2020 ANNUAL REPORT

Enabling Engineering

TABLE OF CONTENTS

I. INTRODUCTION

II. 2020 PROJECTS

2020

2020 ANNUAL REPORT

Disability is one of the most important issues in the contemporary society, with the likelihood increasing as individuals age. Supportive resources for individuals with disabilities are oftentimes costly, inaccessible, and reduce an individual's ability to perform specific tasks independently. Additionally, insurance often fails to cover expensive devices or services needed to carry out everyday tasks.

We seek to support this population via low cost, customized solutions that empower individuals by giving them greater independence, reducing medical burdens, and increasing social connectedness.

This annual report serves as an overview of our projects but is by no means exhaustive. Much of our work is dependent on our collaborators, clients, and supporters and we want to express deep gratitude for all of those who have helped us make 2020 such a successful year.

ENABLING ENGINEERING

Who we are: Enabling Engineering is a Northeastern University student group that designs and builds devices to empower individuals with physical and cognitive disabilities.

What we do: Our students collaborate with clients on projects that provide greater independence, reduce medical burdens, and increase social connectedness. We help family members, clinicians, and teachers care for people with disabilities.

By giving students the opportunity to participate in Enabling Engineering projects, we are training the next generation of engineers to be knowledgeable about, and aware of, the needs of individuals with disabilities.

an inside look at the

ENABLING ENGINEERING TEAM

Management Team

Kerri Lehmann

Liam Sullivan

Tyler Hill

Pragnya Kalidindi

Program Assistants

Brinda Tailor, 2019

Ronak Patel, 2020

Engineering Assistant

Jack Cardin,
3D printing Assistant

OUR IMPACT

- “I’ve been involved with Enabling Engineering for three years and I’m so happy I’ve had the opportunity to both work on project teams and the management team. By being a part of the management team I’ve been able to talk through projects and problem solving with a lot of the different project groups.Through doing this, I’ve learned a lot about different engineering disciplines and different approaches to problem solving that I probably wouldn’t have learned otherwise. One of my favorite parts about being involved with Enabling is being able to see how motivated some students can be to help their clients and provide quality products.” Kerri Lehmann, Mechanical Engineering Major
- “Enabling Engineering has been a fundamental part of my time at Northeastern since my first tour of campus. On my first look at the school I saw a presentation by the then managers of the club, and knew I wanted to be a part of it. I joined adaptive guitar my freshman year and had the opportunity to join up with the management team the year after. Ever since, I’ve learned more than my classes could have ever taught me. I’ve had the opportunities to see interviews from the other side of the table, work with and meet club donors, even speak to the incoming freshman engineering class, the same presentation I was inspired by almost three years ago. Enabling Engineering has been an experience I have learned and grown through, throughout my years in College, and I look forward to continuing the experience into the future.”-Liam Sullivan, Computer Engineering Major
- “Through Enable Engineering I learnt that every person is different with their unique needs. Enable Engineering gave me the opportunity to work with them and solve their needs and make their lives better through science and technology.” - Aman Choudhaty, Mechanical Engineering

- Enabling Engineering's number of projects has steadily increased throughout the year. As our capacity increases, we are able to take on a greater number of projects and thus make a larger impact.
- Throughout the years, more than **600** students have worked on Enabling Engineering projects. These students learn how to critically think about applying engineering principles to enable and empower others.
- Enabling Engineering has worked with over **50** clients (both individuals and organizations) to deliver customized assistive devices.
- Last year, we completed **6** projects. This year, we're excited to announce we have over **16** active projects.

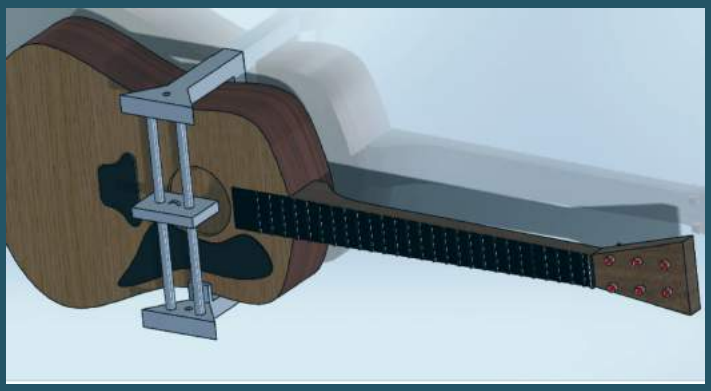
ADAPTIVE GUITAR VERSION 2

Overview: *Build a custom guitar that will help an individual with restricted motor skills play guitar*

Status: In progress

Members:
Aman Choudhary
Fraser Shaw
Lauren Pudvan
Mike Zeleznik

Clients:
Brenda and Brian Manning



The Need

The client has limited use of the left side of his body but wishes to play the acoustic guitar. We have been tasked with creating an apparatus that allows the one-handed usage of an acoustic guitar. The design would be able to press chords and allow the client to strum at the same time with his right hand.

