Final Design Report

Freely Adjustable and Accessible Keyboard with Mouse Pad for Client with Cerebral Palsy

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Abstract

As members of the biomedical engineering senior design class, students are grouped into teams where they learn the aspects that are incorporated in engineering a product. Each team selects a project provided by the National Science Foundation (NSF) or another sponsor.

The “freely adjustable and accessible keyboard and mouse pad” is an NSF project being developed for a client with cerebral palsy. Sam is a fifth grade student at Hampton Elementary who is like any other student: he enjoys sports, he is smart and loves to learn, he is very friendly, and so on. The only problem is that he has athetoid cerebral palsy. This forces him to use an electric wheelchair, and it also affects his motor coordination. He cannot articulate through speaking, so his main means of communication is by typing on his laptop. His motor control is hindered by his disability, and this makes it hard for him to type on a normal keyboard. He also needs the help of his teachers to navigate through the computer, because he cannot use a mouse.

The keyboard that we are building him will greatly help him with his use of a computer. It is more durable, the keys are more spaced out, and it only has the keys that are necessary for him. The greatest aspect is that it contains a mouse pad, which allows him to use keys to move the mouse. Now he will not be dependent on his teachers to move the mouse for him, because he will be able to navigate his CPU solely with his new keyboard.

Figure 1. NSF Logo
Section 1: Introduction

1.1 Background

The client this project is being designed for is a male student at Hampton Elementary School who is currently in fifth grade. He has athetoid cerebral palsy, which is a non-progressive neurological physical disability, and is also quadriplegic. Cerebral Palsy is the second most common neurological impairment in childhood, affecting eight to ten-thousand babies and infants each year.¹ Cerebral palsy is a disability that begins at the fetal or infant stage, which affects the basic motor functions of victims, requiring assistive devices to perform basic everyday tasks. In most cases the need for a wheelchair is essential. Many people with this disorder have limited control over their appendages. Hand and arm movements can become distorted or unusable due to neuromuscular weakness. Walking becomes virtually impossible for most and daily tasks that the average person takes for granted, such as using their hands to grab an item, become extremely difficult. Children at school have it worse because writing or use of the computer becomes problematic.

The client’s cerebral palsy severely hinders all his motor abilities. He cannot walk and is dependent on a motorized wheelchair. He also has major difficulties trying to talk, and is forced to communicate using a keyboard to write what he wants to say. The disability also affects the position of his hands, distorting them in peculiar ways that make it very hard to perform basic everyday tasks.

¹ Cerebral Palsy Injury Resources
1.2 Purpose of the Project

Communication is vital for students in the classroom setting. The client’s disability has made verbal communication virtually impossible, so he is forced to type anything he wants to say. Typing, of course, is also very hard for him, and slows down his typing speed tremendously. Although the client is a smart and bright young boy, he cannot keep up with the rest of his classmates, because he cannot convey his thoughts nearly as fast as the average individual.

Using a keyboard is something that is taken for granted by most people, but is very difficult for people with cerebral palsy. Motor control is very limited, and the actual position of the hand can be altered, forcing it into an unnatural position. Trying to type using a hand that is twisted and distorted is a complex challenge for people with cerebral palsy. This can be very frustrating, as they cannot type nearly as fast as a normal person. The position the arm is stuck in can also put much strain on muscles supporting the arm. Because of this, typing for an extended period can become uncomfortable and eventually unbearable for a person with cerebral palsy.

The keyboard that the client uses right now is not suited to meet his needs. To be able to keep up with his class, he needs to be able to communicate at a somewhat normal speed. To be able to do this, he needs a keyboard that is designed specifically to meet his needs. The position his hand is stuck in makes it easier for him to type if the keyboard can be positioned at somewhat of an angle. Also, his motor control is limited; leading to him to slam the keys on the keyboard, which eventually causes damage to the keys. By the end of the day, his arm becomes so tired from typing that his control is worsened and he is only able to type with his thumb. A keyboard is needed that can be positioned in a way that is desired by the client, eliminating stress on his hands. The keys need to be spaced out more than average, and also extremely durable, so they are able to handle the force of his typing.

Navigating a computer using a mouse is something else that is practically impossible for our client. The precise hand movements that are required to use a mouse render it an ineffective tool. A suitable replacement for a mouse is
a mouse pad that can be put on the keyboard. By replacing a mouse with a mouse pad, he could have greater control with navigating a computer.

The purpose of this project is to design a keyboard and mouse pad that is geared to meet all of the client’s needs. By creating this keyboard, the speed of typing and using a computer will be greatly increased. With increased typing speed, the client will be able to improve his communication skills. When completed, this project will provide a means for the client to convey his thoughts in a timely manner, which will make it possible for him to keep up with his classmates.

1.3 Previous Work Done by Others

1.3.1 Products

A current product available for patients with disabilities is called FrogPad (Figure 2), which is developed by FrogPad Inc. This is a keyboard that is designed for use with only one hand. The keys are big, but each key contains 4 symbols, which make it impractical for someone with cerebral palsy.

Figure 2. FrogPad
1.3.2 Patent Search Results

Searching the patent database turned up no patents on keyboards that resemble the keyboard being designed. The closest product is FrogPad, although this product varies distinctly from the keyboard that is being designed. This design was found in the patent database with number 20060075934. The cost of this product is $149.99.

1.4 Map for the rest of the report

Figure 2. Map Outline
As can be seen in Fig. 2 on the preceding page, this report will mainly go into all aspects of the keyboard. The working prototype will then be shown, and its operation will be described. This will be followed by such sections as: realistic constraints, safety issues, impact of engineering solutions, life-long learning, budget, team member’s contributions to the project, conclusion, references and lastly acknowledgements.

First the three alternative designs from BME 290 will be presented. Please note that these are very different from the final product that was built.
Section 2: Project Design

2.1 Design Alternatives

2.1.1 Design 1

The first alternative design varies greatly from the optimal design. It was known that our client wanted a keyboard that would make it easier for him to type, and another option besides a mouse. The next three pages will summarize the basic subunits presented in Alternative Design 1.

External Hardware

The keyboard was to be designed in the correct form to accommodate the client’s unique typing style. The keyboard would have roughly the same dimensions as a regular keyboard. It was to be 20 inches long and 11 inches tall. When it was to be mounted on the stand, however, it would stand a total height of 15 inches above the desk. The keyboard was to be made with plastic that will be able to withstand normal “wear and tear”. It was decided that there would be far fewer keys on this keyboard than on a regular keyboard. This is a necessity when using extra large keys. If all the keys of a standard keyboard were to be included, the keyboard would have to be much wider and taller than 20 inches x 11 inches. This would make the keyboard too big, and would render it obsolete for our client.

