A L T E R N A T I V E   D E S I G N   3   R E P O R T

HEAD-MOUNTED
&
ARM-MOUNTED
ART DESIGN SYSTEM

NSF SPONSORED PROJECT

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1. ALTERNATIVE DESIGN PROJECT 3:

1.1 INTRODUCTION:

The following design report presents the third design for specialized head and arm-mounted art design systems project that will aid people with cerebral palsy and hydrocephaly to create works of art. The design will assist our main client Stacey and other artists like her at the Passion Works® Studio in reaching their maximum artistic potential. She has limited mobility and requests for devices that may be mounted to her head and her wrist to help draw simple art designs for her. The weight of Stacey’s head and her restricted motor functions are obstacles that the two devices will take into consideration and overcome. The analysis and schematic figures of possible designs for the head and arm mounted art systems will be shown, along with descriptions of the different product components and how the overall device will function.

The third design differs from the other two designs in that it now focuses a lot more on testing of all the components. This ensures that all the components will do their specific tasks with no foreseeable problems to enable both the devices to work successfully. The drawings in Visio are more detailed with newly added dimensions, and more views of the cam setup are available. The guiding beams on the helmet are now stationary again, as having them move left and right will be quite complicated. A more in-depth view of the fiber optic sensors is explained in the sub-units section. The Dremel motor will no longer be used as it will be replaced by a smaller, slower variable speed motor which will be also explained in the sub-units section. The introduction now also offers a better overview of both the devices to go along with the flowcharts below. The flowcharts are updated as well.

As the name suggests, this device will have two separate parts to it: the head mounted part and the arm mounted part. These two parts will not be attached to each other, and therefore can be used by two different people at the same time. However, they will share some similar components such as the motor and its attachments that will make the squiggle designs, and also the rechargeable battery that will power the motor. Both components will be adjustable, as they may be used on multiple artists at the Passion Works® Studio. The design system will be easy to set-up and store since this is a busy studio with many artists originated out of there. The first design will be comfortable, functional, durable and user friendly in hopes that Stacey can fully participate in activities individually at the studio.

The head component of this system will be composed of a headpiece that attaches to an extension to reach the art tools to a desk or an easel while squiggling. The motor hookup will be wired through the extension to make the designs. Stacey will be able to use multiple types of art tools such as markers, brushes, and pencils as the devices will be adaptable to fit any of those circumferences. The origin of the extension system would be from the back of the headpiece, but would be able to have 3-D motion since it will be flexible yet sturdy.

The arm component of the system will contain a wrist support, which will be used to mount the extension that reaches the markers and such to the medium. The extension in the arm will be made similar to the head component with a gooseneck extension to reach whatever lengths the client chooses. The motor will also again power the squiggle designs, which will be made...
possible through the use of cams. A few different cams will allow Stacey to create 2 to 4 different art designs on her paintings and drawings.

For both systems, there will be an easy on/off switch for the caregiver of Stacey and Stacey will also be able to specifically control the power of the entire system through the use of optical eye-blinking reader. If she blinks three times in a row in a slower manner than normal, she will be able to turn on or off the art designs on her paper. Also for both systems, the squiggles will be determined by the size and shapes of lightweight aluminum cams attached to the end of the extension units. The motor will be programmed to do multiple settings of higher and lower frequencies of doodling, as well as different amount of angle rotation in the squiggle from anywhere between 0 to 360 degrees.

Flowcharts of the overall designs are shown below in Figures 1 and 2. The Head Mounted Design consists of a motor, rechargeable battery, adjustable head piece, optical blinking sensors, extension arm, cam with an adjustable thumbscrew and an art utensil as delineated below.

![Figure 1: Block Diagram of Head-Mounted Design](image1)

The Arm Mounted Design consists of a motor, optical blinking sensors, rechargeable battery, extension arm, cam with an adjustable thumbscrew, and an art utensil as outlined below.

![Figure 2: Block Diagram of Arm-Mounted System](image2)
The overall art systems will provide the form and function that the client and her caregivers will be able to use and adapt to very quickly. The systems will be described by the head and then the wrist mounted system. Each subunit of these overall designs will be described from the point of attachment to the client then outwards towards the point of application on the paper or canvas. The subunits that apply to both of these art systems will be described first.

1.2 SUBUNITS:

SUBUNITS FOR BOTH DEVICES:

1.2.1 VARIABLE SPEED & REVERSIBLE MOTOR & HOSE EXTENSION:

The variable speed motor is going to move the hose which will turn the cam, which will be described later, to create the squiggle designs. The motor is going to be attached at the back of the wheel chair so that the weight of it does not affect the client’s head or arm. A hose will run above the headpiece worn by the client toward the canvas through the gooseneck extension that gives it posture and positioning capabilities. The motor will also be programmed to make different movements so that it can help to create squiggles of various configurations. For example, the motor will be programmed to go in random back and forth motions such as +10, -2 etc., and also to go in its regular 360 degree rotations. This will prevent the same squiggling motion to be performed over and over, and to give more available options to Stacey.