The Solution

Our solution is to make an apparatus that has a foot pedal, so the client is free to hold the chords down with his hands. The new structure includes making an attachment (photo included above) that holds the pick and can move up and down the guitar. The previous solution had the structure attached to a motor controlled by a foot pedal. It was an electomechanical system. The client had issues with the electrical part. Hence, our new solution is to design a structure attached to a purely mechanical system operated by the foot pedal and the bike brake wire. Although this will not allow for individual strings to be plucked, it allows for chords to be played easily

BLIND NAVIGATION MAP

Overview: *Creating an 3D map of the Museum for visually impaired.*

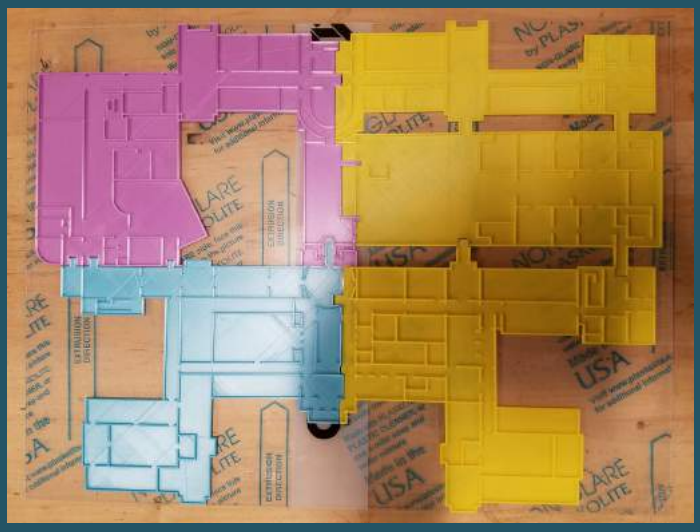
Status: In progress

Members:

Luke Drennan
Jafar Mirza
Tyler Hill

Client:

Ronit Minchom and
Hannah Goodwin,
Museum of Fine Arts



The Need

Individuals with visual impairments have been traditionally limited in their interactions with visual art museums. This project is focused on creating a 3D printed map of the layout of the Museum of Fine Art to enable individuals with visual impairments to independently orient themselves around the MFA.

The Solution

The primary objective is to enhance the MFA way-finding experience for individuals with visual impairments via a portable, tactile map by extruding the digital copy of the map to develop a physical 3D print. The map is easily Transportable, Tactile, and Comprehensible. For transportability, we developed a 3D printed map booklet of the four levels combined by binder rings. While the booklet will be tactile regardless, we want to ensure that the tactile experience is comfortable and discernible. Lastly, to ensure the map is comprehensible, we plan on experimenting with various sizes, extrusion heights and symbol markers

GAIT TRAINER HARNESS VERSION 2

Overview: *To design the harness system comfortable for patients during Gait Training*

Status: In Progress

Members:

Gwendolyn Wilbert
Elizabeth Klemm

Client:

Ross Lilley

The Need

Gait harnesses are used in the physical therapy treatment of patients who have limited walking capabilities to bear the weight of patients. However, the harnesses themselves are a major source of patient discomfort, particularly around the groin and underarm region. Hence the need is to design a harness that is more comfortable and ergonomic to support up to the full weight of a patient during therapeutic exercise.

The Solution

Our solution is to take the weight off from the groin area by having several contact points elsewhere which will minimize the discomfort to the patients. The previous version had a vest and thigh straps that are worn over the patient's clothes. The thigh straps were connected to the vest. The vest was intended to bear patient's full body weight. During the testing of harness, the team came to conclusion that vest was not necessary. Our new version has vest removed from the design. Hence, the harness consists of thigh straps connected to the boots of the patient. This prevents thigh straps from sliding down.
This makes the harness more comfortable than the previous version and just like the previous version, new version can also be worn over the clothes

INTERACTIVE DISABILITY WEBSITE

Members:

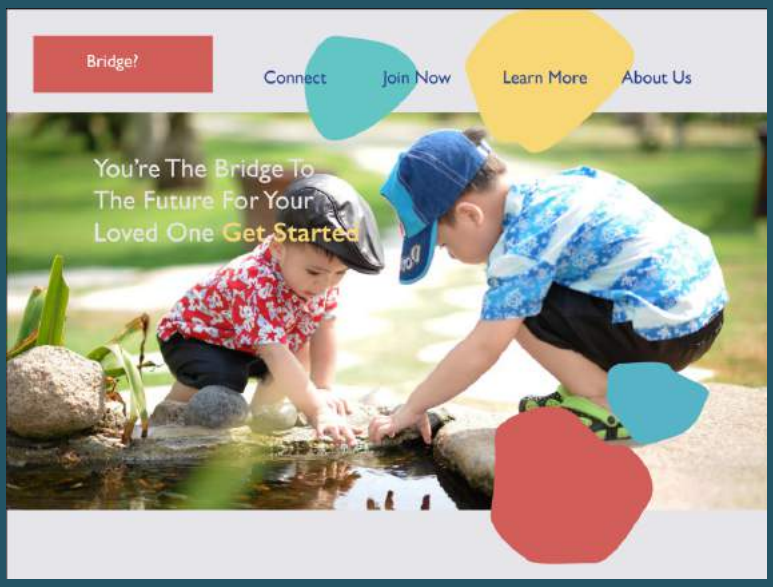
Alec Condry
Amruta Patil

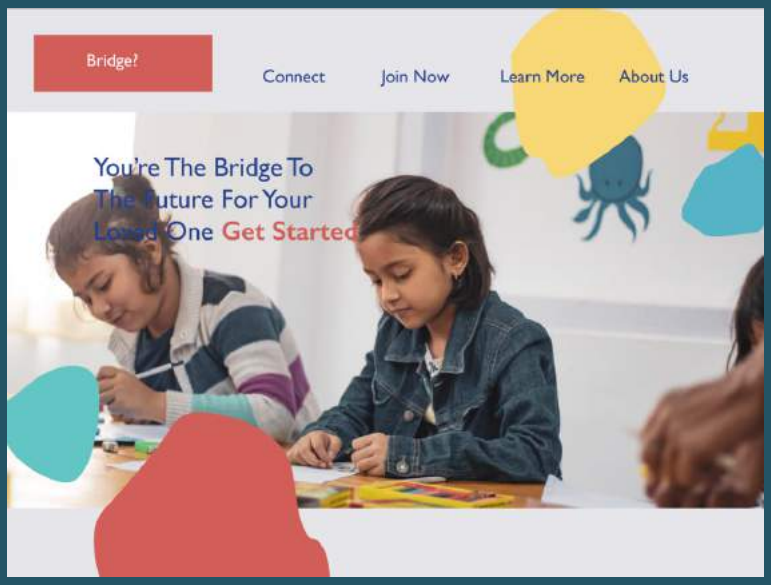
Client:

Michael Plansky

Overview: *Design a website that provides transitional resources for young adults with disabilities*

Status: In Progress





The Need

People with disabilities lack a transitional resource that assists them for life after schooling. The time after a person with disabilities turns 22 is referred to as 'a cliff' because federal and state support systems (ie schools) are no longer available after this age. Families and teachers of people with disabilities need a system to help them plan and track goals to ensure that a child is ready for this sudden loss of support. Whether this is going to college, getting a job, or going into permanent care, a guiding resource is needed to help prepare for the child's future. While resources do exist for this, they can be overwhelming to comb through with a lot of irrelevant information.

The Solution

To address this issue, we are creating a website that serves to be a database of resources for different types of disabilities for a range of needs. This website allows families to set a goal for their child and receive suggested milestones to help prepare for their future. It also allows teachers to access this information, if permitted, to allow clarity and alignment of goals. The core feature of the website is a checklist and timeline feature that provides clear and succinct tasks to build towards the child's future. This feature depends heavily on personalized data chosen during a user survey to gather details about the child and their goals.

IPAD MOUNT

Overview: *Create a secure, non-removable iPad mount for two students with disabilities*

Status: In Progress

Members:

Raymond Lin
Kevin Murphy
Thomas Hedge

Client:

Kevin Crowley- Carter School

The Need

The project is for the students from Carter School. The students tend to throw away the iPad and remove the attachments to catch the attention. One of the students is on the wheelchair hence, the mount needs to be close to the body and on the horizontal/flat surface. The mount should only be removed by the teachers and caregivers.

The Solution

The design includes vacuum clamp to the table attached to a case securing the iPad. Key locks will be implemented in the design. This design is made such that, any model of tablet can be attached and be removed for mobility. The vacuum clamp will have an additional feature so that the handles can only be moved if an adult unlocks it. This helps in preventing from the students to remove the attachments

MELODY MATRIX

Overview: *Create a device to experience the music for both hearing and non-hearing people*