The keyboard being designed was to be 2 inches thick. This would provide enough room for the key matrix, circuitry, LED’s and batteries. The keys would protrude out 0.5 inches, and all except “Enter” and “Space” were to be 1.5 inches x 1.5 inches. The stand would be circular in shape, and would be made using durable plastic. It will also need to be heavy so it will not move when the client is typing on the keyboard. Inside the plastic of the base it was decided there would be steel ball bearings, which would weigh down the unit. This added weight would make the base heavy enough that it cannot move freely on a desk during typing, but it will still be light enough so the keyboard can be picked up and moved when needed.

The stand would be supported by a diagonal member that will connect to the top of the stand, and will extend down
to the end of the bottom of the stand. This member will provide support for the stand when the client is typing on the keyboard. This member was just being decided upon now, but would be very important in later alternative designs. Figure 3 below shows the preliminary design we used for the diagonal member.

![Figure 3. Preliminary Diagonal Member Drawing](image)

The diagonal support member would not be a rigid member. Instead, it would consist of internal springs that will smoothly dissipate the force of the client typing. The spring constant, $K$, will have to be sufficient to handle the load of typing, and not be too small that the keyboard lurches back when it is pressed too hard. Using standard spring physics equations, a value of 174 lbs/in was decided for $K$. 
The keys for the keyboard being designed were to be 1.5 inches x 1.5 inches. The client has cerebral palsy, and his motor control is greatly affected because of it. It was decided that having larger keys would make it easier for him to type.

**Rubber Dome Switches**

In this design we thought we could use a rubber dome layout for the key matrix. Rubber dome switches are standard in regular keyboards, and we figured they would work well for our design also. It was said that the rubber dome switches will make up the key matrix of the keyboard. Each key would have an individual rubber dome switch, when which pressed, would send a signal to the microprocessor. Each of these switches would be connected to the microprocessor through a network of wires. The exact layout of the wires and the position of the microprocessor would be determined when the rubber dome switch layout was being ordered. Figure 4 below shows the layout that was decided upon for the rubber dome switch matrix.

![Rubber Dome Switch Layout](image)

**Bluetooth Connection**

In Alternative Design 1, we planned on using a Bluetooth Connection to connect the keyboard to the PC. Bluetooth is a very interesting new technology, and we
figured it would work perfectly for connecting to the PC. The power source for the keyboard and Bluetooth would be provided through a battery pack that would be connected to the keyboard. The programming of the Bluetooth connector would be done using software from the vendor we bought the product from, or using C++

**Joystick**

For this design, we decided on using a joystick to replace the standard mouse. A group from the previous class had gotten a free joystick that was donated by PQ controls. We decided that we would try and get the same kind of joystick they had used from PQ Controls. The joystick would also be connected to the computer using Bluetooth technology, and the power would be delivered by a separate battery pack. The casing for the joystick would be designed by us and adjusted at the machine shop.

**2.1.2 Design 2**

The second alternative design was an improvement over the first. The layout of the keyboard basically stayed the same, and at this time we were still planning on using a joystick. In the second alternative design, there were numerous changes that had been made. Instead of using rubber dome switches, Cherry MX switches were decided upon. These switches are more durable, and it is much easier to create a custom layout with them. Instead of using plastic for the keyboard casing, it had been decided that Plexiglas would be used. Plexiglas is very durable, and it would be easier to custom build the case using Plexiglas. USB connections were to replace the earlier design of using Bluetooth. USB would provide enough freedom to move the device around, and the connection also provides power from the CPU.

**External Hardware**

The keyboard itself would still have roughly the same dimensions as a regular keyboard. It was to be 55.9 centimeters long and 27.9 centimeters tall. It would still stand a total height of 38.1 centimeters above the desk. The keyboard casing in this design was changed from plastic
to plexiglass, 5 millimeters in thickness, that will be able to withstand normal “wear and tear”. It was still decided that there would be fewer keys than a regular keyboard, because, if all the keys of a standard keyboard were to be included, the keyboard would have to be much wider and taller than 55.9 cm by 27.9 cm. This would make the keyboard too big, and would render it obsolete for our client. In addition, there are various keys that are not necessary to an elementary school child, such as the “pause/break” button or the “F#” buttons.

The keyboard was designed to be 5 centimeters thick, which would provide enough room for the key matrix, circuitry, LED’s and batteries. The keys were to protrude out 1.3 cm, and all except “Enter” and “Space” were to be 5.1 cm by 5.1 cm. The “Enter” button would be 10.2 cm by 5.1 cm and the “Space” button would be 15.2 cm by 5.1 cm. The stand would be circular in shape, and in this design we decided it would be made using chrome, a strong material. It would also need to be heavy so it will not move when the client is typing on the keyboard. The chrome base would weigh down the unit. This added weight would make the base heavy enough that it cannot move freely on a desk during typing, but it would still be light enough so the keyboard can be picked up and moved when needed.

The stand would still be supported by a diagonal member that would connect to the top of the stand, and would extend down to the end of the bottom of the stand. This member would provide support for the stand when the client is typing on the keyboard. In this design it was decided that the diagonal member would be composed of two members. The two tubes would be close enough so they rub together when moving. This would prevent the tube from buckling. The hollow tube would also be lubricated so the two tubes never stick together. When the member is built, it would be tested by pushing it down fifty times to see if it buckles or sticks. If it did not it would be considered usable and would be attached to the keyboard case.

The keys we were using would be purchased from PI Engineering, which supplies keys made for Cherry MX switches. Despite the fact the keys are larger, they snap into the switches, creating a strong connection. This would prevent the keys from not transmitting downward force with an angular hit of the key cap. The result would be
the same if the client were to hit the center of the key as opposed to hitting an edge or corner.

**Cherry MX Switches and Matrix**

The rubber dome switches were replaced with Cherry MX switches in this design. It was also decided that they would be mounted upon a PVC backing. The Cherry MX switches and the PCB backing would make up the internal layout of the keyboard. Each key would have an individual switch and within each switch there is a spring. When the key is pressed, the spring is compressed and the circuitry beneath the switch is completed, allowing for a flow of current to pass through. A diagram of the Cherry MX switches used is shown in Fig. 5.

![Cherry MX switches diagram](image)

*Figure 5. Cherry MX switches, side and top view. The dimensions are displayed both in inches and in (millimeters).*

The switches would be wired into a Column input on the microprocessor of the control board, and the other side of each switch would be connected to a standard signal diode (LN 4148) and will then be connected to a Row Input on the microprocessor. The diode’s were decided upon because they isolate each switch, so if more than one key is pressed down at the same time, the signals will not interfere with each other and cause unwanted symbols to appear.
Keyboard Control Board

For this design, the keyboard would use a Control Board purchased from PI Engineering. The control board would connect directly to the computer using a USB connection. USB was decided upon because it provides power, unlike a Bluetooth Connection. The Cherry MX switches would connect to the control board through a Female Header Receptacle. Once the layout of the switches is designed, and they are connected to the control board, the microprocessor would have to be programmed to interpret each of the incoming signals.

