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# Learn to Play the Guitar: A Prosthetic's Viewpoint

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*University of Tennessee - Knoxville*

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Appendix E - UNIVERSITY HONORS PROGRAM  
SENIOR PROJECT - APPROVAL

Name: MATTHEW A. MOORE

College: ENGINEERING Department: MAES

Faculty Mentor: ELAINE SEAT, PH.D.

PROJECT TITLE: LEARN TO PLAY THE GUITAR:

A PROSTHETIC'S VIEWPOINT

I have reviewed this completed senior honors thesis with this student and certify that it is a project commensurate with honors level undergraduate research in this field.

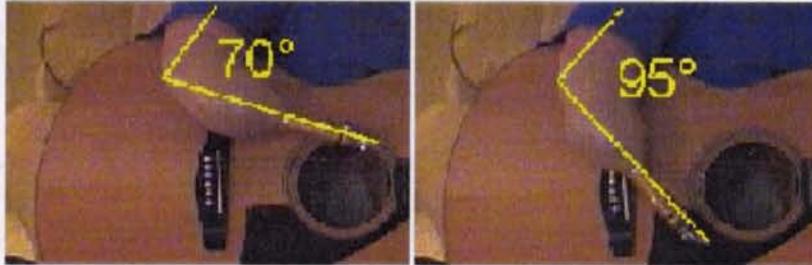
Signed: ELAINE SEAT Faculty Mentor

Date: 05/03/02

General Assessment - please provide a short paragraph that highlights the most significant features of the project.

Comments (Optional):

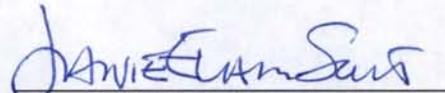
Moore Prosthetics



# Learn To Play The Guitar

*A Prosthetic's Viewpoint*

  
Matthew A. Moore, EIT

  
Elaine Seat, Ph.D.  
Faculty Advisor

## **Abstract**

In recent years, more exposure has been given to amputees who push the use of their prosthesis beyond its intended limit. People who use prosthetics do not like to think that because they have a disability, they have to refrain from competing in athletics and those activities that “normal” individuals can easily do with practice. The Paralympic Games is a prime example of this.

Bethany Anglin lost her forearm to cancer at an early age. After several years of learning to accomplish the basic needs of eating, writing, etc., she now wants to pursue her hobbies. One of these hobbies is playing the guitar. This task is not easy for an individual with one arm but that doesn't stop Bethany. Currently, she is using a crude prosthetic with a pick on the end fabricated by one of her doctors. According to Bethany, this prosthetic is not sufficient in allowing her to play the guitar with ease or efficiency.

Using an existing computer software program (Visual Instruction System v 4.0) that is primarily used to analyze athletes' body mechanics, Bethany was filmed playing the guitar in order to compare her movements with a local guitar instructor. These clips were used to determine the correct plan of action in helping her play the guitar. It is believed that a new prosthetic can be designed in order for Bethany to improve her technique and in turn, improve her hobby of playing the guitar.

May 3, 2002

RE: Senior Honors Project

Dr. Tom Broadhead  
The University of Tennessee  
University Honors  
F101 Melrose Hall  
Knoxville, TN 37996

Dear Dr. Broadhead:

Being presented to you now is a detailed account of my Senior Honors Project. The purpose of my investigation was to study a subject, Bethany Anglin, who previously lost her right arm to the disease cancer, and determine the best course of action in achieving her goal of playing the guitar.

To determine the best solution in reaching this goal, a professional guitar player, Tim Worman, was contacted in order to compare the subject with a control group. Using a computer software package, Visual Instruction System v. 4.0, comparisons were made using video footage of each individual playing the guitar. The data obtained from the analysis was used to formulate several alternatives to the current situation. These alternatives were evaluated using a ranking system and it was determined that a combination of two alternatives would be the best course of action.

The results obtained from this study indicate that improving the technique of the subject to mimic the control group and improving the current prosthetic will enable the subject to play the guitar with ease and accuracy. It is recommended that these measures be implemented in order for the subject to play the guitar with ease and accuracy.

Sincerely,



Matthew A. Moore, EIT  
Moore Prosthetics

cc: Elaine Seat, Ph.D.  
Bethany Anglin

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## **Summary**

In conversation with an amputee patient, it was concluded that there are many things that one cannot accomplish with the use of a regular prosthetic. Miss Bethany Anglin expressed her concern with not being able to play her guitar accurately with her current prosthetic. A crude device was manufactured by one of her doctors in order for her to play the guitar better, however it was not designed for her to play the instrument with the correct technique. A local guitar instructor, Mr. Tim Worman, was contacted in order to document how to play the guitar with the correct technique.

Using the computer software, Visual Instruction System v. 4.0, video footage of Miss Anglin and Mr. Worman was analyzed to determine how the two techniques differ. Understanding how to hold and position the guitar aided in finding the best solution in helping Miss Anglin in playing the guitar better.

Several alternatives were made available by comparing the two individuals' video. These alternatives were evaluated using specific design criteria and can be viewed in Table 1 (p. 20). A combination of alternatives was determined to be the best course of action. The first step in the process will be to improve Miss Anglin's technique. Altering this to mimic the technique of Mr. Worman will enable her to play the guitar with ease and accuracy. When this alternative was put into action, it was determined that the current prosthetic would not be sufficient. This introduced the second alternative of improving the prosthetic device. Lengthening the shaft and designing a new pick holster will be sufficient modifications for her to use the correct technique.