A coil of wire becomes an electromagnet when current passes through it. The electromagnet interacts with a permanent magnet, causing the coil to spin.

![Figure 1: Basic DC Motor Diagram](image)

When electric current passes through a coil in a magnetic coil, the magnetic force produces a torque which turns the DC motor. The direction of rotation can be reversed during motor rotation using a switch. Moving the switch to CW (clockwise) causes the motor to rotate
clockwise; moving the switch to CCW (counter clockwise) causes the motor to rotate counterclockwise.

The direction of rotation depends upon which winding is the "leader" and which is the "follower". The rotation will reverse if either winding is reversed. The center-tapped versions simplify the reversal of current since the center-tap may be tied to Vcc and each end of the coil may be alternately pulled to ground.

The hose that will be used in this project will be made of synthetic rubber that is reinforced with an internal web of fibers. The hose will be attached on one end with the aluminum cam and to the dremel motor at the other end. A hose was chosen as the attaching material because it provides flexibility and at the same time durability. The hose as a whole will be able to comfortably fit into the hollow gooseneck. The gooseneck extension will be lightly lined with a material that will not promote friction, so that the hose from the motor will be able freely rotate in its given patterns appropriately. The hose should be approximately under ½ inch diameter. For the material of the hose, synthetic rubber is the best solution as compared to plastic which can probably snap during the rotations. The hose design is inspired by the Dremel© hose attachment that is often used on Dremel motors to translate rotation over a longer distance, while being able to go through non-linear spaces.

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**Figure 2 Extension Arm Cross Section & Front View**

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A torque test will be performed on the hose attachment with a torque tester to ensure that there will be no harm to Stacey’s head or her wrist. To test the quality of the motor, it will be run through the hose to make sure it does turn the cam and art utensil properly. The noise level and the vibration will be tested also, to make sure that this is kept to a minimum as this may be annoying to Stacey and those around her in the art studio. A revolutions test was done by one of the team members to see how many squiggles the average person would make in a minute. The result came to be about 430 rotations per minute. The team has decided then that a variable speed motor that goes from 0 to about 400 rpm would be the optimal motor for both devices.

1.2.2 RECHARGEABLE BATTERIES AND CHARGER:

Rechargeable batteries are the smarter alternative to regular alkaline batteries. These rechargeable batteries discard the question of throwing out old batteries that do not work any more. This will ultimately save the client money on costly batteries. The most common rechargeable battery is the nickel metal hydride battery. These batteries are better as compared to nickel cadmium batteries which pose an environmental hazard due to the cadmium anion.

As of now, the design calls for about 4 AA rechargeable to turn the cam attached to the end of the hose. Once the necessary power for the motor is determined, the circuit will be run through PSpice to see if the amount of batteries stated will prove enough to power the whole system.

To test the needed power, the circuitry for the optical sensors will be examined when the extent of the power needed for these is fully known. The circuitry will then be modeled into PSpice to view the dynamics of the circuits and to test some possible range values. The upper and lower limits of power will be within a reasonable range for rechargeable batteries. Too many batteries may overpower the circuit causing it to overload. The life of the batteries will be tested as well to make sure that they will not need to be recharged every few hours, and that they will withstand about 2 hours worth of “squiggling” at a time.
In addition, the design includes the battery charger, which may be plugged into any standard outlet. In forecasting how much the client will use the head and arm mounted devices, it is estimated that the batteries will need to be charged approximately once per week, which the caregivers may perform for Stacey.

**SUBUNITS FOR THE HEAD MOUNTED DEVICE:**

**1.2.3 ADJUSTABLE HEADPIECE:**

Per request of the Passion Works® Studio, the head mounted device must be able to fit multiple people in addition to our primary client Stacey. For this reason, the headpiece in which our gooseneck (and Dremel hose) components will be attached to must be easily adjustable. The Studio has also expressed that they do not want a chin strap on the headpiece, as this has proven clumsy and uncomfortable on many people there. The intended headpieces center of mass will be tipped more back and lower on the person’s head so that it may be more stable while providing enough stability for the flexible gooseneck extension.

The inspiration for the headpiece component comes from the common welding shield. There are no strings involved, yet it easily makes the headpiece hug the user’s head better with the adjustable twist mechanism located on the backside of it. The inside of the headpiece straps will
be lined with a type of memory foam to ensure a snug and comfortable fit. However, when the headpiece is not in use, the foam will reposition itself to its original position so that it will mold to the shape of multiple users heads. The comfortable foam pads are also sweat proof and non abrasive in order to maximize user comfort.

The headpiece is composed of one base ring which will be adjustable with a sliding lock mechanism. This function will permit the headpiece to fit any circumference head. Attached to the ring are two crossing latches. These latches are docked to the base ring through four vertical adjustment tabs which allow the X arc braces to mold to the users head. The inside of the entire headpiece will be one even and smooth surface in order to prevent hair from getting cinched.