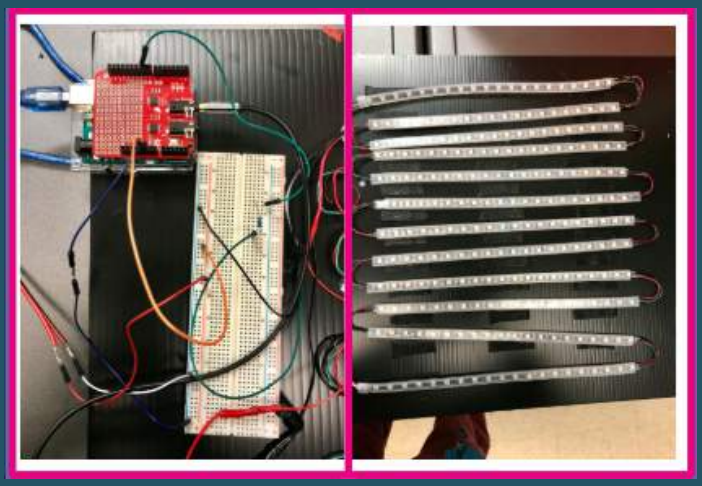
Status: Completed

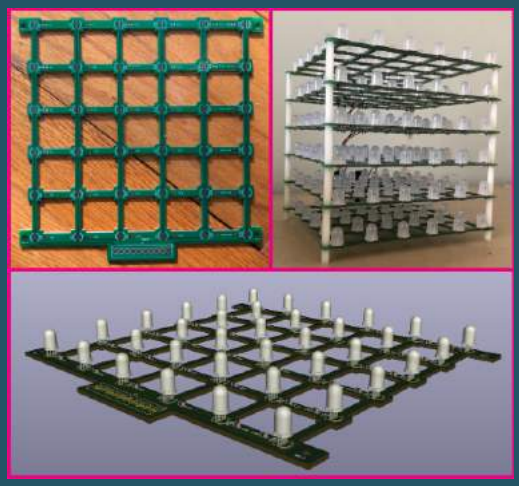
Members:

Andreas Petrides, Kelvin Ma, Yiwen Ma, Teng Zhang, Zach Neveu, Connor Rog

Client:

Alma Bournazian





The Need

Music, in the broadest sense, is an interpretation of mood and a method of storytelling. At its best, it aids people in understanding their lives spiritually and in abstracting their moods. The client has a disability of deafness and is American Sign Language (ASL) professor at Northeastern University. She loves music. Hence, the need is to design a device that makes experiencing music more inclusive, allowing both hearing and non-hearing communities to enjoy the same experience.

The Solution

Our solution is to design a system with minimal overhead that produced evocative visuals that more accurately portrayed musical information. First, we leveraged existing research in machine learning to perform genre classification to allow our system to effectively interpret the mood of the music. Second, we implemented spectral analysis to enable note-detection, which allows our system to portray harmony and melodic structures. Lastly, we opted to create our own 3D display using WS2812-controlled RGB LEDs (also called NeoPixels). We utilized a Raspberry Pi and a 6-mic array audio shield to handle audio processing, along with a NVidia Jetson to run our machine learning pipeline, and finally, an Arduino to control the LEDs. Altogether, the system provides stunning visuals in a manageable form factor with plug-and-play functionality.

PEDALING MUSIC

Overview: *Adapt a restorator to play music whilst students pedal to incentivize exercise and improve mobility*

Status: In Progress

Members:

Zoe Simson, Allia Langill, Zach Bauer, Maya Eisler and Taylor Witte

Client

Barbara Doucet, William E. Carter School

The Need

The William E. Carter School employ restorators, bike-like exercise devices, to help students develop dexterity and control. The school wants a restorator to be modified so that it provides an incentive to continue pedaling, ideally in the form of music the students enjoy. This would help engage students in restorator exercises and improve their dexterity and mobility.

The Solution

We attached a rotary encoder to the restorator's axis. This measures the rotation of the pedals. An Arduino reading the encoder signal makes audio control decisions, and a Bluetooth module sends a HID code (keypress) to the paired device. The device's operating system knows how to interpret an audio control key (pause, play, etc.), and thus pauses or plays music without any special software being installed on it. In this way, the firmware can be implemented with minimal work and no customization of the playing device need occur.

PHYSICALLY VIRTUAL

Members:
James Evans, Kelsie Nakasone, Eden Desta, Jessica Diep, Vinishaa Kumar

Collaborators:
Danielle Levac

Overview: *Create a physical therapy (PT) device that could be utilized outside a clinical setting.*

Status: Complete

The Need

Physical therapy has been used to rehabilitate and strengthen the human body for centuries. While physical therapists were originally utilized as gymnastic reconstruction aides, they now provide essential rehabilitation, habilitation, and risk and prevention training for all types of patients. Physical therapy (PT) and virtual reality (VR) are two distinct practices. Merging the two different disciplines, bringing different aspects from both, to create a device that still works with physical therapy patients, but introduces different capabilities. These include but are not limited to increasing motivation in patients, collecting more threshold values to see if there have been any improvements in users, creating engaging environments, and so much more.