A detailed account of this study follows with an evaluation of each alternative to the problem. Schematic drawings of the modifications to the prosthetic can be found in the Appendices. Recommendations for further study are also discussed at the end of the report.

## ***Introduction***

### **Project Justification**

Many people are born without one or more limbs or lose one throughout the course of one's life. In recent years, this once thought of shortcoming is now far from it. The art of prosthetics has allowed amputees the ability to perform the same everyday tasks that a person with ten fingers and ten toes can do. However, for some individuals, going beyond the everyday tasks is a goal they wish to achieve. Due to the use of aesthetically pleasing prosthetics, individuals may not be able to use them for recreational purposes. This setback renders the user unable to ski, shoot basketball, strum a guitar or perform any other hobby. Bethany Anglin, a forearm amputee, uses a crude prosthetic to play the guitar. It does not allow her to use proper technique when playing and therefore reducing her chances of improving and the continual enjoyment of playing. My task will be to determine the best course of action that will allow her to play the guitar with ease.

### **Purpose**

The solution that arises from this report will be for individuals who have lost any portion of the forearm and below. When playing the guitar correctly, the elbow is placed in the same position for every person (Worman). This allows the prosthetic to be standardized from the mold down. In order to accommodate different size individuals, the solution must be such that it allows the user to strum the strings at the exact position needed. The current device uses a screw to fix the pick tight in place creating a bend in the pick. This bend is not ideal when playing the guitar because it increases the pick's stiffness (Worman). A new fixation device will be designed to grip the pick better and allow for more flexibility.

### **Scope**

The scope of this project entails evaluating alternatives that will aid forearm amputees in playing the guitar with proper technique. The plan of

action is to video Bethany playing the guitar using her current prosthetic and comparing it with video of a professional guitar player. Visual Instruction System 4.0 is a computer program that allows a user to compare video frame-by-frame via measurements drawn on the video as seen on the computer. Comparing Bethany's technique with a professional guitar instructor will allow the differences in techniques made clear and easier to correct. After data is taken from the comparisons, alternatives can be determined. Evaluating these alternatives using specific criteria will narrow the correct solution down and ultimately lead to the selected alternative or alternatives.

Once an alternative is selected, it will be tested and evaluated by shooting video with Bethany using the new system. This will then be compared to the same professional guitar instructor using the computer program. Modifications will be made until a close match is met.

## ***Background***

### **Reasons for Prosthetics**

Currently, thousands of people are born without an arm or leg every year. In addition, thousands more lose an arm or leg every year. In order for these individuals to carry on a normal life, they use prosthetics. Prosthetics can come in several shapes and sizes, depending on the need and preference of the individual. A female professional in need of an arm or hand might want the nails on the fingers to be long in order for her to apply fingernail polish. Some prosthetics are equipped with electrical contacts allowing the amputee to open and close the fingers of the prosthetic in order to grasp an object. These types of devices are good in that it allows an amputee to perform normal daily tasks like any other human being while other people might not even realize anything is different.

Although amputees are able to perform the same daily tasks as the average person, some things are difficult to accomplish with the use of a standard issue prosthetic. One example is a leg amputee who uses a nice prosthetic with toes during the day so open-toed shoes can be worn. This prosthetic is not engineered for use in running. Any force larger than the average amount used in walking may fracture the device and cause it not function properly. In the case of the subject of this study, an average forearm prosthetic is not sufficient to strum the strings of a guitar (Anglin).

### **History of Subject**

Bethany Anglin is a female who lost her arm approximately two inches below her elbow at an early age. She was diagnosed with Synovial Cell Sarcoma in December 1988 at the age of eight. This rare form of cancer is usually found in the lower extremities of adults. This made it all more rare to find it in the hand of a young girl. Bethany was put on a very high dose of Chemotherapy on January 15, 1989. After two weeks had passed, the doctors confirmed that the disease was still spreading. Wasting no time, her arm was amputated on February 2. The treatments continued throughout the year.

Because Bethany was born with both arms, she had to learn to write, eat and brush her hair all over again. People who are born with one or no arms grow up learning to do without. This is not the case for people like Bethany. She was determined to find a prosthetic that would allow her to continue her daily routines as normal as possible. She learned of a company in Texas that catered to children with the loss of a limb. This company primarily deals with children who were born without a limb, but this soon changed. Bethany became the first cancer patient the Texas-based company sold a prosthetic to. It was a basic arm that had a mold of her elbow on the one end and five fingers on the other. She used this prosthetic throughout most of her elementary and high school days because she was used to having two arms and also to remain as normal as possible when interacting with her friends. Bethany was a normal student and even made the cheerleading squad having perfected a back-handspring with only one arm. She was given a guitar by her grandfather and began learning to play it by herself (Anglin).

Using a myoelectric prosthetic, Bethany was able to close the fingers and grasp the pick to play. She quickly learned that it was not easy at all. Having the extra electrical components in the prosthetic dramatically increased the weight of the prosthetic and made Bethany decrease the amount of playing time. On a routine visit to her doctor, she asked him if he could manufacture something that would allow her to play the guitar. In just two hours, the doctor had fashioned a crude prosthetic (Figure 1) with a pick on the end that allowed Bethany to play with a lot more ease and comfort. Bethany has since stopped using her normal prosthetic and chooses to do everything with her left arm and Susie, the name she gave her stump (Anglin).