The guiding beams which will stabilize the movement of the gooseneck will be attached to the sides of the headpiece. The point of attachment will be secured and covered with a smooth polymer composite in order to prevent any hazardous sharp edges.
The headpiece will be tested in several ways as well. To begin with, the headpiece will be fitted to several peoples’ heads to find out if the headpiece will be easily adjustable to many head circumferences. It will then be determined if it is comfortable to wear for long periods of time as well. The stability of the headpiece will be inspected to ensure that it will not move around on the user’s head when the gooseneck extension and fiber optic sensors are fully attached.

1.2.4 FIBER OPTIC SENSORS:
In order to turn the variable speed motor on and off, so that the user can draw when they choose, the fiber optic sensor will come into play. Since blinking is an involuntary reflex, the blinking sensor will function only when the user closes their eyes for a given time which will be decided by the filter designer. In order to accomplish this, a high-pass filter is needed so that all high frequency blinks and frequencies below a certain cutoff frequency will be attenuated. This blocking of high frequencies will allow the system to turn on and off only when the user prompts it to and will not do so otherwise. As the frequency decreases the capacitors impedance will increase and this high impedance will block the signals below the cutoff frequency and prevent them from loading. The high-pass filter is made up of a capacitor, resistor and voltage as can be seen in the below diagram (Figure 12).
The fiber optic switch makes use of a sensor that comprises of an infra-red-sensitive phototransistor. These two electro-optical devices are positioned so that they share virtually the same optical axis. This becomes the optical axis of the sensor. The switch is activated when an infrared-reflective surface, such as skin is placed on this optical axis at a distance within the range of the switch. This distance is called the activation distance.

The Activation Distance can be adjusted in fiber optic switches. This is very useful to implement in the hand device. The maximum distance allowed for activation can be adjusted from a few centimeters to less than a millimeter. This adjustment can be made manually or automatically (self-calibration). When a activation distance of, say, three centimeters, is chosen, the switch can be activated from as far away as three centimeters. This permits more aesthetically appropriate switch position. The advantage of this type of switch is that it can be activated through a transparent material, such as a clear glass or plastic.

Such types of switches often have a self-calibrating mode. This mode becomes helpful when the switch is being activated by a body part that cannot always maintain a constant activation distance from the sensor, the switch can be operated in self-calibrating mode. In this mode, placing the activating body at ANY given distance within the range of the switch will serve to define that distance as the activation distance. Once activated at this distance, the switch may be turned off by moving the body part completely out of the optical axis of the sensor.

(R*C) the resistance times the capacitance give the time constant which is inversely proportional to the cutoff frequency. At the cutoff the outputted power is half that of the input. This relationship can be observed in the equation below:

$$f = \frac{1}{2\pi RC}$$

Fiber optic sensors are grouped into two basic classes referred to as extrinsic or hybrid fiber optic sensors, and intrinsic fiber optic sensors.

The optical fibers lead up to a “box” which impresses information onto the light beam in response to an environmental effect. The information could be impressed in terms of intensity, phase, frequency, polarization, spectral content or other methods. In the case with the eye blink sensor, the information will be in terms of the frequency. An optical fiber then carries the light with the environmentally impressed information back to an optical and/or electronic processor.

Since fiber optic sensors are a relatively new technology, there have been some expressed concerns about the cost, fragility, complexity and reliability of these sensors. Due to these concerns this part of the project will need further evaluation and attention. The pros and cons of this sensor will be compared with other compatible sensors in the same line.

Fiber optics have no moving or electrical components allowing them to be completely free of electrical interference. This is a great quality to have because it reduces the risk of electric shock since the artist will be painting. A potential issue with using glass fibers is that they sometimes tend to break when manhandled too much, therefore only plastic fiber optics will be utilized.
Figure 13 shows that the visible spectrum is between 400 and 700 nanometers. The beam of light to be emitted on the surface of the eye will be at 850nm, a value out of the visible range.

The lens and the cornea work together, (Figure 14) to refract and bend light by converging light to a point which is then focused on to the retinal surface. If the light is very close to the eye, say
a few millimeters, which is traditional for many current eye blink sensors, the light will diverge with more power because the source is so close to the lens as depicted in figure 15.

![Figure 15 Focal Point](image)

Typically having an IR beam pointed perpendicular to the retinal surface will not only be uncomfortable for the user because there vision will be stymied, but a focused and concentrated IR beam will be absorbed and cause a point of damage to the back of the retina.

Over time, constant exposure to the penetrating focused beam will form a region of damage in the retina which will make a noticeable defect in the user’s vision. Thus an absorbed IR beam is very undesirable for the design.

In order to prevent this problem, a different damage free system is created which allows for an IR emitter to comfortable sit in a position which will not block the user’s vision. This will be done by attaching a very durable safe and scratch resistant transparent optical sensor lens which to an IR emitter and detector. The optical sensor lens will just serve as a dock for the emitter, it will not play an active role for the light beams.