The Solution

Our solution is to detect a specific set of signs/ landmarks, output to the user via audio the type of object detected, and approximate distance and heading to the object. We designed a device that allows for users to stay engaged while doing routine exercises outside of the clinical setting. We added a gaming component with VR- ideally. The design of our physical therapy device consists of a balance board and the oculus quest. The game that we have decided to build is a race car game. While the user wears the headset, they are asked to stand on a balance board. The balance board has four directions- right, left, front, and back. We programmed the movements of the board to allow the user to move the race car along the track. The Pi cameras are enclosed in a 3D printed frame and can be attached to any pair of glasses. When a user presses the button, the Pi cameras take an image and transmit wirelessly via the RPi to a python server. The images are passed through an image recognition model on the server. The server then returns a string containing the detected object type, distance, and heading to the RPi client. This is then sent to the user as speech via headphones.

PONYTAIL HELPER

Overview: *Design a device that can assist a client with limited range of motion to put her hair in a ponytail*

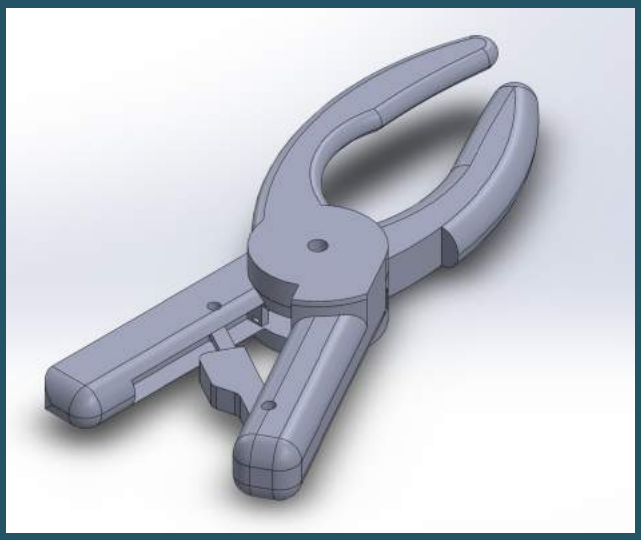
Status: In progress

Members:

Alex Rivas, Nicolas Tan, RachaeChrissanthi Boutalis, Nicholas Gregoirel Biega

Client

Lindsay Lee



The Need

The client has muscular dystrophy, which makes itdifficult for her to put her hair up or change her hairstyle on her own. The goal of the project is to design a mechanism to allow her to put her hair in a ponytail despite her limited range of motion. The ideal end-product would be functional within her range of motion and would also be safe and reusable. It would also be easily removed independently. In the past, she has had an aide assisting her at home, but she would like a mobile device that allows her to independently change her hairstyle

The Solution

After re-examining the design at the end of the previous semesters, we have concluded that it will not fit the needs of the client in an effective way. Therefore, during last semester we created a new design in a different direction that helps her put her hair up. Our new design currently consists of the following features: 1.Creating a clamp that could be placed around the hair and holding the shape of the ponytail while the user puts a hair tie on, 2.Clamp would lock to keep the hair shape and would release on demand, 3.Easy to use hair tie (possibly a bead design like the One-Handed Ponytail).

POWER WHEELCHAIR JOYSTICK COVER

Overview: *To design a waterproof wheelchair joystick cover to withstand all weather conditions*

Status: Completed

Members:

Alexandra Boyd
Michael Parrish

Client:

Jim Wice

The Need

The power wheelchair joystick is used to control speed as well as movement both forward and backward and left and right. This joystick has an electrical circuitry in it which can be damaged due to snowy and rainy weather. This leads to short circuit and prevent the operator from controlling the chair, leading to inconvenient or potentially dangerous situations. The need here is to develop a cover for the joystick that is waterproof, and it should be designed such that it must not impede the use of the joystick and protect the internal wiring from moisture.

The Solution

We designed a cover that is a semi-permanent waterproof attachment meant to cover the joystick and control panel of a power wheelchair. It still allows the user full range of motion and use of the controls and allow the user a line of sight to the controls when necessary. The device does not have sharp edges and skin contacting materials making it irritation free. The device is designed specifically for the client, with the ability to be adapted for use on other power wheelchair models. The device also allows for the attachment of a reflector as a safety add-on for use at night

SENSORY PUZZLE

Overview: *To design a simple puzzle for students with a combination of tactile and audio feedback.*

Status: Completed

Members:

Tom doyle, Denzil leach

Client:

William. E. Carter School

The Need

The William E. Carter School provides education to students with severe disabilities, affecting both their cognition and their bodies. There is still a need for more toys at the school to help students experience that they have agency and the power to change things in their environment. Current jigsaw puzzles on the market are generally comprised of small, plain pieces, which offer very little stimulation to a user's senses other than creating a two-dimensional image. Our puzzle should incorporate feedback that allows for multiple students with different disabilities to enjoy it.