Figure 1: Current Prosthetic

## **Current Technology**

Very few companies invest time and money into designing prosthetics for individuals who wish to use them for hobbies (TRS). There are a few however that do enable patients who have lost a limb to have the opportunity to either begin or continue a valued hobby. One in particular is TRS. They specialize in designing devices for people who have lost a hand. Using a standard mold connected to the arm, several attachments can be interchanged depending on the activity. One of the attachments is meant for use with a stringed instrument. Because the device is primarily for hand amputees, this method would not work in Bethany's case.

A patent search was conducted to determine if any devices were currently available to use and also to make sure that no patent rights would be infringed upon. The method used for the patent search was simple but thorough. A quick search on the United States Patent & Trademark Office web site (<http://www.uspto.gov>) was done using the following keywords: guitar, prosthetic, string instrument and combinations of these. Only one patent was found to have a similar application as in this case. Patent 5,062,860 is a prosthetic attachment for a forearm amputee who wishes assistance in playing a stringed instrument. A chord finger and a note finger are utilized by pulling an operating cable. Though this device is not the design in mind, Bethany expressed her feelings on not using a prosthetic that requires cables to operate. The schematic of the patent in question can be viewed in Figure 2.

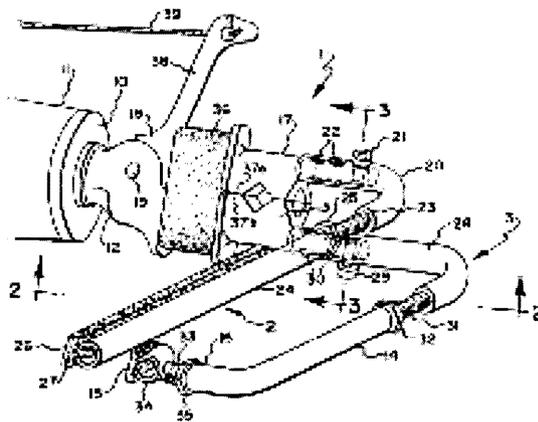


Figure 2: Schematic of Patent 5,062,860

## Objectives

Several objectives are required to be met in order for this project to be considered a success. The main objective and goal of this study is to enable a forearm amputee to play the guitar. The current device in operation does not allow for the user to utilize the correct technique. Incorrect technique causes the range of motion when plucking the strings to increase. The increase in range of motion in turn increases the angle of the pick when plucking the bottom string causing it to be difficult to do so.

The first objective will be to improve the subject's technique. Currently, Bethany has no formal training in playing the guitar. She simply picked the instrument up and played what was comfortable to her. In order for the prosthetic to work properly, Bethany will have to learn some basic skills on how to hold the instrument and where to pluck the strings. Learning these changes will alter the outcome of the next two objectives. A small range of motion over the strings reduces the amount of effort the user has to exert and therefore increases the amount of time one can play. In order to have a small range of motion over an object, the pivot point (elbow) must be positioned far enough away. Increasing the distance from the strings to the elbow will decrease the range of motion and also help to keep the pick relatively horizontal when strumming the strings (Worman). The best prosthetic in the world can be constructed but it would have no use if the

individual it is meant for is unable to use it. The objective of having the device user-friendly is of key importance. It should be easy to put on and take off and an instruction booklet should not be attached. The subject should be able to place the device on and be strumming the strings in seconds. Because the prosthetic will allow the subject to perform a hobby and is not needed to assist in normal functions of life, insurance companies will not pay for its use (TRS). Because of this, an objective that should be considered is low cost. Using the existing device and improving it, this objective should be feasible.

### **Basis for Selection of Alternatives**

Several alternatives will be presented and preliminary evaluations will narrow the list down to those which meet the objectives formally mentioned. Any alternative that will allow the subject to improve on the play of the guitar will be considered. The alternatives that look to have a better chance of meeting the objectives will be evaluated by requirements set forth in the Design Criteria. They will then be compared with the present technique and with each other to determine the best course of action in meeting the objectives.

## ***Methodology***

### **Plan of Study**

In order to design a device that is meant to help someone play an instrument, one must know how to play the instrument or at least employ someone who does. Learning the correct technique of playing the guitar is the first step in this project. If one was able to compare the play of a self-proclaimed professional to the subject, distinctions could be made and areas of improvement can be identified with ease. These distinctions can be taken into account when designing the prosthetic in order to mimic the motions of the said professional (Seat).

### **Sources of Data**

The first data obtained was video footage of the subject, Bethany Anglin, playing the guitar in the same manner she has since she began. Using this video will allow for comparisons to be made with a professional guitar player.

Tim Worman is a local guitar instructor in Knoxville, TN. He is known for his good techniques and regularly lends his services to individuals wanting to learn to play. Mr. Worman agreed to donate his time by being filmed for this study and giving a crash course in guitar play. In conversation with Mr. Worman, a general idea of the correct technique was achieved in order to compare with the subject.

Using existing software, Visual Instruction System v. 4.0, comparisons of the two videos can be made. Dr. Elaine Seat and Mr. Will Schleter designed this software to compare athletes of different skill levels. A novice would be able to compare, frame-by-frame, the movements of a professional. This will allow the novice to alter the current technique in hopes of becoming as successful as the professional. Dr. Seat donated this software to the study in order to help compare Bethany's video with Mr. Worman's.