![Figure 16 Optical Interface](image)

Figure 17 shows an IR beam of 850nm hitting the lens and then refracting to the detector. When artist makes three consecutive purposeful blinks this creates a very specific case for the detector to read and send to be filtered via the fiber optic and transducer.
When the emitted IR ray hits the lens at a high incidence angle the corresponding large reflection coefficient will allow for the IR ray to be reflected. (Figure 17 above) When the eye lid is closed the emitted ray is scattered on the eye lid surface. Therefore there are two different signals that the transducer will record, one when the eye is open and the other when the eye is closed. But the noise differences between the two are still very similar and it would be difficult to have a system which can detect the difference between a regular blink and a purposeful blink.

This is why the special case of three consecutive purposeful blinks is used. This specific case will allow minimal error because of the uniqueness of the probability of the sequential three purpose blink detection. At a high angle of incidence, a high refraction coefficient results as seen in the figure 18.
The emitter and detector location will be crucial to the preservation of a safe eye because when maximum beam refraction occurs, it negates any hazard to the user. The Brewster angle shown in figure 6 is the angle where an incident ray is completely refracted. For a glass material with a air or vacuum atmosphere, this angle is said to be $56^\circ$. For the design it is necessary for the Brewster angle to be maintained because, ultimately it means that there will be no IR beams penetrating and causing irritation to the user.

The reflection coefficient deemed by the variable $R$, and the transmission coefficient $T$ which is the fraction of light that is refracted are responsible for determining an appropriate incidence angle.

The polarization of the incident ray determines the $R$ and $T$ values. When the beam is polarized with an electric light field perpendicular to a orbital surface then the reflection coefficient is:

$$R_s = \left(\frac{\sin(\theta_t - \theta_i)}{\sin(\theta_t + \theta_i)}\right)^2 = \left(\frac{n_1 \cos(\theta_i) - n_2 \cos(\theta_t)}{n_1 \cos(\theta_i) + n_2 \cos(\theta_t)}\right)^2$$

When the he incident IR beam is polarized in the plane or $p$-polarized, the $R$ is:

$$R_p = \left(\frac{\tan(\theta_t - \theta_i)}{\tan(\theta_t + \theta_i)}\right)^2 = \left(\frac{n_1 \cos(\theta_t) - n_2 \cos(\theta_i)}{n_1 \cos(\theta_t) + n_2 \cos(\theta_i)}\right)^2$$

At one particular angle the value of $R_p$ goes to zero and a $p$-polarised incident ray is purely refracted. With the help of the Fresnel and Snell equations, the proper $R$, $T$ and incident angle values can be found.

The pathway depicting the entire optical system is depicted in figure 19.
1.2.5 **Gooseneck Extension Arm:**

The gooseneck extension arm is a structure which will be able to hold up three pounds of weight while maintaining the static position. This allows for more than enough leeway when taking into account, the weight of the cam and utensil device. The gooseneck arm behaves exactly as its lamp counterpart. The only difference is there will be no lamp base or light bulb socket attached. This gooseneck shell is to act as a hollow shell which will allow the incased variable speed motor tube to be maneuverable. With the help of the guiding beams, the gooseneck arm will aid in total control of the location of the artist utensil, in space.

The sum of the moments from the point of attachment onto the adjustable headpiece must be taken into consideration. The sum of the moments ought to be really small, or else it will cause the client’s head to be moved in a downward position (touching the chin to the chest).

The $\Sigma M = \Sigma F \times d$.

In this case, there will be the force from the weight of the extension crane arm, and also the weight of the art utensils at the end of the extension arm. Therefore, $\Sigma M$ about the point of attachment on the headpiece = weight of extension arm*the distance to the center length of the extension + the weight of the cam and thumbscrew*total length of the extension arm.

As it is not yet determined how either of the weights will amount to yet, it is not possible to determine the exact moment. However, the moment will be kept under 10 lbs*in.
The gooseneck extension arms will be ordered from Moffatt Products, Inc. The goosenecks are strong, even in larger diameters, and are very durable. The vinyl covering makes the arm look more professional and makes them easy to clean, while keeping any oils from getting inside to weaken the arm. These heavy duty, spring steel Flexible Arms are covered with matte black vinyl with assorted mounts to be easily attached to the adjustable headpiece.

The extension arms will be tested for everyday wear and tear. Many numerous movements and positions will be applied to the gooseneck to guarantee that the gooseneck will be able to work under these types of conditions. The hose of the motor will be run through it and then turned on.
to test that the vibrations are not too great. This will also test to make sure that the hose will properly run through as predicted with the measurements that have been made. Also, the arms will be submersed in water to see if the system is waterproof, as there is electricity running through them and this would be a potential safety hazard.