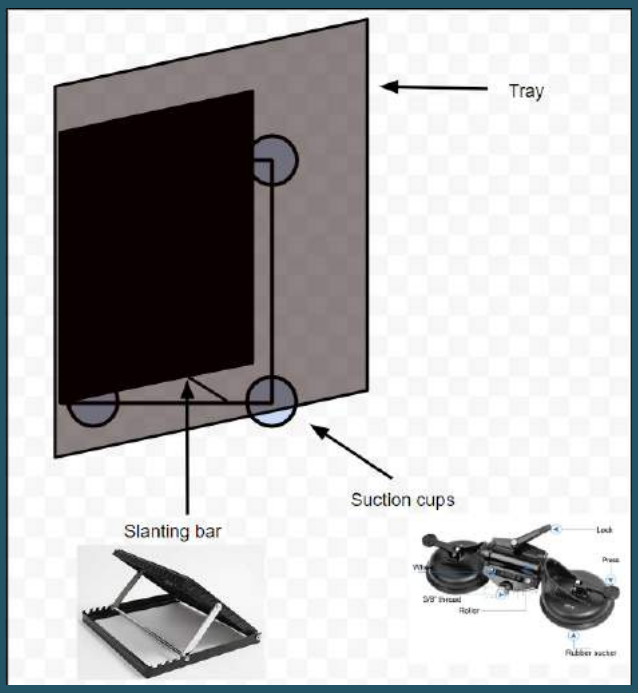
The Solution

Our puzzle includes visual, auditory, and tactile sensory feedback in order to allow students at the Carter school to reinforce the idea that their actions can influence the world. The puzzle forms a three-dimensional shape out of four pieces, so the students experience building a structure or design, and feedback from LEDs allows students to get a sense of enjoyment from placing a correct piece. Speakers gives audio feedback when the client places a puzzle piece in a correct position. Different textures on the base and smaller pieces guide and reinforce the correct locations of the pieces.

SENSORY TRAY V2

Overview: *Create a tray with sensory items to securely attach to a wheelchair*

Status: In Progress



Members:

Owen Egre
Grace Duncan

Client:

Kevin Crowley, William E. Carter School

The Need

This project's goal was to create an easily attachable and detachable sensory tray with the ability to interchange various sensory items. The tray, by nature, had to be secure, as it was attached to a wheelchair. Preferably, this tray had to have the option to be adapted for various wheelchair systems to enable other users to use the tray.

The Solution

We are designing sensory trays for various students that can be securely attached to their wheelchair tray or other flat surfaces. The tray should easily elevate at an inclined angle for better access. We will be clamping the tray onto the chair instead of using buckle straps. The sensory tray has various objects attached to it some being permanent and others interchangeable. The objects on the tray are be durable, so they do not wear down over time. Primary design challenges will include latching/clamping and tilting, as described above.

SENSORY WALL

Overview: *To design a portable sensory wall for individuals with sensory impairments such as tactile and visual to strengthen motor and visual skills.*

Status: In Progress

Members:

Arianna Ranalli, Alison Rogers, Jillian Lombardi, Teertihiveen Parsicha, Yujia Li

Client:

LifeStream

The Need

To design a portable sensory wall for individuals, specifically adults, with sensory impairments such as tactile and visual. The sensory wall should serve as a mode to strengthen motor and visual skills that is conveniently portable. The items fixed to the wall will incorporate aspects of touch, sound, and sight with the intent of creating a stimulating device that will promote interaction with the environment for the users

The Solution

The solution to this problem is to help Lifestream in expanding the treatment of patients with tactile and visual impairments. The deliverable will utilize different sensory techniques to foster development of the senses as well as posture and interaction with the environment. The product emphasizes cause and effect functions. The wall has the dimensions of 50.4 inches in height, and total width of 106.5 inches with each individual panel having a width of 35.43 inches. The design is portable so that it can be used in all patient care rooms. This was done by attaching wheels to the base of the board structure. Lifestream has requested that it demonstrate daily task skills such as light switches or doorknobs as well as sensory stimulation devices, incorporating lights and vibrations. These components will be completed using Arduino software and coding techniques.

STAIR CLIMBING WALKER

**Overview: to design a walker device
that helps client to walk on a staircase.**

Status: In Progress

Members:

Andrew Blunt, Anna DeVries, Brendan McManus, Kelsey Dupont Ozum Ozaygilli

Client:

Jessica Maxwell

The Need

Current walkers are not safe to be used on stairs because the front legs are not automatically adjustable for ascending and descending stairs, and their wheels create a risk of slipping or falling. There isn't a stair walker design that is safe to use on stairs that still has wheels that can be used off stairs. Hence, we plan to design a walker device that remains at surface level when ascending or descending a staircase

The Solution

We plan to design a walker device that remains at surface level when ascending or descending a staircase. we want to create a way for the two front legs of a walker to retract when going up the stairs, and at the same time for them to extend when going down the stairs. Our current prototype uses a linear actuator system to extend and retract the front legs. 3D printed attachments will be developed to ensure the design is complete, professional, and capable of supporting the user.