## Technique

Before any comparisons can be made, a better understanding of how to play the guitar must be explained. In meeting with Mr. Worman, he explained that there are more things to consider than just where to place your fingers and the pick. The first thing to master is holding the instrument. All other variables are dependent on how the individual positions the guitar on the body. Mr. Worman stated that the instrument should be held close to the body propped up under the armpit without allowing the elbow to be locked onto the guitar. The elbow should be placed at the top right of the guitar and the pick should be placed approximately 0.5 inches left of the sound hole. This positioning should allow a  $30^\circ$  angle from the shoulder to the top of the strings. A  $45^\circ$  angle is recorded to the bottom of the strings (Figure 3). This calculates into a range of motion of  $15^\circ$  when strumming all six strings. In doing so, the pick should remain as horizontal as possible (Worman).



Figure 3: Tim Worman Elbow Angles

In viewing Mr. Worman's pick angles (Figure 4), the pick begins at  $25^\circ$  and reaches to a high of  $35^\circ$  when in contact with the strings. When reaching the bottom string, the angle will increase slightly but as long as it stays within  $10^\circ$  of the starting angle it is sufficient (Worman). It is a common mistake to believe that the wrist plays a vital role in playing the guitar. Mr. Worman explained that the wrist should actually remain quite still when playing. All motion should come from the elbow and little if any should be from the wrist (Worman).



Figure 4: Tim Worman Pick Angles

Pressure on the pick is a variable that is hard to quantify. Mr. Worman stated that the pressure is variable with regard to what is being played. A much larger pressure is needed when a hard sound is desired. In contrast, when a soft song is being played, less pressure is utilized. Because a prosthetic cannot sense the amount of pressure being applied, Mr. Worman suggested using different picks. It was learned that picks can be purchased with different stiffness values. In Bethany's case, he suggested a pick with a small stiffness would be beneficial. This would allow for small errors when strumming up the strings instead of hearing every string depressed when using a very stiff pick.

The guitar an individual uses also plays a large role in how it is played. For small individuals, a large guitar might not allow for correct technique to be used. Bethany currently uses a Martin D-28, which is too large for her. Mr. Worman suggested using a 00 (double naught), which is a much smaller instrument. This would allow her to place her elbow in the correct position.

### **Visual Instruction System**

This system is used to analyze video by comparing a subject to a control group, primarily in a sports related area. In this study, Bethany will be considered the subject and Tim Worman will be considered the control group, or professional. The same footage was taken of both individuals strumming the guitar from the front and side views. These views were used in order to measure the angle of the elbow (front view) and pick (side view). It should be noted that all angles used in this study were used as references and guides only. These angles may not represent the exact angle, but are sufficient to use when comparing the differences between two angles (Seat).

The software enabled the video to be seen frame-by-frame and choose individual frames to be keyed and analyzed. The first analysis was of the elbow angle. Two key frames were marked on each subject. The angle of the elbow when the pick is at the top and bottom of the strings shows the entire range of motion. Mr. Worman explained that the motion should be down the strings along a path and return up in that same path. These frames conclude that Mr. Worman began the motion with a  $30^\circ$  angle between his shoulder and the pick. At the end of the motion, the angle was at  $45^\circ$ , a difference of  $15^\circ$ . Bethany, however, began at  $70^\circ$  and traveled  $25^\circ$  to a stopping point at  $95^\circ$  (Figure 5). This shows that not only is her range of motion  $10^\circ$  more, the  $40^\circ$  difference in starting points indicates her elbow is far from where it needs to be.

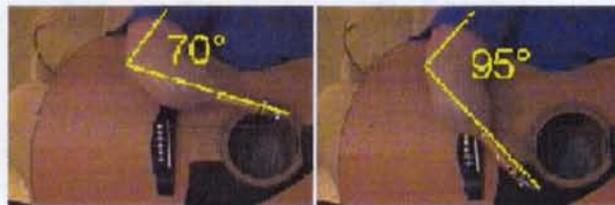


Figure 5: Bethany Elbow Angle

The second view shows the pick angle as it traveled down the strings. As one can see in Figure 4, the pick used by Mr. Worman begins with an angle of  $25^\circ$  and ends with an angle of  $35^\circ$ , a difference of  $10^\circ$ . When comparing this to Bethany's angles (Figure 6), one can see that she begins with the correct angle but as she travels down the strings, she is unable to keep the pick horizontal to the guitar. It ends up with having a difference of  $20^\circ$ ; double what the expected limit should be.



Figure 6: Bethany Pick Angles

## **Description of Alternatives**

After analyzing the video footage, it was noted where improvements should be made in order to allow Bethany to have the same technique as Mr. Worman. These improvements were translated into several alternatives that could be utilized. Although not considered a true alternative, continuing to use the existing technique must be evaluated with the others in the event that the no true alternative is found to be an improvement over the current method.

The first alternative would be to improve Bethany's technique. This alternative could go a long way in helping. It can be compared in Figures 3 and 5 that she does not have her elbow in the correct position. This minor change has the potential to correct all flaws. It is also noted that the pick is being strummed in the middle of the sound hole. As stated previously, it should be approximately 0.5 inches to the left (Worman). It is projected that moving the elbow in turn will move the pick in turn will decrease the moment arm, or range of motion. As one can note, improving the technique will improve the play.