1.2.6 **ART UTENSIL ATTACHMENT / CAM**

The actual drawing device will be composed of a rotating cam, a clamp and two points of attachment, one for the Dremel hose tube and the other for the utensil. The cam like any general cam will be made of a lightweight, rust and corrosion resistant metal material. The edges of the cam will be rounded and wrapped with a thin rubber coating in an effort to maximize safety. The cam hole for the dremel tube will be created to allow a secure attachment to the dremel tube. This will be reinforced with a non-porous material, so that no water or material will corrode the tube and risk the device to fall apart.

A simple set screw thru the cam will allow for the utensil to be properly held in place. This component will be made out of a material with very high mechanical strengths for it will be used very often.

This entire rotating drawing system will be extremely durable, possess strong mechanical properties, high wear resistance, and be water resistant and nonconductive. These qualities will permit a long life for this component.

![Figure 22: Cam](image)
The cam will be tested will a rotational motion and a utensil to prove that a squiggle design will really result from the stated set-up. The rotational movement will also test that the utensil will remain intact in the set screw under rotations up to 400 rpm. Aluminum will be used to see if it will be strong enough to endure rotations and weight under the given circumstances.

Figure 23: Cam Trajectory
1.2.7 GUIDING BEAMS:

There will be two guiding beams (Figure 25) docked at each side of the headpiece and attached at the cam. These beams will be made of a very like material with high tensile and shear strengths. They will be held stationary at the given distance from the headpiece to give additional support to the gooseneck covering Dremel motor tube, cam and art device. There will be a ring at the end to have the extension arm able to move through space in several directions as set-up by the caregiver. This critical movement will allow for maximal utilization of the artists control over the movement of their utensil.
The extension arms will be tested to see if they are durable, yet lightweight enough to be attached to the headpiece. They should not break under positioning of the gooseneck. However, they ought to provide additional stability to the extensions as to not cause excess strain to the user. This will also make sure that the center of gravity of the whole device is where it ought to be in the center of the user’s head.

**SUBUNITS FOR THE ARM MOUNTED DEVICE:**

1.2.8 **WRIST ELEMENT AND GOOSENECK DOCK:**
For the arm mounted art design device, there will be the comfortable wrist cuff and the gooseneck extension arm. The hand device (Figure 26) will be fabricated out of neoprene and other durable and comfortable fastening components. The neoprene fabric will provide the right amount of ductility and firmness, while also being water resistant and easy to maintain which makes it very user friendly in an art studio environment. A very “sticky” Velcro is to be used in the fastening components to its longer life span if no stray fabrics come into contact with it. On top of the hand device will be the extension port which will also serve as the dock to the cam utensil holder. The motor port will be sewed on with very high strength string and glued to the wrist cuff to ensure that the point of attachment is very secure and may withstand any loads from the art utensils and the motor rotating.

The hand mounted art system will be able to endure exposure to sun and rain, but extreme heat will be potentially detrimental some of its components. Moisture and humidity will have no hazards effect on the designs except with respect to client comfort. If the artist is working in extraordinarily hot and humid conditions, they might feel discomfort when using the neoprene hand mounted art device for, the neoprene material is not breathable. It is not recommended that the user work in these conditions with the device, but if they intend on it then a potential breathable nylon mesh membrane, perforated neoprene or Stomatex® neoprene fabric could be used. Stomatex is a new form of neoprene which copies the transpiration processes of plants yielding a nonporous breathable and waterproof material. The devices should be stored at room temperature and in a dry environment at all times when not in use. If all above listed precautions are followed the life span of the system will be increased.

Figure 26: Arm Mounted Art System (Top View)

Figure 27 Example of a Wrist Cuff
The wrist cuff will be analyzed to see if the element will be comfortable to the user, and strong enough to have the extension arm attached to it. Water will be poured on it to make sure that it is waterproof, yet breathable to the user. The cuff will also be scrutinized to see if it will fit a broad range of wrist circumferences.

1.2.9 EXTENSION ARM:

The purpose of the extension arm is to increase accessibility of artists drawing surface to the respective art utensil. The extension will be made of the same material as stated earlier for the head mounted system. The extension will extend 150 millimeters (6 inches) so that this may reach the paper set up in front of Stacey’s wheelchair on a desk. The antenna base will be within a 50 millimeter circumference range so that it may rest comfortably on top of a regular adult size hand. The Dremel hose will also run through this gooseneck extension as well.

At the end of the gooseneck there will be an aluminum cam with the same screw tightening utensil mechanism as the 36 inch gooseneck system. When attached to the optical eye piece, the hand piece system will turn on an off by using the same exact optical sensor technology.

![Hand Mounted Mini Gooseneck](image)

**Figure 28: Hand Mounted Extension Front View (Extended)**

The range of motion will also be carefully considered when the prototype is made. The extension must be able to move to either side of the client’s body, while also being able to reach a canvas or to reach the desk in order to paint or draw. In addition, the gooseneck must give some leeway for the markers or brushes to go towards the left and right sides of the paper. Therefore, the gooseneck coming off the wrist will be able to move approximately 180 degrees so that if Stacey holds her hand in a prone way in the middle of a paper, the designs may be drawn on either sides of her hand onto the paper.

