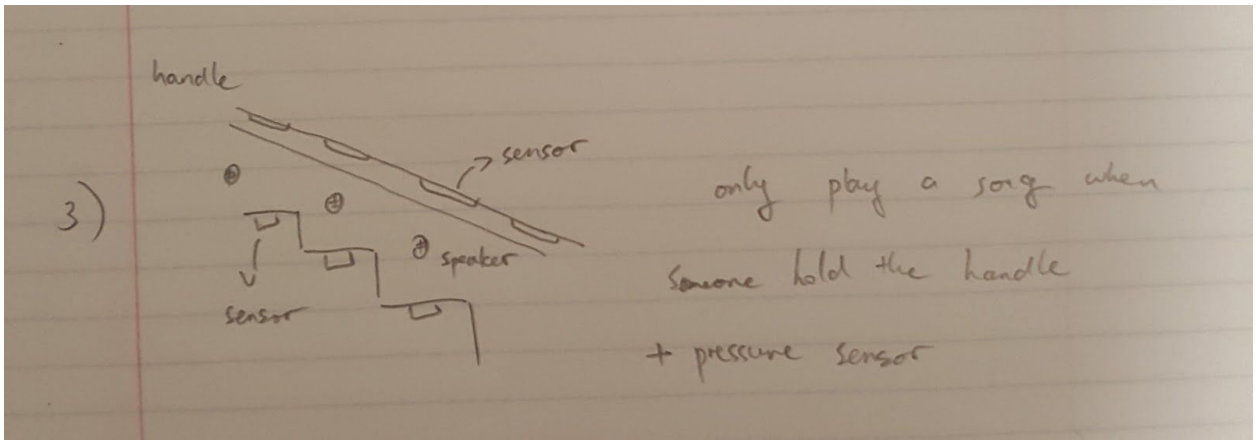
The following design has pressure sensors installed on the stairs. When people walk on the sensors, the sensors will send single to the speakers and start playing songs. The type of songs will depend on the number of pressure sensors triggered.

Design 5:



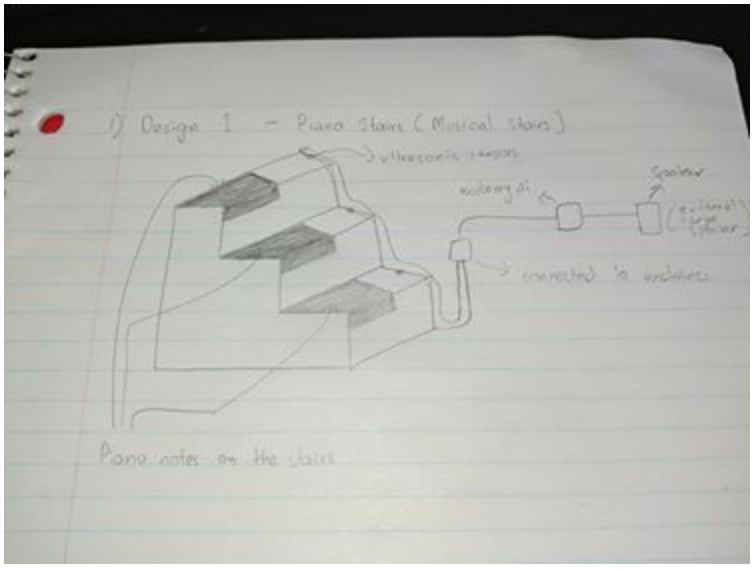
The following design has light sensors installed on the side of the stairs. When people walk across the sensors, the sensors will send single to the speakers and start playing songs. The type of songs will depend on the number of light sensors triggered.

Design 6:



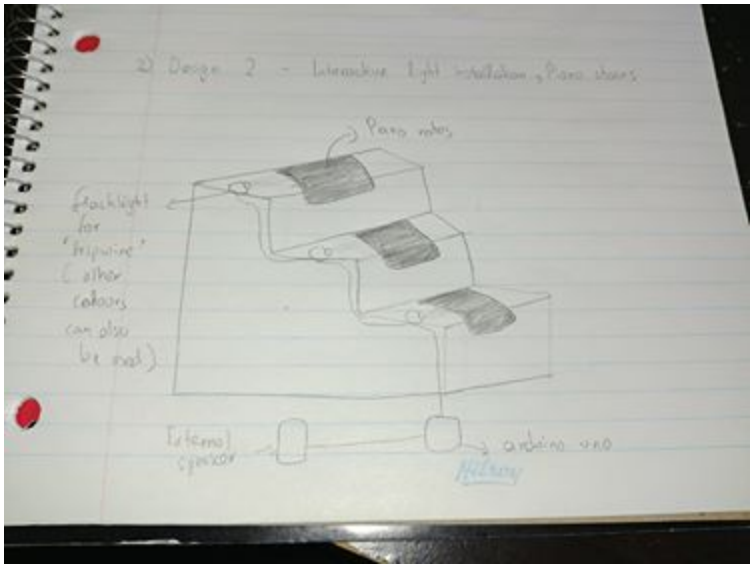
The following design has pressure sensors installed on the stairs and handle. When people walk on the sensors and holding onto the handle, the sensors will send single to the speakers and start playing songs. The type of songs will depend on the number of pressure sensors triggered.

Design 7:



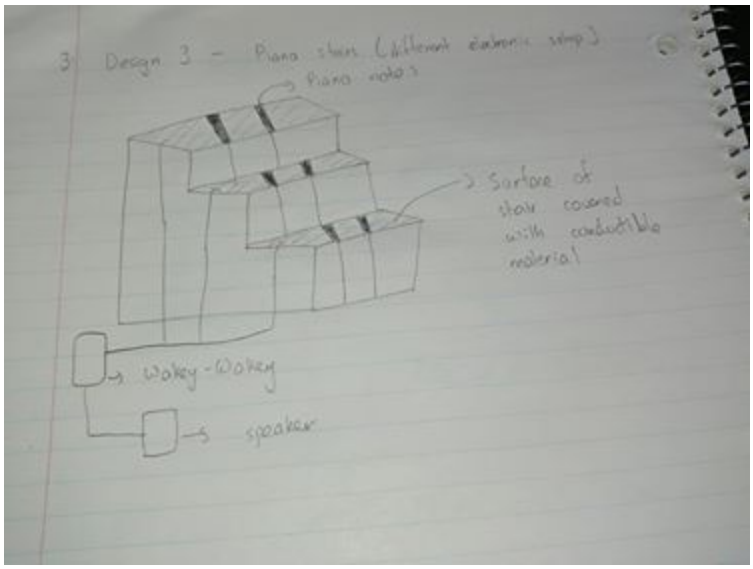
This design uses ultrasonics sound sensors to detect movement, once a movement is detected it sends signal to arduino uno, which then sends signal to the speaker to play the piano soundtrack linked to each step. As a result, makes stairs more fun to use and meeting the design criteria for making it more interactive and increasing it's appeal to users.

Design 8:



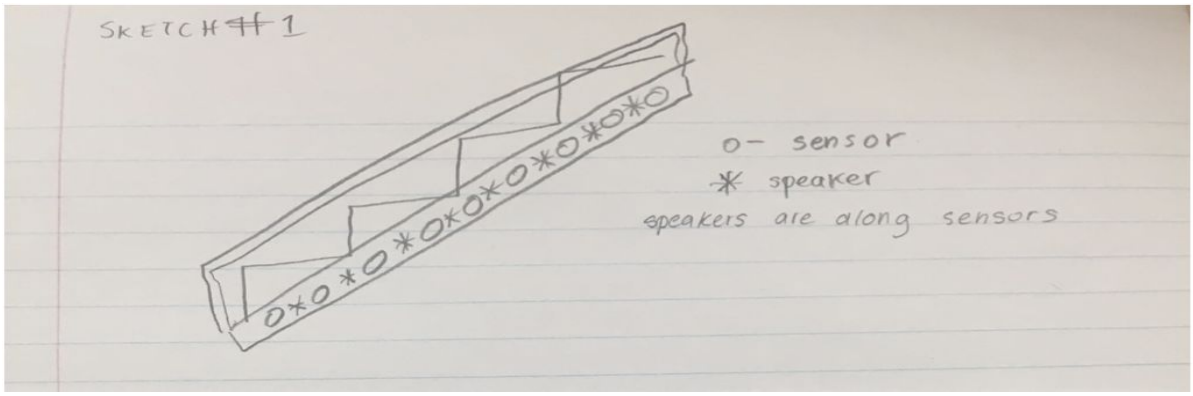
Design 8 uses light as a “tripwire” system, which when triggered sends signal to Arduino. The Arduino connected to the Raspberry Pi starts playing the piano soundtrack connected to each step. This design make the use of both light installation with Piano notes to make stairs more attractive to uses, as a result meeting the design criteria for making it more interactive and increasing it’s appeal to users.

