INTRODUCTION

Project Easel 5000 is a cooperative effort between UConn’s Biomedical Engineering Senior design class and the National Science foundation. The specific project being worked on for the National Science foundation is Engineering Projects to Aid Persons with Disabilities. The mission of this program is to create devices that assist individuals in reaching their maximum potential for enjoyable and productive lives. Dr. Brooke Hallowell will be the National Science Foundation representative consulting on project Easel 5000. The project is being done for an artist at Passion Works Studios. Passion Works is a unique program that creates art opportunities for people with developmental disabilities. Tom Depugh is the artist whose disability is cerebral palsy the project is being completed for. Cerebral palsy is a condition that results from brain damage. The symptoms include loss of fine motor ability, abnormal muscle tone, abnormal muscle movements, and vision problems. The ultimate goal of the project is to build an art easel that will allow Tom to paint from his wheel chair.

PROBLEM STATEMENT

Because cerebral palsy affects Tom’s strength, dexterity and range of motion, the easel will be built to compensate Tom in these areas. Previously, an adjustable easel was designed in 2003, but did not completely fulfill the needs of the artist. The first design did not have the adjustability needed by Tom. It also
had a motor that the artist had difficulty using, and was a tripping hazard because of the motors electric cord at the location where it was used. The ultimate goal of the current project, Easel 5000, is to create a new design better suited to meet the needs of the artist and address the design flaws of the first easel.

The artist is in need of an easel that can be easily adjusted. Since the artist has a limited range of motion, painting with a static easel is incredibly difficult. The artist also cannot use a standard easel with tripod legs due to the fact that he is in a wheelchair. The easel would need to account for wheelchair dimensions in order for the artist to use it appropriately. In addition, the artist is unable to paint unless the canvas projects out closer to his wheelchair.

Tom Depugh

OBJECTIVE

The objectives of the project are to use educational knowledge and background to design an easel that meets the specifications presented by the
National Science Foundation. These specifications fall into four main categories:
environmental, electrical, mechanical, and economical. The environment the easel will be used in will require it to be portable, table top size and easily used in a busy art room setting. The electrical requirements will include a cordless light source with an easy on/off switch. Mechanically the easel will need stability, flexible locking joints, and be able to accommodate a 20’ X 20’ canvas. Economically the design and construction of the easel must cost less than $750. The project is also meant to be an introduction to industry experience. Learning how to develop, organize, and design a project as well as teamwork are all important aspects of the project.

To accomplish the goals defined in the introduction, Team 3 has decided on a three-step plan that should accomplish those objectives efficiently and on budget. In addition, the procedure is dynamic enough so that if changes occur in any one of the stages, it will be easy to modify the design. The overall methodology team 3 intends to use is a three step cyclical process: research, design, and construction. During fall semester, research and design of Easel 5000 will take place, while in the spring semester, construction and ultimate delivery will take place.

The research portion of the project has three primary areas of interest. Those areas are ergonomics, materials, and wireless power sources. Each plays a critical role in the design process. To increase the usability of the easel by the artist, ergonomics research will seek information about how the artist will be positioned in relation to the easel, how the easel will move in relation to the artist,
and the actual painting motions used by the artist. All these components will weigh in when creating our first three preliminary designs.

Aesthetics is also important. One objective of the group is to involve the artist in his work as much as possible. By reviewing the moods generated by certain materials or certain structures and appropriately choosing those designs that create the desired mood, team three hopes to more fully involve the user of the Easel 5000 in art.

Another area of research that is pertinent to the Easel 5000 project is materials research. Materials selected will be robust enough to provide a stationary painting surface for the artist and strong enough to support the weight of the easel when it is moved into various positions. Currently, wood, metal, and plastic materials are being considered for the frame, joint, and light fixture structures. The anticipated load upon the easel does not warrant material selection before mechanical analysis; therefore, the final construction material will be selected after each preliminary design’s mechanical analysis is completed in the design portion of the process.

The third area of interest is in wireless power sources and lighting. To reduce the tripping hazard in the Passion Works Studio, the lighting source cannot have a cord attached for power from an outlet. The challenges will be to deliver a relatively maintenance free power source. Team three is currently exploring two options: battery power, and solar. Battery power has the advantages of higher power output, and smaller size. This would allow the use of
higher wattage incandescent bulbs. However, batteries also have the disadvantage of needing to be replaced and replacement means upkeep cost.

The other power source being considered is solar. Solar has the advantage of being essentially maintenance free. Once the array is set up, it would constantly provide power to the lamps, and personnel at the studio would not need to be concerned with replacing batteries. From an environmental standpoint, solar energy also produces no trash, as a battery-powered system does.

