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Controller and Headset Stand: Designing and Manufacturing

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The creation of the controller and headset stand was a long journey in taking it from an idea to mass producible product. We would like to thank all the Center for Manufacturing Excellence faculty for their help along the way in preparing us for our capstone. Special thanks to Mike Gill in his mentorship through both the capstone and our thesis. Additionally, we appreciated Richard Hairston's help on the factory floor throughout the year. It truly has taken a team, and we are grateful for all those involved.

ABSTRACT

This report shows how our Senior Center for Manufacturing Excellence team took our product, a controller and headset stand, from an idea into a mass producible product. We first identified the problem of headphones and controller storage and sought to solve it through our product design. Market research was performed to ensure that this would be a successful product in today's marketplace. The trials of prototypes demonstrated what features could and could not be implemented into the design of the product. The group then designed a manufacturing plan for the product and found the projected market for the product. This allowed for the team to determine whether the product would be profitable and if the team should go to market with their controller and headset stand.

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INTRODUCTION

The Center for Manufacturing Excellence is an emphasis program at the University of Mississippi that is culminated with a year-long Senior Capstone Project. This project is predicated on the ideation of a product and the eventual manufacturing of this product. The year-long project was designed in two parts. The first part was the prototyping phase centered around the physical creation of the product that would be put into production. The second part was the manufacturing phase, which took this product and implemented a small-scale manufacturing layout and process. Throughout this year-long project, lean manufacturing was the methodology used to complete the project deliverables.

Lean manufacturing is a philosophy built on the elimination of waste and the growth of customer value (Mulholland 1). Lean manufacturing focuses on wastes in eight major categories. The categories are as follows: defects, overproduction, transportation, inventory, waiting, motion, under-utilizing talent, and excessive processing (“8 Wastes of Lean” 1). These pillars of waste allow manufacturers to pinpoint the wastes in their process with accuracy. Aside from these specific waste categories, lean manufacturing focuses on kaizen, or continual improvement. Along with eliminating waste, lean manufacturing is an ideology which always looks to continually improve the process (Mulholland 1). This continual improvement is done by utilizing lean manufacturing principles such as the 5S system.

The 5S's of lean manufacturing are sort, set-in-order, shine, standardize, and sustain. In sorting, the elimination of waste is the focal point. Anything nonvalue added and unnecessary for the process is eliminated to streamline the process. In set-in-order, the process is improved by ensuring parts or other equipment is properly placed for ease of use for the user. In shine, the process is polished by cleaning any loose ends that are left. In standardize, the process is maintained daily by keeping ahold of these changes and principles made in the first three stages. In sustain, the user or manufacturer keeps a process stable by adhering to the first four stages of the 5S principles ("What are the Five S's (5S) of Lean" 1).

In the entirety of the project, the lean manufacturing methodology was followed. The 5S and kaizen principles were the backbone of the manufacturing process realization.

TEAM ORGANIZATION

The capstone team consisted of five members in the Center for Manufacturing Excellence program. These five members came from different technical backgrounds in three main disciplines of engineering, accounting, and business. As such, the roles were dispersed to meet the strengths of the individual.

Tyler Butler, a Mechanical Engineering major, was the Project Leader throughout the project's duration. He oversaw the administrative duties such as ensuring deadlines were met and delegating tasks to be performed. Also, he was the Design Lead, and he was responsible for the design and creation of a prototype. Along with these roles, Tyler was one of the authors.

Chad Gutierrez, a Chemical Engineering major, was the Point of Contact for the team. He was the "middle-man" between the Project Supervisor, Mike Gill, and the group. Chad also held the role of Risks and Challenges Manager. He ensured the team adequately understood the challenges that would arise throughout the project. Along with these roles, Chad was one of the authors.

Katie Ramos, a Mechanical Engineering major, was the Production Expert and Recording Secretary. She oversaw taking the prototype and leading the effort in creating a production process for the prototype. She also recorded our meetings and handled any documentation needed.

Ridge Brohaugh, an Accounting major, was the Financial Consultant. He managed the team's budget, and he handled the marketing for the product. With these responsibilities, he managed the expenditures and costs associated with the project.