Design 9:



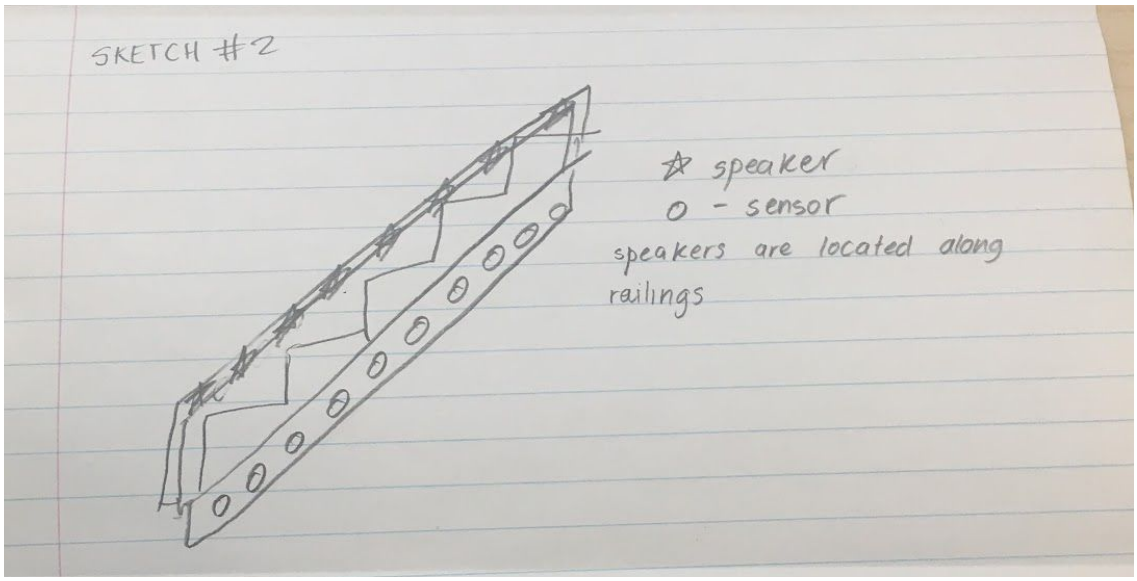
This design does not use any sensors unlike previous designs, rather it’s much simpler. It requires making the stairs conductible, which are connected together to the motherboard/computer which makes use of MakeyMakey.com to produce the Piano notes. When the conductible stepped on, sends signal to computer which in turn plays the note. (Note, making stairs conductible won’t cause electricity hazard in this case.)

Design 10:



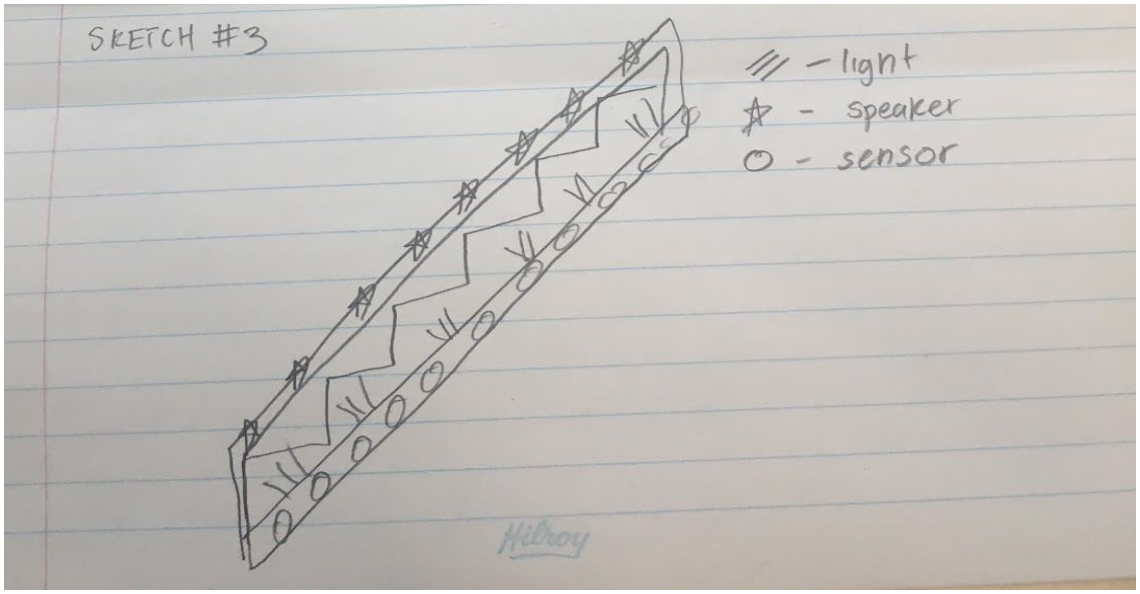
In prototype 1, the stairs are made out of stacked shoe boxes, and the sensors and speakers are placed beside each other under a panel.