LEDs

This design also incorporated LED’s for a background lighting effect and aesthetics. The power for the LED’s would come from the control board, which is powered from the CPU through USB. The LED’s would be positioned along the edges of the keyboard to provide an impressive lighting display. The LED’s were going to be incorporated into our circuit prior to the switch on the key matrix. This would allow the LED to remain lit as long as there is power, neglecting the act of typing.

Joystick

A joystick was still used in the design, to replace the mouse, and it still would be provided by PQ Controls. It is composed of steel and thick-walled glass reinforced nylon components. It is extremely durable and versatile. The joystick from PQ Controls that we were planning on using was the M212 Multi-Axis Joystick. It would be connected to the PC using USB, which will provide power and be long enough so the joystick can be positioned where the client wishes. This is different from Alternative Design 1, in which we thought we would use Bluetooth. The joystick would be mounted in a 0.5 cm thick plexiglass box, which will provide enough support for the movements that are created by the client.
2.1.3 Design 3

The third alternative design was an improvement over the first two. There were numerous changes from the last design. Instead of implementing a joystick in the design, it has been decided that an arrow pad would be easier for the client to use. In the last design, Plexiglas was chosen to build the keyboard case from. It was brought to our attention that Plexiglas does not have the durability that is needed, so in this design the case was to be made from PVC. The diagrams of the stand were much more detailed, and much more analysis was performed on the members. The diagrams of the internal structure of the keyboard were also improved upon in greater detail. Lastly, means of testing the stand and the keyboard while they are being built were described, improving greatly on a topic that was basically skimmed over in the first two proposals.

External Hardware

The basic layout of the keyboard remained relatively unchanged from Alternative Design 2. The dimensions were all the same, and the diagrams remained basically the same. The stand was to be constructed of PVC this time, not Plexiglas. The stand was still circular in shape, and would be made using PVC. It would also need to be heavy so it will not move when the client is typing on the keyboard. To accomplish this, the base was to be filled with heavy steel ball bearings. The bearings would then be secured inside a matrix using a gel that hardens after a certain period of time. This is an improvement on Design 2, in which we only had ball bearings freely moving inside the base. The base would weigh down the unit and the added weight will make the base heavy enough that it cannot move freely on a desk during typing, but it will still be light enough so the keyboard can be picked up and moved when needed.

To test the base, five random individuals from the senior design class would then be asked to pretend to type on the “keyboard” for about 20 seconds. The movement of the stand, if any, will be noted. The subjects would then be asked if they noticed any movement, and if this movement is enough to hinder their normal typing speed. If the stand does move enough to cause a negative response, more steel ball bearings will be added to the base to increase
the weight of the stand. Then testing will be performed again, and this will go on until it is confirmed that the base has no unwanted movements.

The diagonal member would be mounted on a pin in this design, so that it could move freely. The diagonal member would still be composed of two members, both made from PVC. The hollow tube member would be lubricated so the two tubes never stick together. When the member is built, it will be tested by pushing it down fifty times to see if it buckles or sticks. If it does not it will be considered usable and will be attached to the keyboard case.

Both ends of the support member would be secured to the stand using industrial strength epoxy. The spring would be mounted on a cutout piece of PVC secured by epoxy on the bottom of the hollow member. The other end of the spring would be attached to the second part of the diagonal member that is attached to the vertical member of the stand. The spring would be securely attached by having it go through both ends, then using epoxy it would be glued down. To make sure the spring doesn’t detach, and one end of the diagonal support member does not pop out, testing would be needed. After all the epoxy had set, approximately 24 hours, the member would be held vertical, so that the end that attaches to the vertical member would only be held in place by the spring. The spring would then be fully compressed, then let go. This would be performed 50 times, to make sure the spring does not come loose. If the member passes this test, it would be considered usable and will be secured onto the stand.

The keys would still have the same dimensions, and would still be purchased from PI Engineering. To make sure the keys would not fail when being hit, testing would have to take place. Once the keycaps had been securely fastened, the key would be compressed and decompressed in the center continually for a time of 1 minute. Then this would be done again, except the key would be hit at one of its four corners. Once this had been done for all four corners, and it had been determined that the keycap is fastened securely, the keys would be connected to the control board.
Cherry MX Switches and Matrix

The Cherry MX switches, the PVC backing and the wiring of the switches to the control board were to make up the internal layout of the keyboard. Each key would have an individual switch and within each switch there is a spring. When the key is pressed, the spring is compressed and the circuitry beneath the switch is completed, allowing for a flow of current to pass through. These switches have an actuating force of approximately 2N. It was estimated that a force of at least 100N can be sustained by a switch (well suitable for the purposes of our device).

Each switch would be mounted on PVC, and connected below the PVC. The back layer would be solid PVC, with minor holes cut out to have the row and column inputs open for soldering. It would be secured using epoxy and screws. The top layer would have to be altered in the machine shop to have precisely cut holes for every switch to fit into. It would then also be secured to the keyboard casing using screws and epoxy.

Testing would be necessary in the fabrication of the PVC layers. Precise measurements must be made to make sure they are being cut exact. After the first hole is cut in the top PVC layer, a Cherry MX switch would be snapped into place, to make sure the hole is the correct size. Every hole after this would be treated the same way, to make sure there are no mistakes. Once all the switches were snapped in, and the PVC frames had been mounted in the keyboard casing, it would be necessary to test that the PVC frames are securely in place. Significant pressure would be applied on all parts of the top and bottom frame, for a total of five minutes. If the PVC backings do not move, they would be considered to be secure, and no adjustments would be needed.

Keyboard Control Board

The keyboard control board would still be the same one that was described in Design 2, ordered from PI controls.

LEDs

The LEDs would still be used to provide a “cool” look to the keyboard. The power for the LED’s would come from
the control board, which is powered from the CPU through USB. The LED’s would be positioned along the edges of the keyboard to provide an impressive lighting display. The LED’s were going to be incorporated into our circuit prior to the switch on the key matrix. This would allow the LED to remain lit as long as there is power, neglecting the act of typing.