The next alternative involves purchasing a smaller guitar. Decreasing the size of the guitar currently used by Bethany will enable her to stick the instrument under her armpit. This will then allow her to move her elbow to the correct position, again moving the pick placement. She currently uses a 000 (triple naught) and it is suggested she reduce this to a 00 (double naught). Different size guitars can be purchased at any local music store.

Another alternative involving the guitar is altering the current one being used now. It is possible to design a guitar that has a notch cut out of the top left side in order for the player to drop the armpit lower than on a regular guitar. In Bethany's case, this drop will allow her to place her elbow in a more comfortable spot. Currently, her prosthetic is too short to place her elbow in the correct position. Cutting on the guitar will make room for her to drop her elbow and decrease the distance to the sound hole.

The next alternative is improving upon the current prosthetic (Figure 1). This could be altering the existing device or designing a new one. The

current prosthetic is crude in that it was designed in a couple of hours with no regard to correct technique of playing the instrument. The doctor simply created a mold for the arm and attached a pipe with a pick on the end. The pick is held on the device by placing it between a metal bracket and a screw (Figure 7).



Figure 7: Current Pick Holster

The screw tightens the pick onto the bracket at the rear. Because the screw is smaller than the back of the pick, it must be very tight to hold the pick on. When the screw is this tight, it begins to create a bend in the middle of the pick. This bend increases the stiffness of the pick and alters the shape (Worman). Because of this, a new part can be designed to hold the pick in a fashion more similar to the way fingers grasp a pick, across the entire back of the pick (Worman). Another indication that the doctor did not take technique into account is the fact that the length of the shaft is too short measuring approximately 8 cm (Figure 8). An increase in the shaft would be necessary when altering the device in order for the subject to reach the sound hole when the elbow is placed in the correct position.



Figure 8: Current Shaft

The last alternative that should be considered takes every other alternative into account. A hybrid of the alternatives may give the best solution instead of just choosing one. This alternative can be a combination of

two or more previously mentioned alternatives. Each alternative will be evaluated and the combination of some selected alternatives will be evaluated.

## ***Design Criteria***

The technical objectives for this study depend on what alternative is chosen. The only design that will be considered is if the alternative of improving the prosthetic is chosen. No other alternative involves having a design criterion. In this case, the criteria for an improved prosthetic will be discussed for the simple fact that this alternative could be chosen.

As stated previously, two major modifications must be made to improve the current prosthetic. The first would be to increase the length of the shaft. This can be accomplished by using the same material. In order to account for different size individuals, a shaft that can be extended and retracted will be utilized. The second modification would be to create a device that would hold the pick without bending or increasing the stiffness of it. This will require it to hold the pick along the entire back and not just in the center. It will also have to be soft and flexible but firm enough to grip it tightly. Another criteria would be to design the new device so that it can attach to the existing prosthetic without adding bulk and weight.

Other criteria to consider would be to maintain the lightweight design and make sure the mold is comfortable in the position that the user will be playing the guitar.

## ***Evaluation of Alternatives***

### **Design Alternatives for Justification**

The current situation in that Bethany uses the existing prosthetic and technique was designated as the reference group. The expected worth of each criterion was assigned to this alternative. When evaluating the other alternatives, they were ranked in accordance to how they compared to the reference group. By establishing a base line, this prevents trying to randomly decide how much each criterion should be worth for the different alternatives. If the points change for the current situation alternative, then it will directly affect the points for the other alternatives. Four criteria were used in evaluating these alternatives and their respective point allowance is shown in Table 1. Each alternative will be evaluated on cost to the subject, ease of use, angle of the elbow and angle of the pick.

### **Current Situation**

This alternative is considered to be the control group when evaluating the other alternatives. This is due to the fact that every alternative will either be better or worse in each criterion. An average rating was given in each criterion except the cost to subject. This is because if this alternative were chosen, there would be no cost incurred. Bethany would simply continue to play the guitar with her existing prosthetic and existing technique. The remaining three criteria ratings can be viewed in Table 1.

### **Improve Technique**

The first alternative that is to be evaluated is one that would allow Bethany to use her current prosthetic while altering her technique. The new technique that would be used would come from either this study or lessons with a guitar instructor, such as Tim Worman. Comparing Bethany's video with Mr. Worman, one can see that her technique is not what it should be to play well. It is projected that if she learned the correct way to play a guitar

and the correct position to hold a guitar, it would lead to an improvement in the angle of the elbow and pick.

Altering anything that one has done for a long period of time is very difficult. A golf instructor does not wish to change a golfer's swing entirely, but tries to work with what is already in use. Because of this, it would not be easy to alter the way Bethany holds and plays the guitar. It would take several hours lessons and many more hours of practice (Worman). It would however improve the angle of her elbow and in turn, the angle of the pick. Learning where the correct placement of her elbow on the guitar will greatly reduce this angle because the distance to the sound hole is increased. However, when this distance increases, the pick will not be able to reach the desired position because the prosthetic is too short.