Design 11:



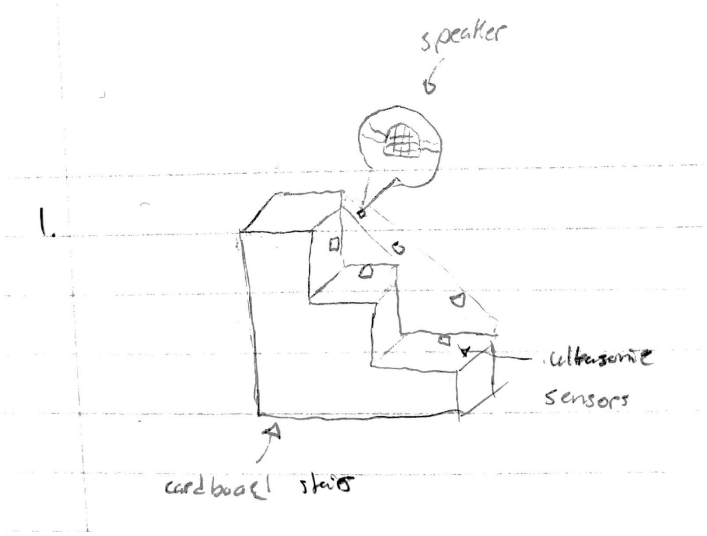
The only difference between design 1 and 2 is the placement of the sensors. Here, the speakers are placed alongside the railings so that the sounds can be heard better.

Design 12:



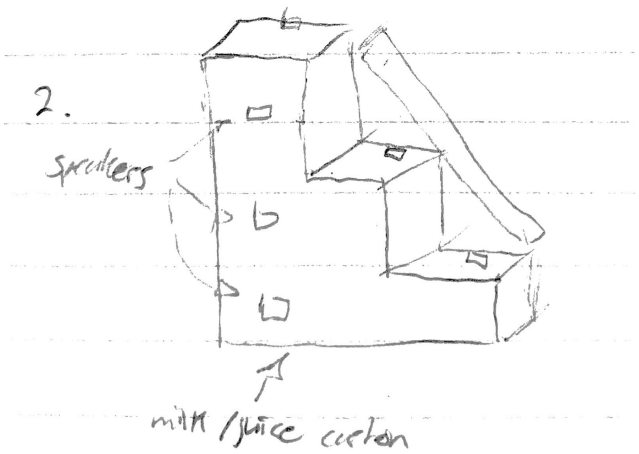
Sketch 3 includes lights. Colour-changing lights can be synced up to the hanging installation to light the stairs, with speakers placed alongside the railings.

Design 13:



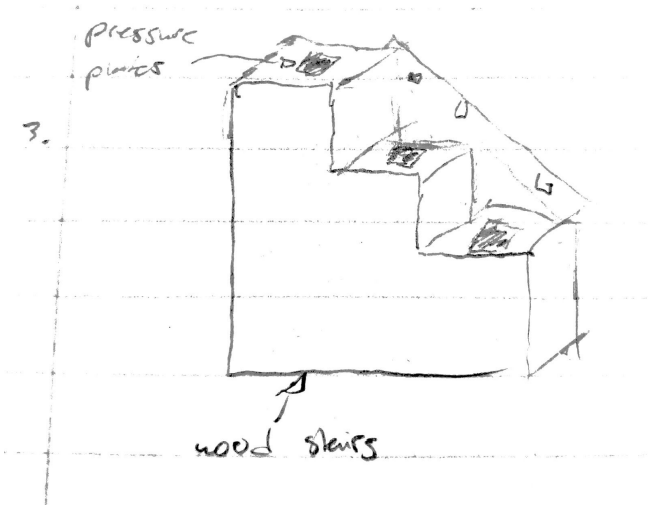
This design is composed of a cardboard set of stairs. The pre-existing set of ultrasonic sensors shall be used to read pedestrian proximity along the stairs. Speakers within the railing shall produces sounds according to proximity.