**Arrow Pad**

Instead of using a joystick to replace the mouse, it was decided that an arrow pad would be a better option. The arrow pad would consist of 8 keys, all of which will be the same size used in the keyboard. It would use Cherry MX switches like the keyboard, and the switches would be mounted in the same way. The arrow pad would connect to J6 of the control board, which is an input area for number and arrow pads. The arrow pad is basically the same as the keyboard, and it would be built the same way. All the testing done on the keyboard would also be done on the arrow pad. The arrow pad itself would be 17 cm x 17 cm.
2.2 Optimal Design

2.2.1 Objective

This project report will describe the design of a custom made keyboard for a child with cerebral palsy. The client this device is being designed for has athetoid cerebral palsy, and has trouble controlling his motor movements. He is a very smart child, but has trouble keeping up with his classmates because he is non-verbal. His only means of communication is by typing words on his computer. However, his cerebral palsy contorts his hand in a position that slows down his typing speed. This causes him to be slower than his other classmates, and fall behind in his schoolwork. The device being designed will be custom built to meet his requirements for a keyboard that will be easy for him to use.

To accomplish this, the keyboard must larger and more accessible than a normal keyboard. It must be able to be positioned at an angle, and be adjustable so the client can choose the position he likes best. It must be able to withstand the pressure of slamming keys without wobbling or falling over. To accommodate for the client’s poor motor controls, the keys will be regular sized but will be spaced out so he can easily hit a desired key. Also, a mouse pad will be used to replace a standard mouse.

In addition to the normal internal architecture of the keyboard, LED’s will also be used to create a backlighting effect. The client is in elementary school, and having a keyboard that will look different in a negative way may make him stick out. By using LED backlighting, the keyboard will look “cool”, and will help him fit in better.

The main components of the device are the case, the control board, the PCB and the switches. Figure 6 on the next page shows an outline for building the project.
Figure 6. Project Outline
2.2.2 Subunits

Introduction

In this section, a detailed description of each subunit of the design will be provided. The project can be divided up into two parts, electrical and mechanical. This section will begin with the electrical parts: switches, PCB, Control Board, and other electrical components. Then a description of the mechanical aspect will be described, which can be encompassed by describing the design of the external case. Let us now begin with the section on the switches.

Switches

One of the most important components of the keyboard are the switches used in the design. These must very durable and long lasting, so the keyboard will last a long time for the client. After much deliberation, it was decided that Cherry MX Switches were the best choice for the keyboard. These are very durable switches that are made to be mounted in a printed circuit board. Listed below are their features, and following this are their specifications:

Features:

- Desktop profile, 0.60 inch (15.2mm) from PCB (no keycap)
- Choice of feel: linear, soft tactile, click tactile
- PCB or frame mount
- Long life: 50 million operations (linear) and 20 million operations minimum (tactile)
- 4mm travel
- LED, diode or jumper option
- 12V maximum AC/DC
- Current Rating: 10mA
- Insulation Resistance: <100MΩ at 100V DC

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2 Cherry Corp. Website
Specifications

**Electrical**

**Voltage:**
- 12 VAC/DC max.
- 2 VDC min.

**Current:**
- 10mA AC/DC max.
- 10µA DC min.

**Insulation Resistance:** 100MΩ at 100V

**Initial Contact Resistance:** 200mΩ (25mΩ typical)

**Bounce Time:** ≤5msec (at 16 in/sec. actuation speed)

**Capacitance:** <2pF (at 1kHz)

**Operating Temperature:** -10°C to +70°C

**Storage Temperature:** -40°C to +70°C

**Flammability Rating:** UL94HB

**Materials**

**Case:** Thermoplastic

**Contacts:** Silver-Gold?? (AuAg 10)

**Spring:** Stainless Steel

**Solderability:** Wave solder, 5 seconds at 500°F

As can be seen, these are very durable keys. These switches have an actuating force of approximately 2N. The maximum force they can withstand is not defined in the data sheets, however it is estimated that a force of at least 100N can be sustained by a switch (well suitable for the purposes of our device). A diagram of the Cherry MX switches used is shown in Fig. 7 on the next page.
Figure 7. Cherry MX switches, side and top view. The dimensions are displayed both in inches and in (millimeters).  

Figure 11 below shows an image of the Cherry MX switch mounted on a PVC backing.  

Figure 11. Cherry MX switch with PVC backing and photo
PCB

The printed circuit board is the backbone of the design. The switches and other electrical components are all mounted on it, and it is through this that the signals are sent to the control board. It was very important that the design of the PCB was accurate, because it is very expensive, and once it was ordered, it had to be used.

To design the PCB, Express PCB software was used. It was very intuitive software, and took little time to master the program. The PCB was to be centered around the switches, so the first task was to create pads for the switches. Figure 12 below shows a diagram made in MS Visio of the dimensions of the pad to be inputted into Express PCB.

![Figure 12. Switch Hole Positions](image)

Figure 12. Switch Hole Positions
The switches had to be placed in a matrix of rows and columns, following the outline of Figure 13 below.

Figure 13. Switch Matrix
Once an outline was made corresponding to the dimensions in Fig. 12 of the holes for the switches, it was easy to replicate that for all the switches. It had to be made sure that every switch was placed one inch apart, to correspond with our design. Figure 14 below shows the first preliminary design. This contains five rows of switches with no wiring. The important thing is that each switch is placed one inch apart.

Figure 14. First PCB Design

In this design, the rows are wired together, but the columns are not. Pads are also present for diodes and LEDs that were to be mounted.

The next task was to complete the wiring of the rows and columns. This was somewhat challenging, but by using the bottom and top layers, every row and column was connected successfully. Figure 15 on the next page shows the progression of the PCB, as the rows and columns are wired together.
As the design of the PCB changed, so did the design of the keyboard. The next step in the PCB design incorporated the new switch layout, along with running the rows and columns into the correct outputs. Figure 16 below shows how the rows and columns were to be output from the PCB.

Only the shaded holes were to be utilized on the control board. This meant that the rows and columns had to be wired to these holes. Figure 17 on the next page shows the output pads from the PCB, to be wired to these inputs.
Along with arranging the outputs, the third PCB design also experimented with incorporated LEDs (circuit and components explained in next section) into the design. This proved to be too much wiring, and would have to be changed in the final design. Figure 18 on the following page shows the third design of the PCB, with all the changes that were mentioned.
LED backlighting could not be incorporated into the entire keyboard, so another option had to be chosen. It was decided to put LEDs only behind the mouse pad. This is the most important aspect of the keyboard, so it seemed fitting to have those keys illuminated through LED backlighting.

Figure 19 below shows the fourth design of the PCB. As can be seen, the layout of the switches also changed somewhat.

To save area, the PCB outline was also changed. Along with saving room, this also acted to make the PCB cheaper in cost.
The LED circuitry of the mouse pad of the PCB can be seen in detail below in Fig. 20.