TOOTHPASTE DISPENSER

Overview: *To design a digitally and electronically enabled toothpaste dispenser to dispense specified amounts of toothpaste onto the brush.*

Status: Completed

Members:

Aiden Bradley, Chengyang Xi

Client:

Julie Wolfman

The Need

Children with or without physical or cognitive disabilities are expected to learn some level of independence as they grow, and one of the first things most children are taught to do is brush their own teeth. But teaching them does not ensure kids acquire the hand-eye coordination to effectively apply toothpaste to their own brush. As a result of that, they do not know the amount of toothpaste to be used. We propose a digitally and electronically enabled toothpaste dispenser with the ability to dispense specified amounts of toothpaste onto the brush via an adjustable knob or buttons, or even a digital display.

The Solution

Our product is a truly automatic toothpaste dispenser. The user is prompted to screw a tube of their favorite toothpaste into a standard-sized port within the product. From there, a tube leading to a small pump pulls a vacuum on the bottle and passed the toothpaste down another tube to the dispenser nozzle. A sensor mounted near the dispenser nozzle detects when a toothbrush is brought up to it and triggers the product to dispense toothpaste. The product has a basic interface for adjustable toothpaste amounts. The product has an array of LEDs to indicate where the toothbrush should be placed

VOCAL SWITCH

Overview: : *to create a device that can help the students to integrate with the virtual learning at the school.*

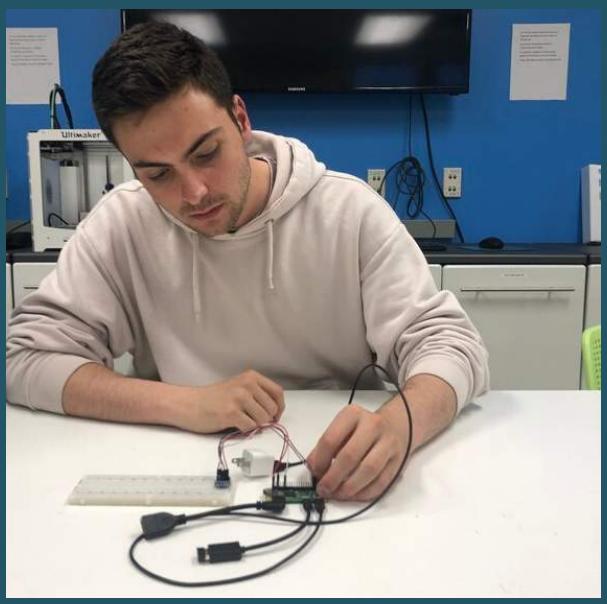
Status: In Progress

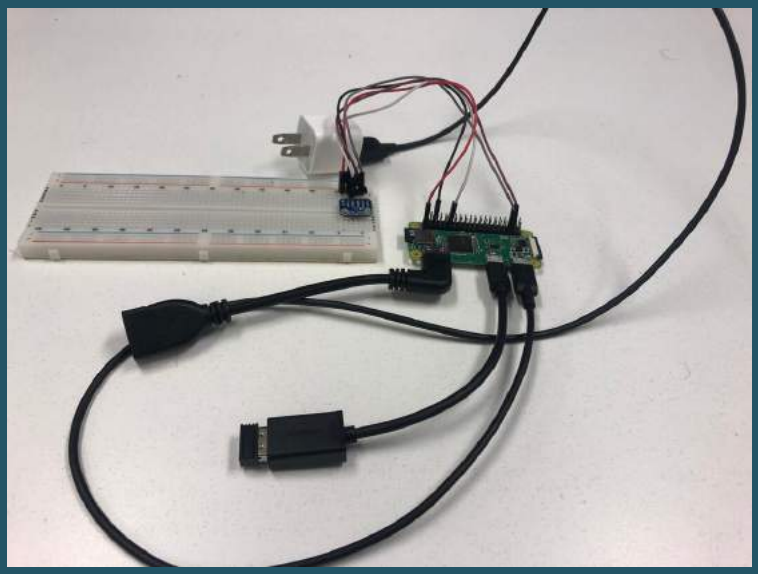
Members:

Lake Jacobs-Skolik, Leona Lau, Marley Robinson, Owen Wang

Client:

The South Shore Educational Collaborative





The Need

Students with Cerebral Palsy at the Carter School have trouble integrating with their computer software. Hence, we need to create a device that can, without using fine motor skills, integrate with the existing hardware and software used for virtual learning at the school. We are developing an audio-controlled switch—as opposed to a mechanical switch—to help these students interact with virtual learning software.