The sliding disk on which the entire gooseneck system moves will rotate 270° symmetrically left and right. There is no need for the base to rotate the full 360° degrees because having the
extension and utensil holder, face the artist would be useless and inefficient. This is also a safety precaution because if the user were to not pay attention and if the extension arm was rotating in a full circle, it might probe the user and cause discomfort.

After constructing the entire device a waterproof test will be preformed to see test if the device is properly able to handle its users environment. This test will look for specific areas of water collection which could potentially lead to material corrosion and will make sure that certain junctions will be lined with a waterproof material.

2. REALISTIC CONSTRAINTS:

Engineering standards are very important to incorporate into the designing of a biomedical device. References such as the FDA Medical Device Use: Safety and the National Society of Professional Engineers Code of Ethics for Engineers should be thoroughly examined beforehand. The designs are practice basic static laws of applied loads, moments, and points of application in order to analyze how to properly and securely attach the devices to Stacey’s head and wrist. The International System of Units (SI units) will be used in the designs to follow engineering standards around the world, so that all engineers may understand our project subunits. In addition, basic static and dynamic laws of applied loads, moments, and points of application in have been reflected upon in order to make an efficient product for Stacey that will not fail her like previous contraptions have done.

The main economic consideration for this design is the budget allowance donated by the National Science Foundation. These are two separate projects with an allowance of $750 USD each, therefore having a grand total of $1500 altogether. From an ideal consumer standpoint, a low cost and high quality product will be the goal of the design. After performing a thorough background check, the possibility of possible patent infringement has been excluded. There are companies that create the different components that will go into the two devices, but no product completely encompasses the overall concept of applying the different components towards helping a person with cerebral palsy paint and draw. No known competitors have created similar devices permitting a completely unique product on the current market. There are no apparent political effects as a result of the Head and Arm Mounted Art Design System.

The materials used in the creation of this device will not only be durable and long lasting, but also it will follow all Environmental and Human Health EPA regulations and cause no harm to the environment or its user. A major environmental consideration for this design project is the temperature ranges and humidity levels in the Passion Works® Studio. The devices may be left out in open sunlight or come into contact with water and cleaning solutions, therefore it will have to be UV durable and non-corrosive. The art design systems will need to be easily storable so that they may fit into supply closets that may or may not have a good source of heat or air conditioning and will need to survive the fluctuating temperatures that may result in the art studio. These systems use the latest good quality materials available which will provide a long sustainability and operational functionality of several years or more. The high-grade aluminums,nylons, and plastics being used are able to withstand extreme conditions without failing or becoming damaged over time. Since there are no foreseen extreme conditions, this benefits the lifetime of the two art design systems. The chosen materials provide the user with the reliability
that is desired with any product on the market today. Products that are purchased by a consumer on the current market are expected to endure many wear cycles; power turned on and off, and withstands the constant forces and motor rotations applied to it.

A previous head mounted design made for Stacey entailed a paint brush connected to a pair of goggles worn on her head, and therefore did not provide her with the proper sustainability or functions which she desired. These art systems will be made with the specifications of Stacey as relayed by her liaison. After an analysis of the clients needs, a more reliable system will be able to make squiggle designs without the motor failing or breaking under the pressure of paper contact. The aforementioned design will save the client the indirect costs of time, stress, and happiness. The power source for the motor and the optical sensors is simply a rechargeable battery, which only needs to be plugged into a wall unit periodically to power its functions. The metal extensions that will reach to the art medium will be properly insulated to not contain any currents along its perimeter. There will be no possible threat to the client for conducting electricity or stray current because of this.

Pertinent ethical constraints for this design project may be found in the Code of Ethics for Engineers. The first ethical constraint listed is to “Strive to prevent a person from being placed at risk due to the use of technology.” This constraint states that the devices be designed and implemented in such a manner that will keep the client safe at all times of set-up adjustments and squiggler operation. The second ethical constraint is to “Work toward the containment of costs by the better management and utilization of technology”. For this reason, our design uses materials that are readily available and are relatively priced on the market in order to make customized components that are more cost-effective than the Studio trying to make a device on their own to help Stacey. Another ethical plus to the devices is that they do not attach to the human body in any way (like a surgical implantation) and do not harm any living creatures in its manufacturing or testing processes.

This system is not meant to offend or demean the client’s disabilities, but rather an aid to help them achieve their creative goals and perhaps improve their livelihood. Contact with the advisor has already eliminated possible material allergies so that the system’s mechanical design may use the materials outlined in the subunits section above. Basic electrical and mechanical components are expected to be used in the art design system, thus preventing any difficulty if the time arises to mass-produce this prototype. If manufactured in bulk, the prices would be reduced due to their availability. This product, however, is mostly focused on the customization of a art system for the specific needs of the client. All the materials of each of the components are readily available, and the parts are interchangeable allowing for relatively easy fixing and repairing of the system. For safety’s sake, no sharp, potentially harmful components will be made part of the system. Also, an appropriate center of gravity for the head device will prevent further strain on the client’s neck and head region.