It is obvious that the wiring is very "busy" in this area. Many wires are crossing, and it was not easy to accommodate every row and column. To go from one layer to another, vias (small filled holes) were used in many places. Without the use of vias, this circuit could not have been created.

The final design of the PCB had minimal changes. The circuit was condensed as much as possible to save space and money. Figure 21 on the next page shows the finished PCB that was ordered from Express PCB. The total cost came to $168.00.
Figure 21. Final PCB Design
Figure 22 below is a picture of the PCB that arrived about three days after the order had been placed.
The next step was to solder all the electrical components to the PCB. This was an arduous task, but was completed successfully. Figure 23 below shows the PCB with everything soldered to the board.

Figure 23. PCB with soldered components

Current is also passing through the LEDs, which is how they are lit up in this picture.

Figure 24 on the next page shows the control board which is wired to the PCB.
Figure 24. PCB with Control Board

Figure 25 on the next page shows a front view of the PCB. From this picture the height of the switches can be seen.
Figure 25. Front View of PCB
Diodes

Diodes were implemented into the design of the keyboard to eliminate “ghosting”. They are placed in between the switches and the control board. When a key is depressed on a normal keyboard, it will keep registering until the key is elevated. For our client, this is a major problem. For example, sentences that he types will normally look like this. By utilizing diodes, this is prevented. No matter how long a key is depressed, it will only register once. Figure 26 below shows an image of a normal diode.

Figure 26. Diode
LEDs

To illuminate the keyboard and make it more aesthetically pleasing, LEDs were incorporated into the design. At first it was planned to have LEDs behind every switch, but as was explained in the PCB section, this was not plausible. Instead, LEDs are incorporated behind the arrow pad of the keyboard.

The basic circuit of the LEDs is given below in Fig. 26.

![LED Circuit](image)

Figure 26. LED Circuit.

It is a very simple circuit in which a resistor is placed in between the voltage source and the LED, so that too much current does not pass through the LED. On the next page in Fig. 27, the LED circuit used in the design is shown.
This circuit is the same as fig. 26, except there is a potentiometer in between the voltage source and the LEDs. In the final design, the potentiometer was replaced with a switch. This allows the client to turn the LEDs on and off.

To figure out the correct resistors to use, Kirchoff's voltage equation was used.

\[ V = IR \]

\text{Equation 1}

In this equation, \( V \) stands for voltage, \( I \) for current, and \( R \) for the resistance of the resistor. The voltage in our design was taken from the USB connection, and was 5 volts. The voltage drop of our LEDs was 2.4 volts, and the LED current rating was about 20mA. Equation 2 below shows the equation that was used to find the correct resistance.

\[ \text{Resistance} = \frac{\text{Voltage of supply} - \text{LED voltage drop}}{\text{LED current rating}} \]

\text{Equation 2}

Solving gives a resistance of 330 ohms. On the next page in Figure 28 is an image of the LED circuit being tested on a protoboard.
Figure 28. LED circuit.

Figure 29 on the next page shows an image of the LED circuit functioning on the PCB.
Figure 29. LEDs on PCB

Figure 30 on the next page is an image of the LED circuit on Express PCB.
The voltage comes in through the resistor, passes through the LED, and then goes to ground. The top wires are the incoming voltage from the USB connection, and the bottom connects to ground.
LED’s (light emitting diodes) are semiconductors and contain a material that has varying ability in conducting electricity. The material used is usually aluminum-gallium arsenide, AlGaAs. There are two layers of the LED, one containing negatively charged particles and one containing positively charged particles. When current passes through the LED properly, that is the positive charged particles are connected to the negative end of the battery, the zone in between (depletion zone) gets larger. This effect coupled with a specific arrangement of electrons produces light.
Control Board

The control board that was used in this design was purchased from PI Engineering. Figure 33 below shows an image of the control board.

The thirty-pin header on the bottom of the board receives the current from the various switches when they are triggered. This header allows for one hundred and twenty eight keys, many more than were needed. The holes, labeled with a “C#” or “R#”, represent the columns and rows of the keyboard respectively. The control board is connecting the CPU through a USB connection, which also provides the 5V power source. In the center of the board is a microprocessor. This device was programmed to fit the keyboard’s specific needs.

This integrated circuit is 2 inches by 2 inches and has four mounting holes to secure it. As mentioned earlier, the control board connects directly to the computer using a USB connection. The Cherry MX switches
connect to the control board through a double row Female Header Receptacle (see Fig. 34 below). Once the switches are all wired to the control board (see Fig. 13 for wiring layout), the microprocessor was programmed to interpret each of the incoming signals.

![Female Header Receptacle Diagram]

Figure 34. Female Header Receptacle

Figure 35 on the next page shows an image of the control board with a single switch connected.
To connect the control board to the switches, the female header receptacle had to be wired to the control board inputs. Referring to fig. 33 and the inputs figure below, each input point can be determined.

Figure 35. Control Board

Figure 36. Inputs
Wires were soldered to the PCB and then connected to the female header receptacles. Figure 37 below shows a picture of the wires and the connections.

Figure 37. Wiring
To program the control board, the program that was included with the matrix board was used. This is called “Macro Works”. Figure 38 below shows the basic screen of the program.

Figure 38. Macro Works
Each box in the picture represents a row and column point. The program that was used for the keyboard contained five rows and thirteen columns. There is also a layer toggle key, so each switch has two functions. The mouse pad acts to control the mouse in layer 1, and layer 2 it acts as arrow keys. Each letter key has a lowercase and uppercase option, and miscellaneous symbols are included on the number keys.

The control board is also able to eliminate “ghosting” through the use of the diodes used on the PCB. When our client presses and holds a key down, it only registers it once. This was a problem our client was having which is solved through the use of this keyboard.
External Case Design

Before the external case could be designed, the layout of the keyboard had to be determined. It was narrowed down to two options, a five row keyboard (Fig. 39), or a four row keyboard (Fig. 40).

Figure 39. Five Row Design
Figure 40. Four Row Design
After reviewing with Miriam and Sam’s team, it was determined that the five row design would be the best option. The whole case would be made from PVC, so the next step would be to cut out the key holes. The keys and their dimensions can be seen in Fig. 41 below.

![Figure 41. Keys and Dimensions](image)

The hole size can also be seen in fig. 41.

The center of each hole was determined using Visio in fig. 42 below.

![Figure 42. Hole Centers](image)
Figure 43 below shows an image of the keys with their hole outlines around them.

As can be seen, the diameter of the milling bit was to be 0.15 inches.