Noah Carpenter, a Business major, was the Production Expert. He handled the exterior market research associated with headset and controller stands. He also handled surveying the market to help influence the prototype.

IDEATION

The ideation of a headset and controller stand originated from an unfortunate situation with Tyler. Tyler, an avid gamer, was sitting to eat his dinner when he sat on his headset and broke them. The $50 headset was irreparable, which meant he would have to buy another headset. While this situation might seem trivial, most quality headsets run in the hundreds of dollars, and even the poorer quality headsets begin in the thirty-dollar range. From this realization, the idea of creating a headset and controller stand to house such expensive equipment was born. The presence of a headset and controller stand would eliminate the possibility of breaking the equipment, and the stand would allow for an aesthetically pleasing storage of the equipment. With this idea of the stand, a pitch was delivered to the Center for Manufacturing Excellence as his Senior Capstone Project. The idea was chosen to be put into the prototype phase.

PROBLEM DEFINITION

The team was tasked with the problem of designing a headset and controller stand that alleviated the absence of storage for this expensive equipment. The focus of the problem was to find storage for most modern controllers such as Xbox® or PlayStation® controllers. Also, the stand needed to allow for storage of all headphones as there are many different brands, sizes, and shapes. The problem was further compounded by the need for an aesthetically pleasing product along with the capability to store the equipment. Moreover, the stand needed to not only house the controllers and headset, but the stand needed to fit in the home environment in terms of aesthetics.

MARKET

Before developing the product, the team investigated the gaming industry market to see if they had a product that would do well in this ever-changing space. The first thing analyzed was to see the total revenue in the gaming industry space, which is projected to be $300 billion per year by 2025 (Koksal 1). This predicted number led to further analysis, and it was seen that gamers spent $36 billion dollars in 2017 with the average gamer spending $216 per year on hardware ("How Much Money Does the Average Person Spend on Video Games?" 1**)**.

The team immediately knew that this $216 per year was the exact expenditure our product was trying to infiltrate. Keeping this in mind, the team wanted to create a high-quality product along with a low price to cut into that $216.00 as little as possible. This then prompted the group to create a survey to go to the Esports Team as seen in Survey 1.

Survey 1: Esports Survey for Product Design

1. What type of material do you prefer?
   a. Dark Finish   b. Light Finish
2. If you answered wood, what stain would you prefer?
   b. Dark Finish   b. Light Finish
3. How would you Utilize this stand?
   a. Hold Headset   b. Hold Controller   c. Hold Both   d. Other
4. How many controllers would you like to have fit on the stand?
   Short Answer
5. How many spindles should the stand have to organize wires?
   Short Answer
6. Please describe features that you would like in a headset stand. Are there features that current stands do not have but should? Are there features that current stands do have but need to be changed?
   Short answer

This survey was sent out to the University of Mississippi Esports team along with peers that are experienced gamers. A total of 39 responses were recorded. The important pieces of data that came from this was as seen in Figures 1, 2, 3, & 4.