Design 14:



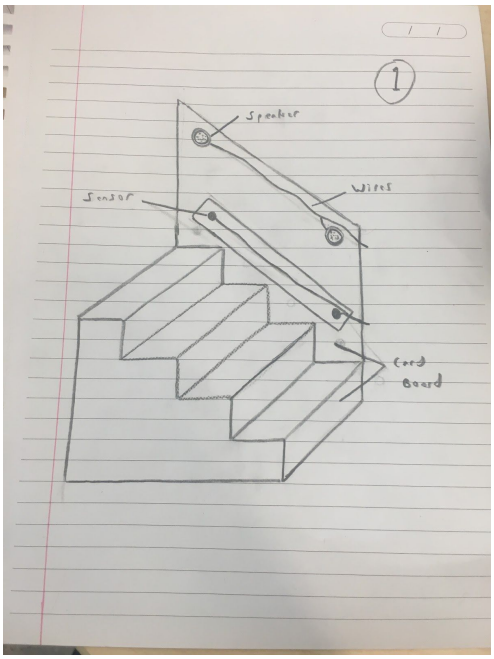
This design is composed of recycled grocery cartons for the stairs. The pre-existing set of ultrasonic sensors shall be used to read pedestrian proximity along the stairs. Speakers placed along the side wall on the other side of the stairs shall produces sounds according to proximity.

Design 15:



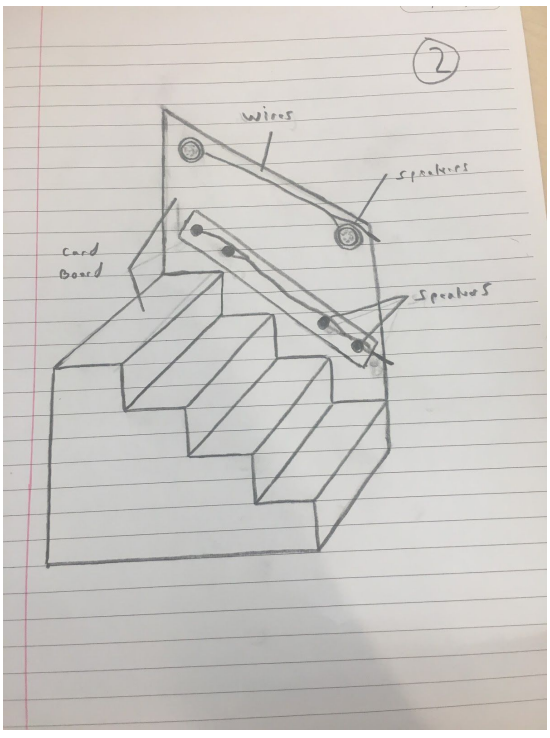
This design is composed of a set of wooden (plywood) stairs. Pressure plates shall be placed on each stair, connected to speakers embedded within the railing. The speaker shall be triggered by a specific pressure reading.

Design 16:



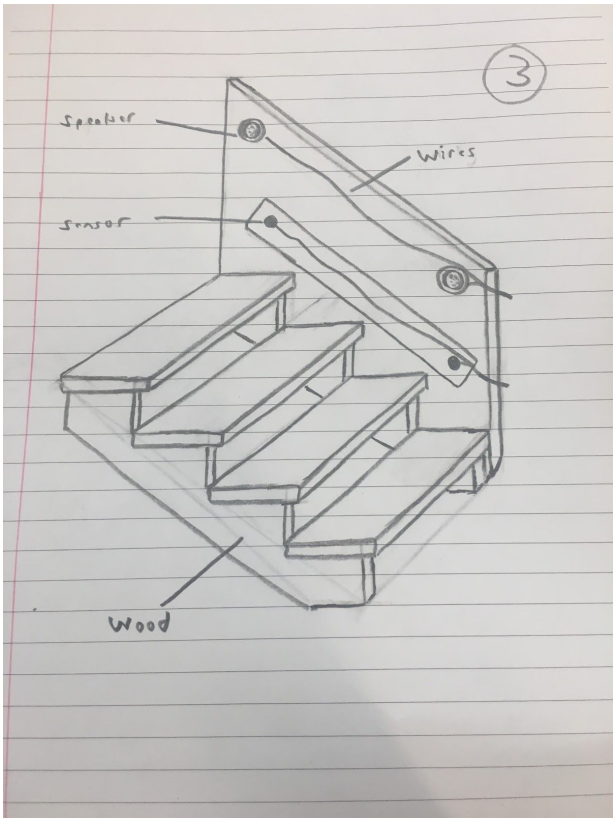
This design prototype is a basic design where people walking on the stairs would trip sensors located every few steps and sounds would play. The stairs and railing are made out of cardboard which is cheap and easy to work with.