Figure 44 on the next page shows an image of the expected top piece cutout.
To cut out the PVC, the milling machine was programmed with the help of Rich and Serge to cut out each individual hole at exact positions. The end product can be seen in Fig. 45 on the next page.
Figure 45. Top Piece Cutout

Figure 46 on the next page shows a side view of the top piece, and Fig. 47 shows the top piece with the keys in between the cutouts.
Figure 46. Top Piece Side View
Figure 47. Top Piece with Keys
The next step was to cut out the bottom piece. This would be constructed of a double layer of PVC glued together using PVC Cement. There would have to be holes to mount the switch PCB, and to mount the top piece. Figure 48 below shows the Visio image used to model the switch PCB and control board on the bottom piece. Figure 49 then shows the holes that were to be drilled.

Figure 48. Bottom Piece
Figure 49. Bottom Piece w/ Holes

The bottom piece was then given a final model with nothing imposed on it in fig. 50 on the next page.
The PVC was then milled and the holes were at the correct position. To mount the switch PCB, mounting pieces were cut out to a height of 0.70”, and were threaded to fit screws with a machine thread of 6-23. The top piece would be mounted using spacers with a height of 1.0”. 

Figure 50. Bottom Piece w/ Mounting Holes
Figure 50A below shows the finished case with the mounting spacers screwed in.

Figure 50A. External Case Bottom
Figure 50B below shows an image of the case with the top placed on.

Figure 50B. External Case with Top

Figure 51 on the next page shows a front view image showcasing the spacers and how the PCB would be mounted.
Figure 51. Front View of Case
As can be seen, the two layers of PVC act for support and for room so the top of the screws can be flush with the rest of the case. Figure 52 below shows a side view of the case, with the keys included.

Figure 52. Side View with Switches

Figure 53 on the next page shows a picture of the PCB mounted to the bottom piece of the PVC.
As can be seen in this image, the PCB is very securely connected to the bottom piece.
The last step in the construction of the case was to add the supports to raise the case at an angle. This was done by putting supports on the back of the keyboard. Figure 54 shows an image of this.

As can be seen, when the supports are extended the case raises at a certain angle. The supports were made of two pieces of PVC glued together using PVC cement. The height of the supports is 3 inches.
2.3 Prototype

Figure 56. Keyboard

Figure 56 shows the completed freely accessible keyboard with mouse pad. The main components are labeled in Figs. 57 and 58 on the next two pages.
Figure 57. Keyboard Internal Parts
Figure 58. Keyboard External Parts
Figures 58A and 58B show side views of the keyboard with the cover on and off.

Figure 58A. Side View of Keyboard
Figure 58B. Side View of Keyboard (top removed)
As can be seen from the two figures, there are not many components that need to be tested with the keyboard. When first using the keyboard, the client should plug in the USB Cable to an available USB outlet on the computer or laptop. Figure 59 below gives an example of the USB Cable being plugged in.

Figure 59. USB Cable being plugged in
After the keyboard is plugged in, the computer should recognize it automatically and it should be functional. To test each key, open a Word document and test each key by pressing each key down. Refer to Fig. 60 below.

Figure 60. Key being tested (note: cover should normally be on)
After testing the keys, the mouse pad should be tested. Figure 60 below shows an image of the mouse pad. The arrows should move the mouse in the direction they are pointed in, and “left click” refers to the left mouse button, “right click” refers to the right mouse button, and “double click” refers to double clicking the left mouse button.

Figure 61. Mouse Pad
Once the keys have been tested, it is important to test the “shift lock” key. Figure 62 below has the shift lock key highlighted.

Figure 62. Shift Lock Key
When the keyboard is in the second layer, all the letters should be capitalized. The keys with two symbols will refer to the top symbol. The mouse pad should also act as an arrow pad. When the keyboard is in the first layer, the green light on the control board will be lit up (Fig. 63). When it is in the second layer, the red light should be lit up.

Figure 63. Control Board in first layer
After all of the keys have been tested, it is important to test the LEDs that are under the mouse pad. Figure 64 below shows an image of the on/off switch. The up position should turn the LEDs on, and the off switch should turn the LEDs off. Try flipping the switch a couple of times to make sure it is working.

Figure 64. Front View of Keyboard with LED switch in view
The LEDs when lit up should be noticeable. Figure 65 below shows a close up of the LEDs with the top of the keyboard removed.

Figure 65. LEDs under Mouse Pad
This keyboard also has lift supports on the back that can raise the keyboard at an angle. Figure 66 shows the back of the keyboard with the lifts.

Figure 66. Back of Keyboard with Lifts
To raise the keyboard, simply turn the lifts until they are orthogonal to the desk. Figures 66 and 67 show the keyboard raised to an angle with the lifts extended.

Figure 66. Front View of Keyboard at an angle with Lifts extended
Figure 67. Side View of Keyboard with Lifts extended
If there is any need to access the interior of the keyboard, the top cover can be removed relatively easily. It is attached with four flathead screws, which are labeled in Fig. 68 below.

Figure 68. Top Cover with Screws Labeled
To remove the top cover, simply unscrew the four screws and lift the cover up and off. Figure 69 below shows an image of the keyboard with the top cover removed.

Figure 69. Internal Keyboard
If there are any problems, after opening the keyboard one should first check the control board, pictured below in Fig. 70.

Figure 70. Control Board

First make sure that the female header receptacles (connect the control board to the PCB) are secured firmly. Second, make sure the USB Cable is attached firmly to the control board. This should fix any problems that have been occurring.
Section 3: Realistic Constraints

This project incorporates many industry engineering standards concerning economic, environmental, social political, ethical, safety, manufacturability and sustainability factors, along with realistic constraints, into the design of the keyboard and arrow pad. ASTM publishes information on industry standards every year, and they are in place to set guidelines and put the safety of the public, buyers, or client in our case above all. The standards require that economically the product must be at a competitive price. The product, in no way, should pose any threat to the environment, and any byproducts must be environmentally safe. The product must not be too hard to manufacture, or there must be some means to produce a large quantity if the market requires it. It should meet all ethical standards, and in no way can be a health threat. The safety of the device must be considered extremely important, and there must be no way that people using the device can harm themselves or others.

The keyboard that is being designed meets many engineering standards, basically because it is safe, and will last a long time. Although computer keyboards are incredibly common today, this keyboard is different in that it is being custom built for client, and will be significantly different than the average keyboard.

Economically, the keyboard will be somewhat more expensive than an average keyboard. The keyboard must be made to last a long time, so flimsy or fragile parts cannot be used throughout the design. To save money, the parts must also not be too expensive. The keyboard was designed using parts that are good in quality but not too expensive. A good example of this is the Cherry MX switches. They are inexpensive, but can withstand normal keyboard wear and tear for years, making them a good choice. The stand in the design was modeled after a “common” flat panel monitor stand that can be ordered at a relatively inexpensive cost, if it is too much to order a custom stand. There are keys that are built for large key keyboards that come in the dimensions specified in the design, so these can be ordered. LED’s were chosen to give the keyboard an aesthetical appeal, because they are inexpensive and have a decent lifespan.
The keyboard and arrow pad will be used in a classroom environment, so there aren’t many environmental concerns that have to be considered. The average operating temperature is expected to be 70°F, which normal electrical components should have no trouble operating in.