This system is also intended to improve the social comfort of the client by allowing them to better fit in the art studio and participate in the same activities as others. Designing the art systems to have a low profile and be unobtrusive was an aesthetic concern so that the client does not stand out at the art studio. Socially, the systems will be of neutral colors and be of acceptable
sizes to not make the users feel cast out and to help her stand out because of her artistic skills and not for how she looks while painting or drawing.

3. SAFETY ISSUES:

When creating any device involving another human being, one must take into account all safety precautions in order to foresee and prevent any discomfort or damage to the client. Also during the course of building the device, the inventor must take proper safety measures to prevent any damage to themselves or surrounding environment. The entire system will be focused on electrical and mechanical properties. Material selection will also play a crucial role in the developmental process.

The head and arm mounted design systems both are made up of multiple components. Since some of these components will be interchangeable all components will have a safe lock in mechanism so that while the artist is using the device, all parts will stay intact and not be dislodged when certain movable system components move. All sharp edges on the design have been taken into account and will be covered with a protective and durable polymer coating. Such a cover will exist over the contact point between the two symmetrical gooseneck stabilizers and the head piece. The entire head mounted device will be constructed in such a manner that no extra strain will be added on the patients head and neck. The usage of lightweight materials will be critical in accomplishing this goal.

The client specifically requested that there be no chin strap on the head piece. This means that the head piece must stay intact without falling down due to the momentum of the gooseneck arm. Firm and comfortable materials such as memory form will allow for the head piece to behave like a comfortable glove which will not budge even with extraneous moving components.

Since the device is going to be exposed to water from painting, therefore all wiring and motors will be coated with a water sealing agent, thus eliminating chances of electrical shock. The motor will also come with a fastening device so that it can be safely attached to a location near the artist. All of the electrical devices will be isolated from the main power source by being grounded. Correctly sized cables will be purchased; this prevents cases where the voltage generated is too great for the wire, in turn causing an electrical fire. The materials used will be able to withstand temperature ranges from -40 to 85°C. Any buildup of moisture from either the artist or the ambient temperature will not affect the adhesion of the motor port to the wrist element. Proper sealing and inherent water resistant material qualities will prevent any corrosion of metal components, and system failure. The inner part of the gooseneck extensions will be lined with a polymer that will reduce the amount of friction between the gooseneck and Dremel hose extension. Also, the inside of the gooseneck tube will be lubricated as well.

During the construction of the device, all team members will be certain to wear the necessary safety equipment when handling mechanical shop equipment. All actions preformed will give highest priority to the group members, the client, surrounding personnel, and lab equipment.
4. IMPACT OF ENGINEERING SOLUTIONS:

The head and arm mounted art design systems will definitely impact, in a positive manner, the market global, economic, environmental and societal ways. These systems will better the lives of physically challenged artists with very limited motor skills by allowing them to pursue art. Specifically, one of the main concerns of the client is her ability to draw and paint like other artists at the Passion Works Studio. Alternative options that the client has used to display her artistic talent have been gawky and aesthetically displeasing. This device will work in conjunction with the client to come up with a unique piece that only represents the thoughts and imaginations of the creator. A device such as this has potential to become an aid for not only the client specifically, but for many others who may share similar conditions to the client. In this way, people will understand disabled artists in a much more depth. This form of aided art will also reduce the barrier of communication that people have with people that have cerebral palsy. If this device can prove to be this beneficial to one person, one can only imagine the benefit it can have to others with similar disabilities.

Globally, companies, institutions and governments are constantly trying to better the lives of disabled individuals. These attempts include designing the web in a way that can be easily maneuvered by disabled people, designing buildings that result in easy movement, designing cars that can be used by slightly disabled people and designing smart home systems. This device will add to this growing list of things and steps that are being taken to better the lives of people with disabilities. The United States alone has more than 500,000 people that have cerebral palsy and a similar number of people that have some level of hydrocephaly. The numbers of people that have these disorders are increasing in the world today. Art is a very global concept that people have been using throughout time as a way to convey their feelings. As long as people still have interest in creating art, the art design systems will continue to impact many individuals throughout the world.

The head and arm mounted system, as mentioned above, will be used to enhance the art skills of people with disabilities. This design system will vision art to be a therapy to help people with disabilities. The growing expectation for a quality life, demands tools to better serve the recovery or treatment process and the art design system may serve as one of these tools. The use of the head and arm mounted art design system as an aide to understand people with disabilities has a positive impact on the society. By discovering ways to interact with the people who cannot always express themselves fully through their word of mouth, healthcare professionals will be able to provide better medical treatment or therapy. In return, these treatments could help patients become more productive and independent.