Design 17:



The seconds design is very similar to the first design but with a different setup of the speakers and sensors. This design incorporates one of our original ideas of playing different tracks of music as more people walk on the stairway. Two seniors are located at the bottom and the top of the stairs which sense when a person enters and exits the stairs.

Design 18:



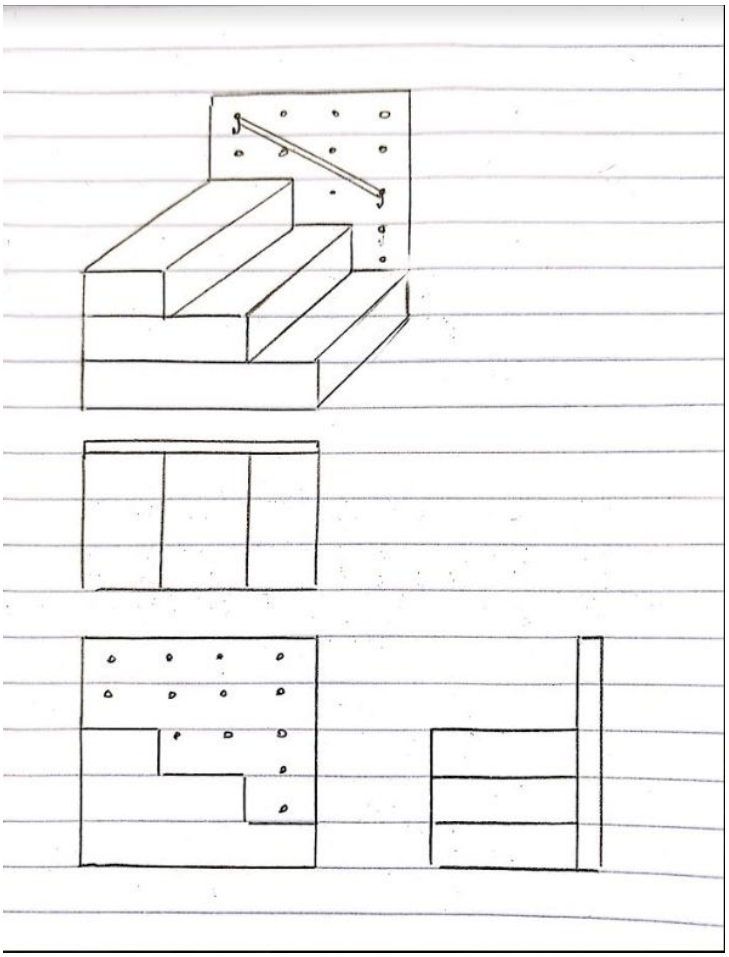
The third design has the same speaker and sensor layout of the first design but instead of using cardboard wood is used to build the stairs. Although wood is more expensive than cardboard and harder to work with, wood stairs would be stronger and at a higher quality than cardboard stairs.