When designing the keyboard in conjunction with the arrow pad, sustainability was a big factor. This keyboard and arrow pad will have to last the client throughout his elementary, middle and high-school education. He is in fifth grade right now, so this means it will have to last him seven years. To prevent broken parts, durable PVC and plastic parts are being incorporated in the design of the keyboard. The keycaps will be detachable; therefore easy to clean. Simple computer wipes, a damp cloth, or q-tips will be sufficient enough to clean the device.

Manufacturability of the keyboard is a serious constraint, because most keyboards are manufactured hundreds at a time. Manufacturing a single keyboard is difficult, because it requires custom built parts that may be hard to create. The switches used in the keyboard are very common, and should be easy to use in the design of the keyboard. As mentioned earlier, the keys themselves may be ordered from a company that builds large keys, avoiding the trouble of having custom built keys made. The stand may follow the same path, again avoiding the trouble of ordering custom built parts. The keyboard base may be custom built, but this should not prove a huge constraint in the manufacturing of the keyboard. Most of the other parts are very common, and should not be a problem.

The keyboard and arrow pad should pose no ethical constraints for the project. In no way does the project directly affect the health or well-being of the client. The keyboard and joystick do not attach to the client in any way. USB technology was used to make the keyboard and joystick portable enough for our client’s use. Durable plastic was also incorporated into the design, so that no parts could accidentally break off and pose a hazard to people nearby the keyboard.

By using such a different looking keyboard, it was considered that the client may feel socially awkward. This is why LED backlighting was decided upon when designing the keyboard. With these added to the keyboard, the project will not be an eyesore to anyone who looks at it. Instead,
LED backlighting will have quite the opposite effect. Instead of being socially awkward, our client’s keyboard will look “cool”, and other classmates may even be envious of it.

As can be seen, the optimal design of this product does indeed incorporate many engineering standards and realistic constraints. When designing the product, these constraints were given good consideration and helped in the final design of the product.
Section 4: Safety Issues

Safety was of course a major concern in the design of this project. It would be horrible if in any way this project caused physical harm to the client or anyone else. Precautions were taken in the design of the keyboard and arrow pad to make sure that the project meets safety requirements and in no way can pose a safety threat.

Mechanically, the keyboard could pose a threat if it is typed on with significant force. If a piece of the keyboard broke off, it would be a dangerous projectile that could cause harm. To avoid this from happening, the keyboard was designed with durable plastic and Plexiglas that can withstand mechanical abuse. The Cherry MX switches used for the key matrix have internal springs, and smoothly absorb the energy caused by typing on the keys. The safety aspects of the keyboard integrated with optimal mechanics is essential in preventing the keyboard from falling apart.

Another safety concern is the fire hazards that the LED’s pose. By running at lower power, the LED’s will not generate enough heat to pose a fire hazard. In addition, the LED’s will not be placed within a considerably close proximity to any electrical or plastic parts. By doing this, it can be ensured that no parts will melt or get burned, which could then pose a threat to the client.

The electrical connections are all sealed within the keyboard case, so there is no danger that the client will somehow get electrically shocked from the keyboard. The power is provided through a USB connection, and these wires are sealed and also pose no danger. It is important to ensure the keyboard is sealed properly for protection and sustainability.

All the corners of the keyboard will be rounded to prevent any sharp corners puncturing the skin. The wires will be insulated to prevent any electrical problems that could pose a threat to the client. Along with the keyboard, the arrow pad is made in the exact same manner, which is very durable and will not pose any threat to the client. In this project, safety is addressed and the keyboard and arrow pad will not cause harm to its user or anyone else.
Section 5: Impact of Engineering Solutions

Designing an alternative keyboard for people with cerebral palsy can have global, economical, environmental and societal impacts. This effect can hopefully benefit patients with cerebral palsy while adding to the biomedical research currently used. Such impacts can enhance engineering solutions for people with similar conditions.

In a global viewpoint, the freely adjustable and accessible keyboard can provide people all around the world with an improved communication device. The disorder affects approximately two to four individuals for every 1000 births. It is estimated that over 750,000 people living in America alone have some degree of cerebral palsy. The worldwide statistics of people with cerebral palsy have yet to be calculated with such elevated levels. This keyboard, if mass produced on the market, can have an enormous impact on the international level. Many countries have organizations trying to prevent or treat people with cerebral palsy. The Spastic Children's Association of Singapore (SCAS), established in 1957, provide treatment, therapy, and information to families dealing with cerebral palsy. However, most corporations focus on preventing the disorder through chemical tests and alterations than treating the ones currently affected. The projected keyboard can provide a solution to many children worldwide.

From an economical perspective medical treatment for people with cerebral palsy can be very expensive. Not only do they have to afford direct medical attention, physical therapists, occupational therapists, speech pathologists, but also assistive devices such as a wheelchair (usual electric) can increase cost of living. Frequently, parents can not afford to provide their children with technological devices to aid them in school. The keyboard being designed, will be inexpensive whereby all children with that condition will be able to posses one. When produced on a large scale, keyboards can be fairly cheap, from your basic keyboard at approximately 15 dollars to your more advanced keyboard between 50 and 100 dollars.

The freely adjustable and accessible keyboard and arrow pad not only is durable, inexpensive and efficient but it is environmentally safe. All parts used in the design process are non toxic. Most of the composition is electrical and the other half is either plastic, chrome or
PVC. These materials eventually have to be recycled or disposed. The plastic, chrome and PVC parts can be melted or reformed when they are discarded to create new products. The electrical components, when obsolete, can be discarded or recycled.

This product can not only become of use to the client himself, but also other people with similar disabilities. The device can offer a faster, easier means of communication for those with cerebral palsy. In addition this keyboard can indirectly affect others. People involved in the client’s life, whether friend, teacher or family member, will be able to interact easier and understand his thoughts better.

Other products available on the market result in one of two situations. One of the current devices is inexpensive; however it lacks durability and accuracy towards helping the client’s problem. The other devices that the client debates using, is either too expensive, or does not fit his custom requests. The product we are developing is not only within a reasonable cost, but it is durable, and is the most beneficial to the clients needs. Provided there are other patients with a similar disability and similar complications with communication, this device can become a universal tool to help people with athetoid quadriplegia. Furthermore, the keyboard may aid people that have diseases or disorders that limit them in the same manner as with cerebral palsy. For example, people that are partially paralyzed or have Parkinson’s may be able to find more easy in typing with the freely adjustable and accessible keyboard.