### **Smaller Guitar**

This alternative arose when it was realized that Bethany was using a large guitar to play. She was having trouble putting the instrument under her armpit where it is supposed to be placed. She had to drop the guitar very low in order to place her arm over it. When this occurred, the position of the guitar was not correct (Worman). The angle of her arm was sacrificed and this created a very large range of motion as seen in Figure 5. Switching to a smaller guitar will allow Bethany to keep the guitar close to her chest and still allow it to fit under her armpit.

Because Bethany does not currently possess a smaller guitar, the cost to obtain one would be significant. It would be relatively easy to use in that she would play the same way and use the same prosthetic. The only thing that would be different is the fact that she would be able to hold the guitar better. In doing so, it would assist her in decreasing her range of motion and allowing for the pick to become more horizontal.

### **Alter Guitar**

Another alternative would be to alter the design of the guitar. The problem with Bethany playing the guitar with ease is the fact that she is

unable to drop her arm over the guitar. This prevents her from keeping the pick horizontal over the strings. If there was a way that the top left of the guitar could be cut out, she could drop her armpit low enough to keep the prosthetic, and pick, horizontal to the strings. She could also move her elbow close enough that the prosthetic would not have to be modified. The pick would be able to rest at the suggested 0.5 inches to the left of the sound hole.

Using a new designed guitar would be easy for Bethany. Nothing in her prosthetic would be altered and only a slight modification in her technique would be required. It is projected that it will actually feel better for her and increase her enjoyment of playing. It would greatly increase the elbow angle and pick angle. Mr. Worman mentioned, however, that altering the design of the guitar would sacrifice some acoustics though not enough to tell when used by a novice. The major downfall for this alternative would be the cost involved in designing a new guitar. Unlike buying a new guitar as in the previous alternative, designing and manufacturing a new type of guitar would be outrageous; not to mention that there would only be a need for one of them (Worman). This is not the demand wanted when manufacturing new products.

### **Improve Prosthetic**

The last individual alternative is to improve the prosthetic. To decrease the amount of cost involved, the decision of altering the current prosthetic will be used instead of designing and fabricating a new one from scratch. As mentioned previously in this study, two main modifications can be made to improve the overall performance of the device, varying the length of the shaft and creating a new device to hold the pick.

Currently, the shaft is a fixed length and cannot be increased or decreased. This option would be necessary when playing different size guitars or a different stringed instrument. Different instruments require the individual to hold them in different positions. Because of this, the shaft can be variable in length allowing for any person to play any stringed instrument.

The pick is currently held in place by a screw and washer in the center of the back (Figure 7). This creates a bend in the pick that increases its stiffness and alters the way the strings are plucked (Worman). A new device can be designed that clamps on the entire back of the pick simulating being held by a thumb and forefinger (Worman). This device should be able to connect to the prosthetic using the same screw that was used to hold the pick.

These modifications will help remedy the angle of the elbow and pick by a small amount but mainly it would create more options in playing a stringed instrument. It would be easier to use than the current prosthetic having the new pick holder attached. Cost would be negligible due to the fact that material could be obtained from the Mechanical, Aerospace and Biomedical Engineering Machine Shop located in Dougherty 109 of the University of Tennessee.

### **Combination of Alternatives**

This alternative is made available because each alternative is good in its own capacity but a hybrid of two or more may turn out to be a better option in the long run. A non-scientific preliminary evaluation was conducted to determine which alternatives would work best together. The one discussed below proved to be the best out of all combinations evaluated.

The first alternative chosen for this combination was to improve Bethany's technique. This alternative would be a recommendation even if not chosen to be the selected alternative. In order to play an instrument and hope to improve, the correct technique must be utilized. When comparing the video of Bethany and Mr. Worman, it was easily noticed that she was not playing the guitar correctly. As mentioned before, just watching the existing video footage of Mr. Worman and determining how to hold the guitar correctly can accomplish this alternative.

To determine if this alternative would be sufficient alone, more video was taken with Bethany using the same technique as Mr. Worman. It was determined that when using the correct technique, the prosthetic is too short for the pick to reach the desired position next to the sound hole. Realizing

this, the next alternative of improving the prosthetic was added to the combination. With the elbow in the correct position, it should be easy to calculate the exact dimensions needed in modifying the prosthetic. Again, no cost should be incurred in implementing this alternative.

**Table 1: Evaluation of Alternatives**

ALTERNATIVES CRITERIA	Maximum Point Allowance	Current Situation	Improve Technique	Smaller Guitar	Alter Guitar	Improve Prosthetic	Combination of Alternatives
Cost to subject	35	35	30	20	15	35	35
Ease of use	25	10	15	15	20	20	20
Angle of elbow	20	10	18	12	18	15	18
Angle of pick	20	10	18	12	18	15	18
<b>TOTAL</b>	<b>100</b>	<b>65</b>	<b>81</b>	<b>59</b>	<b>71</b>	<b>85</b>	<b>91</b>

## ***Selected Alternative***

As one can see in the previous table, the alternative that ranked the best when evaluated using the design criteria is actually a combination of alternatives. This solution will bear no cost to the subject, is fairly easy to use and will improve the angle of the elbow and pick. The reason the ease of use criteria received a low number is the fact that it will take some time for the subject to learn a new way to hold and play the guitar. Although it only requires a small adjustment in position, it is drastic in that she has been playing a different way all her life.