Contending Designs

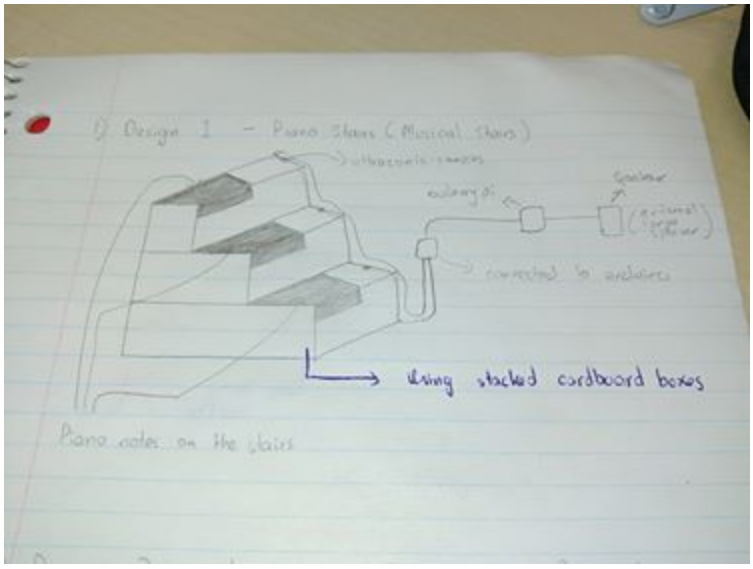
Based upon the 18 designs above, three new designs have been adapted based upon a group discussion where factors such as originality, functionality, cost, along with the rest of the design criteria were considered. Each of the chosen three designs attempt to implement sound as an interactive element using varying detection techniques, hardware and types of speakers. All three of the designs, however, use the same fundamental stair design outlined below.

Stair Design

The concept for the stairs is very similar to those found in design 2 and 13. The main body of the stairs will be built using cardboard boxes. The size of the stairs is not definite as it will be based on the availability of boxes. The goal, however is to create a stair with 3 steps and the base of the stairs shall be roughly the size of a shoebox. On the side of the cardboard stairs, a large pegboard will be attached, and hooks will be hung from the pegboard. Inside of the hooks a piece of wood or plastic shall be hung to create a railing.

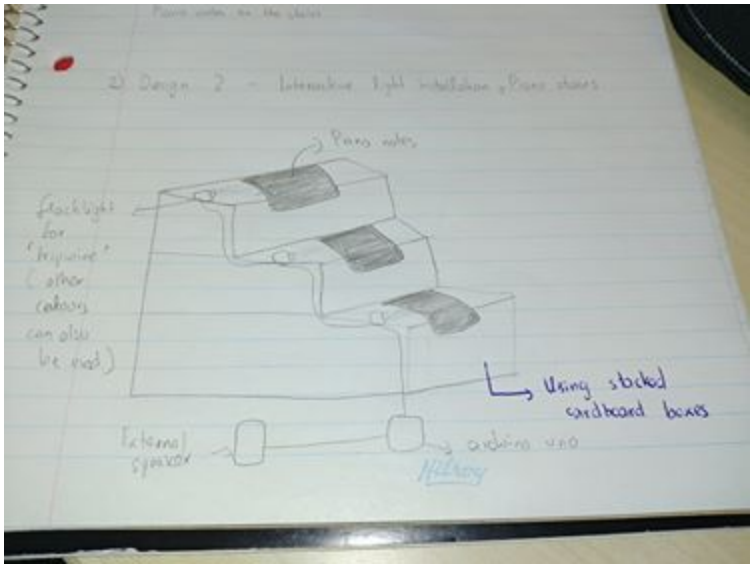


Proximity Design



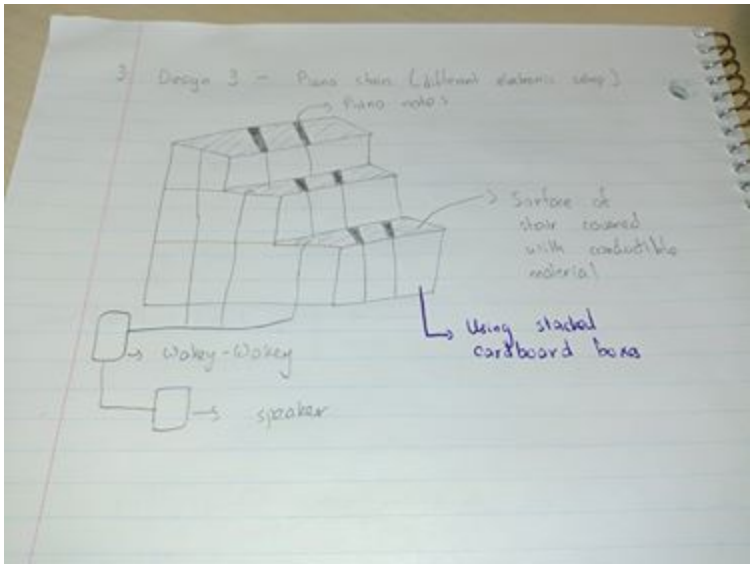
The concept of the Proximity Design is the use of a basic ultrasonic proximity sensor to detect movements on the stairs. Similar to the design currently used in STEM that activates the lights, the same sensors would be used to trigger a set of sounds. The sensors would be attached to the edge of each step and parallel to the length of the stair. The speakers would be attached to the railing created via the peg board. In order to facilitate the ultrasonic sensor readings, walls will be installed on the opposite side of each stair to allow the sound waves to rebound back to the sensor. The main control unit of this design is a Arduino.