While solar is a feasibly power source for small devices like ours, there are several issues that arise when attempting to implement such a system. Solar power is initially more costly than the battery power, due to both the complexity of implementing solar cells and the cost of the cells themselves. Solar power is also dependent on the amount of ambient light in the studio and may not be able to deliver the maximum amount of electricity to the lamps. Because of the relatively low voltage provided by solar cells, incandescent bulbs may not work as well as LEDs.

The type of light source will also affect the artist's experience, and thus will be examined. The three light source types being considered are incandescent bulbs, LEDs (Light-Emitting Diodes), and Laser diodes. Incandescent bulbs can supply richer color tones, but required higher voltages and more power than LEDs. For the project, LEDs, and laser diodes have the same advantages. Both have long bulb-lives and have relatively low power consumption when compared
to incandescent bulbs. LEDs and laser diodes are also very bright light sources, but can be prone to slightly tinting illuminated surfaces.

After research is completed, the design process will begin. The first step of the design process will center on what the easel will look like and how it will function. In this stage, the group will determine how the easel will attach to the table, how the joints will articulate, how the canvas will be attached, and how the canvas surface will be lit. Each of the three preliminary designs will address the design criteria. To review, the easel must have the following features: the canvas surface needs to project forward; the canvas surface must have adjustable angles and must be able to lock into place. The easel must also have a light source with an easy to use on/off switch, an attachable base, and be the appropriate size for the client.

The mechanical analysis of each design will be done in the design step. Static analysis of the device, and stresses and strains put on the easel based on the estimated weights of potential materials will be analyzed.

Materials analysis and selection will also be completed during the design phase and will be based on the mechanical analysis and ergonomic factors. The final construction material will be based on cost, mechanical properties, and aesthetics. If the group encounters new information after the analysis that warrants further research, the appropriate topics will be researched and the new information will be applied to the design.
TIMELINE

The project’s schedule outlines a plan for the fall semester leading up to the beginning of the construction phase during semester 2. At this point, it would be presumptive to develop a schedule for spring semester, so it has been simply listed as construction. The dynamic schedule outlined for the fall semester is as follows:

1. Week of Oct. 9: Proposal report is due
2. Week of Oct. 16: First preliminary design due
3. Week of Oct. 23: Second Preliminary design due
4. Week of Oct. 30: Third Preliminary design due
5. Week of Nov. 6: Analysis to determine optimum project
6. Week of Nov. 13: Final parts order on optimal design.
7. Week of Nov. 20: Thanksgiving break
8. Week of Nov. 27: Final PowerPoint presentation
9. Semester 2: Construction

Assuming the fall semester schedule is followed, prototype construction can begin on time.

Project timeline in Microsoft Project
QUALIFICATIONS

The members of team three are qualified to complete this project. Justin Yu and Seth Novoson have completed the standard biomechanics course work integrated into the Biomedical Engineering program. In addition, they have completed course work in mechanics, including a mechanics of materials class, and are currently enrolled in a machine parts design course. Justin has also completed CE 212, a dynamics course involving the analysis of moving systems. The mechanics courses taken will prove useful in the design and analysis of the easel.

Alison Biercevicz has a biomaterials background and has taken the standard biomaterials classes as part of the Biomedical Engineering curriculum. She has also taken additional classes in corrosion technology and phase transform kinetics, and is also a painter and has been commissioned to do works. Her materials expertise will be of use for the material selection process and her painting experience will be of use in the aesthetic and functional design of the easel.

The three-step cycle for the development of the easel will ensure an organized research, development, and construction. Alison has the materials and artistic knowledge that will be advantageous in the design process, and Seth and Justin have a greater understanding of the mechanics that will be involved. Team 3 also has a rigorous schedule that should keep the development of the easel on track. In summary, Team 3 has the process, schedule, experience, and people aptly suited to complete this project on time, and on budget.
MARKET ANALYSIS

There are many products out in the market with similar designs as the Easel 5000. These products range in price drastically and have varying degrees of adjustability as well as quality. Three specific products shall be discussed, all of which were found on AbleData.com. The first product is called the “Able Table.” The Able Table costs $64.95. It is advertised as the most flexible adjustable product on the market. It is very flexible and supports numerous positions, as seen in the figure below. The Able Table is able to support up to 30 pounds of weight and is very versatile in its use. Though this adjustable device may be used as an art easel, “the Able Table also serves as a bed table, easel, portable desk, copy holder, music stand, drawing table, lap computer holder, lectern, etc.” Disadvantages of this device come in the difficulties to adjust it to any specific desired position. Tweaking positions on the Able Table is arduous and may be more time consuming than desired. Furthermore, it is noted on the Able Table website that the device is fragile and should not be handled roughly or else it will likely break.
Another marketed product is called the “Versa-Table.” The Versa-Table costs about $115. This product is much closer to the specifications of the design for the Easel 5000. It is much sturdier than the Able Table. Being lightweight and portable are major advantages to this product as it is able to fold up to a flat shape in to be stored when not in use. Adjustability is very easy for this device with a manual knob lock as seen in the figure below. The Versa-Table adjusts for height, depth, and angle similarly to the needs of the Easel 5000.