The first of the combination of alternatives requires Bethany to position the guitar in such a manner it mimics Mr. Worman's. As one can see in Figure 9, Bethany was filmed with her elbow at the correct position as stated by Mr. Worman. In holding the guitar in this manner, it will greatly reduce the angle of the elbow and the range of motion. The starting angle indicates a value of  $70^{\circ}$  and an ending angle of  $85^{\circ}$ . Though they seem to be large in value, the difference is what should be noted. A change of  $15^{\circ}$  is the same that was seen in Mr. Worman's video (Figure 3). This indicates that the range of motion was decreased from a previous value of  $25^{\circ}$  (Figure 5).

Also, Figure 10 shows the new pick angles when the guitar is held in the new position. The pick starts at  $20^{\circ}$  and ends at  $30^{\circ}$ . The difference of  $10^{\circ}$  is within the standard set by Mr. Worman. It is also a great improvement on the previous change of angle of  $20^{\circ}$  seen in Figure 6. This decrease is on account of moving the elbow to the left and allowing the range of motion to decrease. When this occurs, the pick is able to remain horizontal as it goes down the strings.

When Bethany holds the guitar in this manner, it is noticed that the pick is not able to strum the strings in the optimal position approximately 0.5 inches to the left of the sound hole (Worman). Because of this, the second alternative in the hybrid solution must be utilized.

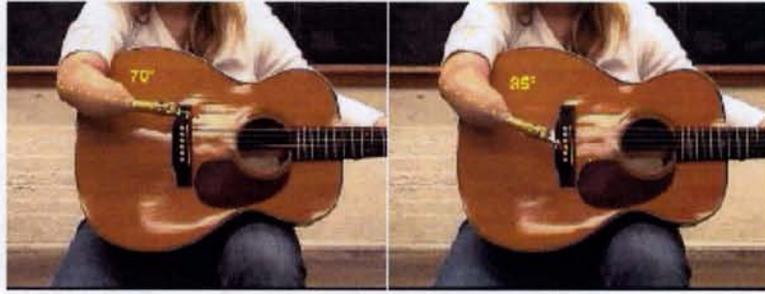


Figure 9: Bethany New Elbow Angle



Figure 10: Bethany New Pick Angle

One can see that the prosthetic must be modified in such a way that the pick is able to reach the sound hole. Because the mold is already made, increasing the length of the shaft on the prosthetic is the optimal solution. The shaft is currently 8 cm long from the mold to the pick. It is suggested that this increase to a maximum length of 13 cm. In doing so, the pick will be able to strum the strings at the correct position. It is also projected that an increase in the length of the shaft will allow the elbow to move further to the left, decreasing the starting angle of the elbow. Instead of fixing the shaft at a certain length, as it is currently, it will be designed to extend and retract. This feature will allow Bethany to find the most comfortable position for her and adjust the shaft accordingly. It will also give her the option of playing another stringed instrument that requires a different way of holding it. One last use of making the shaft adjustable is the option of someone else using the design. A mold of the arm must be made to fit the individual, but from the mold down it would be standard.

Another modification to the design of the prosthetic includes a change to the way the pick is attached. Currently, the pick is held between a piece of metal and a screw and washer as seen in Figure 7. Because of this, the pick becomes bent and its stiffness increased. In order to combat this, a new

holster will be utilized. It will be a C-shaped clamp that will attach to the current prosthetic where the pick is held now. Two screws will be on the top of the clamp on either side. These screws will not be in contact with the pick but will hold it firmly in place. Rubber will be used in the middle of the clamp in order to keep the pick in place while allowing for some flexibility. A detailed schematic of this design can be found in Appendix B.

## ***Conclusions***

It was concluded from this study that Bethany had a problem playing the guitar using her current prosthetic device. Using the video footage of local guitar instructor, Mr. Tim Worman, comparisons of the two techniques were analyzed using the software, Video Instruction System v. 4.0. Evaluating several alternatives to improve her play of the instrument brought forth a solution by combining of two of the alternatives. Improving Bethany's technique by mimicking the movements of Mr. Worman will enable her to play the guitar with more ease and accuracy. One can see the new elbow angle in Figure 9. As one can also see that in order to accomplish this goal, modifications to the existing prosthetic must be made.

When Bethany moves her elbow back to the correct position, it causes the pick to move as well. When this happens, the pick is not in the optimal position to strum the guitars (Worman). Because of this, the shaft on the prosthetic can be lengthened to make up the required distance. When doing so, instead of molding the shaft to a desired length, it will be designed to be adjustable for people of different sizes or in the case that Bethany wants to play a stringed instrument that requires her to hold it in a different position. A detailed schematic of the proposed shaft can be seen in Appendix A.

The pick is currently held in place with a screw and washer. It was concluded that this setup is not ideal when playing the guitar (Worman). This type of apparatus creates the pick to bend in the middle, increasing the stiffness. Mr. Worman indicated that the pick should be held with the thumb and forefinger over the entire back of the pick. A holster was designed to accomplish this goal and can be viewed in Appendix B. This device will be able to attach to the current prosthetic where the pick was originally.

The selected alternatives were evaluated against the design criteria set forth previously in the report and were found to be the best solution to the problem. Further recommendations for this study can be found in the next section.