The economic impact can affect consumers, both clients and their caregivers who personally buy the products for them. Since consumer products may not be covered by the health insurances of the clients since this is a therapeutic tool, it is ideal to keep the budget low to help the consumers. In terms of the economic aspect, the art design systems are going to be under the $1500 budget allotted by the National Science Foundation for the two separate projects. These products will be easy to use, durable, yet be made of low-cost materials, therefore promising to be relatively inexpensive. The durability of the art design system offers a much more reliable product, in terms of accomplishing the clients’ needs and still being in the relatively low budget. These
devices may withstand the high impact forces of the client’s extraneous movements and the high strength of his regular movements. Mass production of these devices would most likely keep the price under $200 USD.

In terms of the environmental aspect, the most inevitable impact this product will have is its ultimate disposal. The individual products that are going to be used in this art design system are not going to degrade over time unless exposed to extreme physical forces and reactive chemical solutions. The main components of this system will be made of plastic, aluminum, steel or a composite of some materials. All materials used to construct the device are also non-toxic and safe for all users, as well as environmentally safe. It is important to note that not all the components of the art design system will be recycled; however, every try to recycle the materials should be made because if the materials are disposed of in the wrong manner, they can cause irreversible damage to the environment.

The patient’s environment could be impacted greatly as well. The environment in which the client lives could improve and expand greatly. This may mean the patient becomes more self-confident and assertive and is able to gain control in areas of their environment that were previously hard for the client before. Their artwork made with the art design devices may allow the client to regain involvement in the art studio environment and in regular society.

Engineering projects like these shows the world that there is more than one solution to any given problem. If something is not meeting the demands of the user, there has to be some sort of improvement possible to meet their specific needs. The art devices show that although they are customized towards one client, they may be used by many in similar situations. Even if other people do not have hydrocephaly and cerebral palsy, they may use these devices if they have some sort of motor inability. Engineering solutions are often applicable to many people, since many people may be experiencing similar situations but not even realize that they are not alone in their desires for a better quality of life. Senior engineering students may apply the principles they have learned to a challenging task. With more experience, engineers may help better the world in all aspects possible. Engineers are life-long learners and will continue to have their engineering solutions impact the world in a positive manner.

Producing a head and arm mounted art design system will impact the health care world in a global, societal, economic, and environmental sense. By designing this system, Team 1 has shown that biomedical engineering solutions like these can possibly make a positive difference in the world.

5. LIFE LONG LEARNING:

In the process of designing the head and arm mounted art design system, team 1 came across new concepts that were not covered in previous classes. Implementing fiber-optic technology into the design was a challenge because this aspect of technology was not explored by any of us before. This is where life long learning played its role. The fiber optic motion detectors were needed because they would take advantage of the normal blinking movements of the client. Sensors that may detect blinking is a whole new concept for the whole group, so utilizing this in the ultimate design will definitely prove to be a learning process within itself. This technology
would therefore require use the clients’ hands, arms or legs. This is what was needed because the client has limited motor abilities.

The art design system also incorporated the use of variable speed motors in the project. The motors themselves were not a new concept, but how they worked was not understood until the design of this project. The fact that there are many different adaptors and extensions to this simple motor is great to know since this may apply to many aspects in everyday human lives. An in-depth analysis of how a motor works was done to fully understand its interaction with the project. Also, after understanding the basics, a suitable slow-rotating motor was chosen for the project.

Drawing technical diagrams was also one of the issues that team 1 faced while designing the project. To make technical drawings of the different components of the system, familiarization with a technical drawing program was required. Microsoft Visio was chosen for this task after careful comparison with other technical drawing programs like Auto CAD. Visio provides a user-friendly interface and allows for detailed drawings in a shorter amount of time compared to Auto CAD and other CAD programs.

The whole process of researching and designing a new biomedical product was learned. Knowing to look for potential patent infringements is a key aspect of the process. Being able to interact with a customer not only allows the team to learn valuable communication skills, but also allows the exact specifications of the client for the two products to be known exactly. Narrowing down engineering concepts that will meet these specifications is a hard, but necessary thing to do. Next, picking out the appropriate materials and making sure that these fit into the allotted budget are monumental things in the product design process. One of the team members will be taking a machine shop class which is something that no one has yet been introduced to. This will allow the team to make components on our own, without needing to pay others for manual labor. This also introduces the team to the many things a machine can accomplish with a material to fully transform it into a finished product.

Overall, the project reinforces to the team the idea of life-long learning. Developing a product takes a lot of time, effort, research, and work. Alterations may be applied to the devices down the road, when it is determined that small parts of the product will not work. Being adaptable and able to keep up to timelines while creating a great product are all things engineers will do throughout their entire life. Refining the team’s communication skills also occurs with all the client contact. Not all the things learned from making these two devices are technical. The team learns that there are many ways to tackle one problem, but we will find the best one for our team and for the client while keeping an open mind along the way.
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