The Versa-Table

However, the Easel 5000 will be more adjustable than this device. The easel will need to be adjustable enough so that the easel face can be projected much closer to the artist. In addition, the easel face shall tilt toward and away from the user so that the artist may paint in a position where he is actually under the easel, as shown in the figure below. Due to this positioning of the easel face, the Easel 5000 will not merely be a drawing surface that many other marketed products such as the Versa-Table provide, but be an easel that will hold a canvas in place while the artist paints.
The last marketed product observed is a product called “The Dreamer.” The Dreamer is the highest along the price scale and will be much more expensive than the Easel 5000, costing more than $3000. The Dreamer has two sizes. The smaller version is depicted in the figure below. This product is fully adjustable, allowing for adjustments in height, length, direction, and angle through motorized parts and actuators. It is by far the most stable product in the market and allows for huge canvases.
All of the aforementioned devices are made for people with impairments. However, even the smaller version of The Dreamer is an extremely large device that takes up a large portion of a room. There are no storage options for this product as it does not fold up neatly when not in use. It is a very expensive solution that plainly may not be an affordable option for a casual painter.

The final product discussed will be the previous Senior Design product completed in the spring semester of 2003. The Accessible Easel design, shown below, has many of the adjustable features incorporated into the Easel 5000 design. However, the design of Easel 5000 strives to eliminate many of the user friendliness problems that the Accessible Easel struggled with. Elimination of the motor and having an easel that clamps onto the artist’s table entirely eliminates the safety hazards that the previous design had.
The Easel 5000 design will be looking at taking the user friendliness and optimal designs of all of the already marketed products while at the same time eliminating many of the design problems. As mentioned in the project statement, the Easel 5000 will be able to support a canvas size up to 20”x20”. It will be more user friendly than the previous accessible easel project. Included in its features, the easel shall be stable as well as portable and easily stored when not in use. The design shall have no motors or exposed wires in order to eliminate related safety hazard problems.

RESOURCES

In order to complete this project, funding will consist of $750. This funding will cover costs of materials as well as labor hours. Labor hours include any costs needed to pay for welding as well as machine shop certification for use of the machine shop facility. However, the Easel 5000 design may not incorporate welding.

The primary materials needed to build the Easel 5000 are the raw materials which will be either wood or metal. These raw materials will be the mainframe of the easel and the easel face. In order to articulate the easel face for adjustability, a prefabricated ball joint will be used. This ball joint system will have a manually adjustable locking mechanism so that after adjusting the easel, the position can be locked in place for stability. Metal clips will hold the canvas onto the easel, while either plastic or metal clamps will provide a stable base support for attaching the easel to the table. A lighting system shall be attached to the easel and will be battery operated with a simple on/off switch for easy user
interfacing. Miscellaneous costs will go towards metal nuts, bolts, screws, rails, and tracks, any of which may be incorporated into the design. The following is a budget breakdown for materials and labor.

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw materials</td>
<td>$80 - $300</td>
</tr>
<tr>
<td>Locking ball joint</td>
<td>$15 - $70</td>
</tr>
<tr>
<td>Clips</td>
<td>$10 - $20</td>
</tr>
<tr>
<td>Lighting system</td>
<td>$30 - $130</td>
</tr>
<tr>
<td>Nuts/bolts/screws</td>
<td>$25 - $100</td>
</tr>
<tr>
<td>Easel clamps</td>
<td>$40 - $50</td>
</tr>
<tr>
<td>Labor hours ($10/hour)</td>
<td>$0 - $30</td>
</tr>
<tr>
<td><strong>TOTAL COST</strong></td>
<td><strong>$200 - $30</strong></td>
</tr>
</tbody>
</table>

**COST/BENEFIT ANALYSIS**

There is a large market already existent for this type of product. Numerous products may be found through AbleData.com that have somewhat similar designs to the Easel 5000. However, the design aspect of the Easel 5000 incorporates the advantages of these existing products while eliminating many of the disadvantages. Additionally, the Easel 5000 will integrate new elements unseen in any existing devices, such as the attachment of a lighting system. Many marketed products do not have fully adjustable easel faces for impaired artists. As seen through the budget breakdown, essentially the Easel 5000 will be more expensive than products such as the Able Table or the Versa-Table. The costs necessary for building and designing the Easel 5000 may be more expensive due to the new features that will more easily help the artist interface with the easel.