As specified by the client, it was mandatory for the keyboard to be socially acceptable. The keyboard is designed using LED technology to provide an aesthetically pleasing backlit board. The client was concerned the device would put any emotional stress, by making him stand out in a negative way or embarrassing him in front of the other students. The unique design complimented with a modern backlighting tool provides the optimal socially accepting device. The portability, both in size and in weight, enables the device for easy transport. Though help is necessary, there will be less reliance on people assisting in his communication process.
Section 6: Life-Long learning

One of the most important aspects incorporated in this project is life-long learning. Many of the techniques used in designing this project require extensive research due to their unfamiliarity. The project concentrates on numerous electrical engineering and computer programming aspects. The one computer programming class, CSE123, electrical engineering class, ECE 210, and instrumentation class BME 252 was not sufficient enough to design such a device. It was essential for the team to completely understand the workings of the standard keyboard before being able to design the alternative device. Books, and online resources as well as taking apart an old keyboard, played a major role in this process. Each step involved in the workings of the keyboard were studied piece by piece, from the time the button is hit on the key matrix to the eventual command or content sent to the computer.

Furthermore, there has been limited experience with microcontrollers with exception to the one used in BME 252. Likewise research was necessary and the additional from help from the computer science department. Whether our team decides to use MPLAB to program the microcontroller to perform its specified tasks or to use LabVIEW, there will still be fresh pertinent information learned.

Besides the engineering aspect of the design project there were still other life-long learning experiences. Researching the appropriate parts, finding the correct vendors and order them was all foreign to the team. More importantly was the customization of the keyboard to fit the clients needs best. To fully comprehend the client’s situation a meeting was arranged with the physical therapist, occupational therapist, speech pathologist and other members of his support team. They were able to provide us with the obstacles and daily problems the client faces. By emulating his every-day tasks and investigating his primary needs, a custom design was able to be formulated.

An important life-long learning tool is realizing your mistakes and adjusting to them. In this alternative design we made many changes. The original plans used rubber dome switches and Bluetooth connections, but it was realized that these would not be plausible to use in the design. Bluetooth connections do not provide power themselves, and
individual connectors were not found available online. It was also found that rubber dome switches could not be used, because they require a pre-built layout that cannot be custom ordered. Cherry MX switches were an obvious alternative, which was learned.

Working with a partner for this project is very important to the experience. When entering in a career or research opportunity in the “real world” there are going to times where one has to rely on other people. This idea of group work is significant to a company or team’s success. Everyone has to be thinking on the same wavelength, cooperate fully, and contribute to their best ability.
Section 7: Budget

The National Science Foundation had provided us with a $750 budget. When the project was completed, we had spent a total of $560.03, leaving us with $189.97 remaining.

The main expenditures were the Control Board, the Cherry MX Switches, the keycaps, the PVC for the case, and the printed circuit board. A detailed spreadsheet of the budget can be found on the next page.
INSERT BUDGET ON THIS PAGE
Section 8: Team Members Contributions to the Project

Team Member 1: Stephen Heussler

Stephen was essential in designing and building the mechanical aspects of the keyboard, and in designing the final PCB. He also drew all of the files done in MS Visio, and was in charge of the webpage.

Stephen took the machine shop certification class over winter break, so he was able to construct the external case. He drew all of the MS Visio files for the case, and was in charge of designing, machining, and assembling the external case.

Stephen also constructed the final PCB with all the wiring through the program Express PCB.

Along with all of this, Stephen was also in charge of the webpage, updating the weekly reports along with other files at least once a week.

Team Member 2: Nolan Skop

Nolan played a major role in the electrical aspects of the keyboard. He was responsible for designing the interior architecture of the keyboard as well as determine the parts required for its success. When creating the electrical design Nolan worked on the equations and circuitry necessary to achieve the desired specifications.

Similar to the mechanical parts of the keyboard, the electrical aspects had to undergo certain alterations and options to determine the best choice. For example, configuring the LED and resistor combinations that would allow the five volt USB to power the mouse pad.

In addition, Nolan was able to contact Cherry Corp. to learn more about their Cherry MX switches and Vishay for information on their backlighting LEDs. Nolan determined the switches and LEDs necessary for the project. He is also responsible for the management of the teams budget. It is important the budget is within limits and that products are ordered properly.

Nolan used the programming software to encode the switches according to our design and began the preliminary
design for the PCB. He assisted Stephen in design the blueprints to the external architecture of the keyboard and corroborated for the final design.

All in all, most of the preliminary designs for each section of the keyboard and arrow pad, both internal and external architecture, were formulated by both team members. With input from each team member an idea of the design was formulated. Team work was important to our groups success.
Section 9: Conclusion

The keyboard that was designed for the client will improve his typing speed greatly. This will improve his ability to do classroom work, and will also improve the speed at which he can communicate with the rest of his class. The mouse pad would provide an easy means for him to scroll a mouse pointer across the screen.

The design of the keyboard is somewhat similar to a regular keyboard, but there are many major differences so it can accommodate the needs of the client. It connects to the CPU through a USB connection that provides a 5V source to power the device. The keys are more spaced apart than standard keyboard keys, so the client has an easier time pressing the right key. To adjust for the spaced out keys, unnecessary keys were removed from the layout. These keys are not important and were just taking up space in the design. Diodes were implemented into the design so that once a key is pressed, it does not continually register. This is a major problem for our client, and will be solved through the use of this keyboard.

LEDs were incorporated into the design to give the keyboard a “cool” look. The client’s contact said he would not want a keyboard that would make him stand out, so by using LEDs the keyboard will be aesthetically pleasing, and he will want to have it and use it.

This keyboard will provide a much better means of typing and navigating a computer for our client. It will increase his productivity and make his less reliable on his teacher for help.
Section 10: References


Section 11: Acknowledgements

Team Six would like to thank our client, Sam, and Hampton Elementary School for allowing us to visit and assess their facilities. Also we greatly appreciate the contribution Miriam Kurland, the client’s speech pathologist, has provided. Miriam kept us up to date and informed with the clients needs and was our main contact. We would also like to thank Rich and Serge from the machine shop. In addition, we would like to thank the client’s staff of occupational therapists, physical therapists and teachers. We would like to thank the National Science foundation for providing the funding for the NSF Project to Aid the Disabled Project. We would also like to thank Serge and Rich from the machine shop. Lastly, our team would like to thank Dr. John Enderle and William Prueshner for making this design project possible and for all the assistance they have provided.