Light Plane Design



The Light Plane Design attempts to add multiple interactive components to the stairs through light and sound. Lights are installed on the edge of each step and shall project a plane of light across the step. When the light plane is broken, the system will play a sound. This design was considered for its additional interactive element and an improvement to the stairs aesthetics. The speakers are once again mounted to the railing of the of the stairs. The system may require a Raspberry Pi unit to function.

Conductive Stair Design



The Conductive Stair Design mainly attempts to be as simple as possible in the detection of traffic flow on the stairs. The stop of each stair is simply covered with a conductive material such as aluminum foil, which will send a signal when stepped on. This system requires a *MakeyMakey* device in order to implement this detection system. This design varies from the other designs as instead of speakers mounted along the raining, one main speaker unit is used, which is both larger and louder than the individual speakers used in the other designs.

Chosen Designs

Metric for Contending Design

Legend: 3 points | 2 points | 1 point |

Design Criteria	Proximity Design	Light Plane Design	Conductive Stair Design
Sensors at the top of the stairs must be fixed and operate consistently	Design fixes and uses the sensor at the top of the stairs	Design requires replacement of stairs sensors instead of fixing	Design requires replacement of stairs sensors instead of fixing
Sound must be a feature of the design built around the stairs	Sound is a major feature of design	Sound is a major feature of design	Sound is a major feature of design
Any sensors, speakers or lights used must be arduino compatible	Ultrasonic sensors used in this design are arduino compatible	Flashlight or LED used are arduino compatible	Uses no sensors, a complete different electronic system thus not arduino compatible
The design should improve the experience of taking the stairs	Adds audio component to the steps	Adds some visual and audio flair to using the steps	Adds audio component to the steps
The design must take up little space and not impact the use of the stairs	Can use the same sensors that are currently installed, no need to make room for new ones	New sensors are necessary. May require new space for Raspberry Pi	Cover on steps, and need to make space for MakeyMakey device
The design must be focus on the stairs and electronics and will not touch the hanging sculpture	Does not impact the sculpture	Does not impact the sculpture	Does not impact the sculpture
Modifications should not seem out of place in the context of the	Same sensors as the original design. Sound adds new	Light theming fits with hanging sculpture. Sound	Sound adds new interactive element

rest of the installation	interactive element	adds new interactive element	
The design must be durable and last through everyday use	Sensors should work reliably as there is no human contact with the sensors themselves	Sensors should work reliably as there is no human contact with the sensors themselves	Durability could be an issue with debris on the covered stairs impacting its long term use, water could react with the conductive material
Modifications must not impact the use of the stairs and remain hidden or discreet	These components are very discreet and nothing visible on the stairs	This design projects lights on the steps the of the stairs, the rest of the components are hidden	Each step will require a conductive cover on each step, all other componentry is hidden
Total Points	25	23	15

*Some values below a estimates of the design's performance

Metric	Proximity Design	Light Plane Design	Conductive Stair Design
Functional Top Sensors	95%*	95%*	70%*
Sound	88dB	88dB	120dB
Take up a small amount of space	Speaker - 174.24 mm^3 Arduino Uno - 51.29 cm^3	Speaker - 174.24 mm^3 Arduino Uno - 51.29 cm^3 Raspberry Pie - 65.32 cm^3	Speaker - 1897.2 cm^3 MakeyMakey - 80 cm^3
Processing Unit Cost	35$	$45	$100
Speaker Cost (per unit)	$6	$6	Free (already own the speaker)
Total Points	13	11	9

Conclusion

From the metrics and matrix tables, it is clear that the proximity design is the best contender. It is the cheapest as it uses the pre-existing sensors, which will translate into less time for construction and setup. In the end, the proximity design consists of elements that would be easy to integrate into the pre-existing Equilibrium art installation.