The Solution

We designed a prototype that use the vibrations of a vocal cord as inputs with limited success; however, this prototype must be tested in real time with various users. The method of using the vibrations was far too complicated. Now, we plan to implement a microphone to capture the audio. When the audio remains at a constant tone for a specified length of time, the switch will be activated by the Don Johnston switch controller.

WHEELCHAIR COOLING BACK PAD

Overview: *Create a cushion or pad that sits behind the users back to provide cooling effect on user's back*

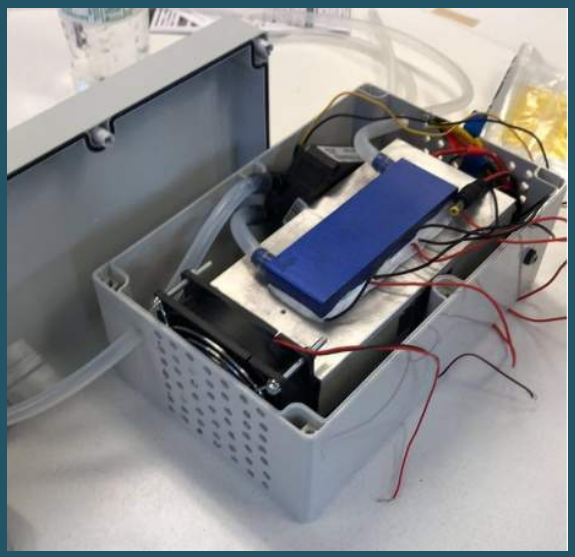
Status: Completed

Members:

Megan Sapack and Philip Del Signore

Client:

Adriana Mallozzi



The Need

Sometimes wheelchair users have issues where they get too hot. Staying in the seated position in a wheelchair causes heat to build up in the lumbar support area. This causes discomfort and unfortunately for many wheelchair users they cannot move or get up out of the chair to relieve the discomfort. This unfortunately causes these patients to be prone to overheating. We will create a cushion or pad that sits behind the users back that contains a line of silicon tubing that pumps cool water throughout the pad.

The Solution

We created a cooling cushion that employs the use of water cooled using a Peltier. A Peltier utilizes the phenomenon of thermoelectric cooling to transfer heat from one side of the device to the other side. It is a solid-state heat pump that works off the consumption of electric power. By having the Peltier module be external and only cool water circulating through the pad, the effect will be much greater. We used standard batteries as a power source and regulate the voltage through a DC-DC converter in order to satisfy the needs of the Peltier. We have the silicone tubing snake back and forth along the cool side of the Peltier in order to cool the water. Using a small pump that is powered using a 9 volts battery, the cooled water is circulated through the cushion and provide a cooling effect on the back of the user.

X-MAX GAME CONTROLLER

Overview: *Develop an alternative Xbox experience for a client with cerebral palsy*

Status: In Progress

Members:

Sebastian Ardila, Vivian Xing

Client:

Max Planksy

The Need

The client has cerebral palsy which inhibits his motor skills to the point where it is impossible for him to play video games, specifically Xbox, using traditional control systems. Our controller aims to enable him to play XBox with minimal external assistance.

The Solution

Our current solution is an array of mechanical switches suspended around Max's head which allow him to control 4 of the 10 buttons on a traditional Xbox controller. The switches are covered with large foam pads to enable comfortable head operation. The most recent update includes an inline companion controller so that an occupational therapist or friend can play the game with Max and aid him as he learns to use the device. We have currently also been working on myoelectric controls and updating it into the prototype.

YOU'RE WITH US! MENTORSHIP

Overview: *Increase social inclusion for individuals with disabilities via integration into project teams*

Status: Active

Member:

Brendan McManus

Collaborator:

You're With Us!

Overview

There is a huge need for social inclusion among individuals with disabilities. To ensure we actively engage with the populations we serve, we've partnered with You're With Us. You're With Us! is a non-profit 501(c)(3) organization and a Department of Developmental Services (DDS) service provider that creates inclusion opportunities for young adults with disabilities. The program identifies and trains college clubs, groups, and teams to welcome individuals with disabilities into their groups as they are. You're With Us! believes that a meaningful life includes a home, a job, family, friends and social opportunities with their peers - able and otherwise.

We've recently welcomed Brendan McManus, a member of You're with Us, into the Enabling Engineering family. Brendan has joined 2 project teams, Ponytail Helper (pictured above left) and Pedaling Music (above right). Brendan has a special interest in mechanical engineering and has supported both teams in assembling prototypes, determining dimensions, and brainstorming prototype improvements.

THANK YOU

Enabling Engineering wants to thank all of those that have made it possible for us to continue to scale our impact. We want to express gratitude to our collaborators for offering professional and technical expertise, our clients for providing essential feedback, and our donors for ensuring we have the resources needed to operate.

Enabling Engineering particularly thanks our major donors, without whom our work would not be possible:

Lanes Family
Richard J. Scranton Fund
Timothy Moore