## ***Recommendations***

In reviewing the data and conclusions, it is the recommendation that the selected alternatives be implemented in order for the subject to improve in playing the guitar. In order to accomplish this, the current prosthetic must be modified in the fashion shown in the design schematics (Appendices A and B). These modifications can be fabricated in the Mechanical, Aerospace and Biomedical Engineering Machine Shop located in Dougherty 109 at the University of Tennessee. After such said modifications are made, the next alternative can be implemented. To improve one's technique in playing the guitar, several hours of lessons and practice must be sacrificed. Mr. Tim Worman, the control subject, is available to teach lessons to individuals such as Bethany at his guitar store, *Pick n Grin*. If the money or time is not available to the subject, review of the video footage shot for this study can be substituted for minor technique improvements.

Though not a feasible alternative for this study due to funding, using a smaller guitar will enhance Bethany's technique greatly. She is currently using a 000 (triple naught) guitar that does not allow her to position the guitar correctly. It is recommended that Bethany use a smaller guitar, possibly a 00 (double naught), if she plans to pursue the hobby of playing the guitar in the future. Guitars can be purchased at any local music store.

## ***References***

Anglin, Bethany. Meeting held on March 13, 2002: 4:30-5:30 pm.

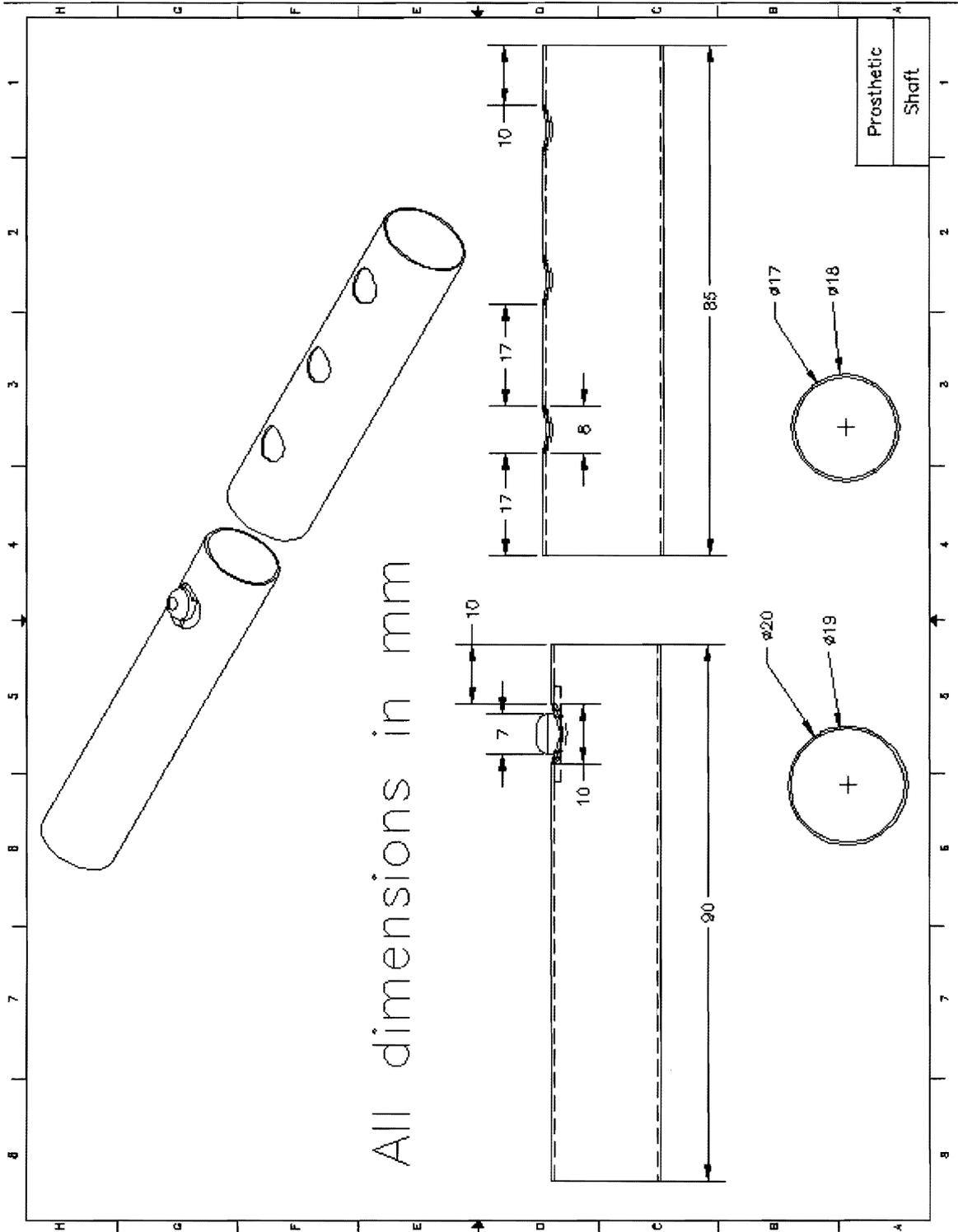
Seat, Elaine Ph.D. Visual Instruction System v. 4.0. Digital Video Motion Analysis Software, 2001 Creative Information Solutions.

Worman, Tim. Meeting held on November 14, 2001 at Pick n Grin: 8:30-9:30 am.

## ***Appendices***

Appendix A: Schematic of Prosthetic Shaft.....	A
Appendix B: Schematic of Pick Holster .....	B

## Appendix A: Schematic of Prosthetic Shaft



## Appendix B: Schematic of Pick Holster