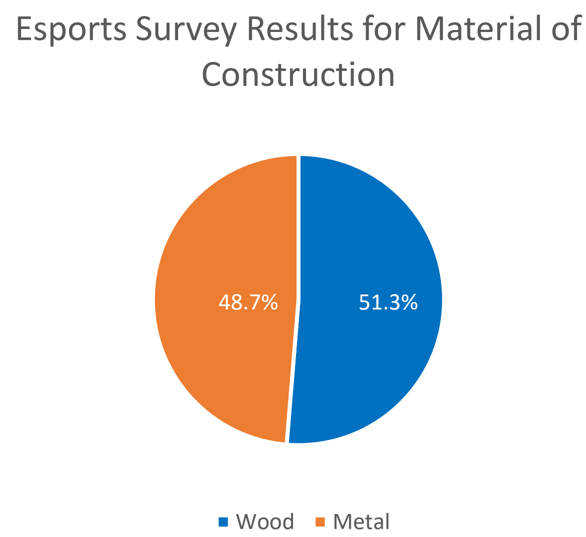

Figure 1: Survey Results for Material of Construction

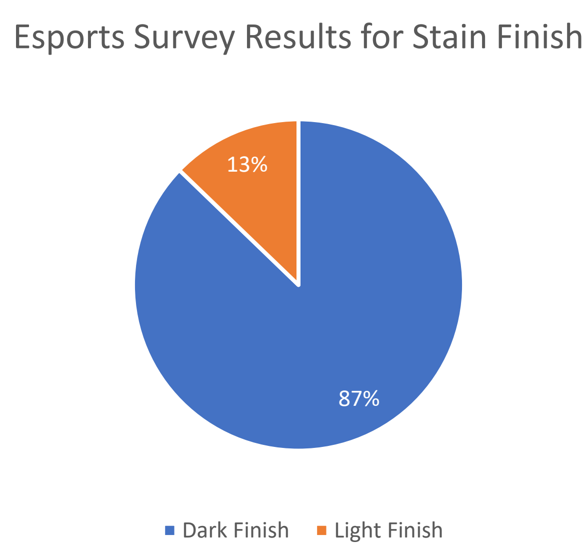

Figure 2: Survey Results for Stain Finish

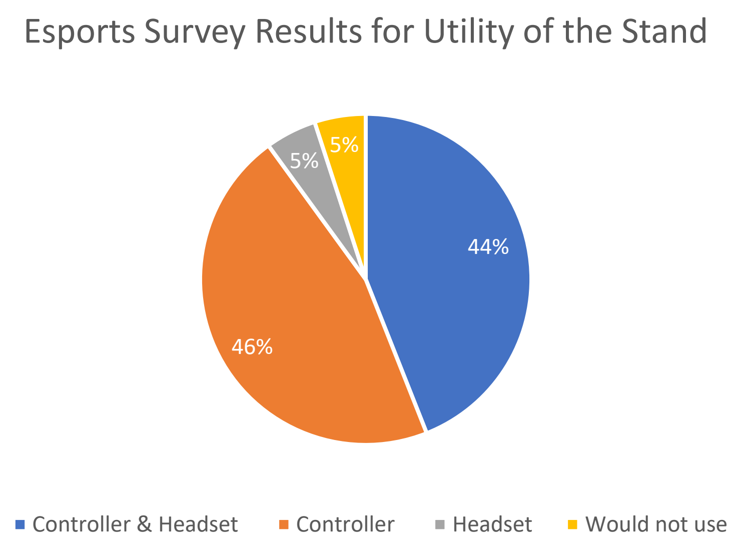

Figure 3: Survey Results for Utility of the Stand

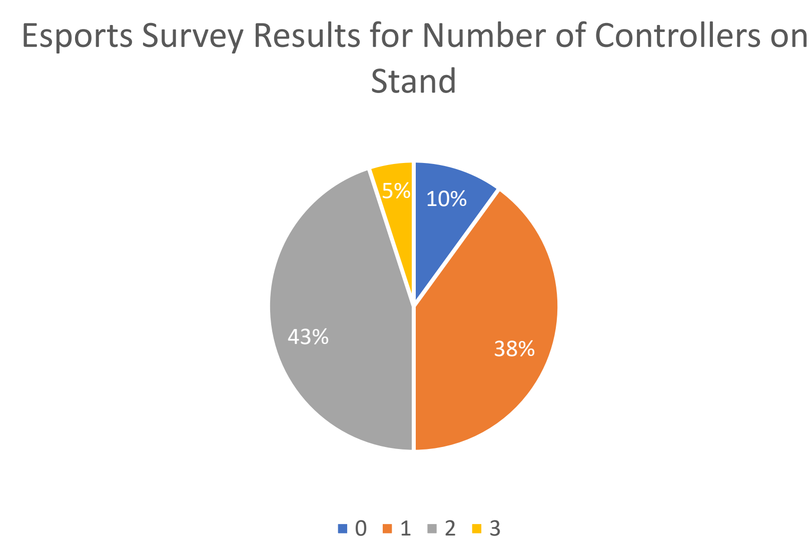

Figure 4: Survey Results for Number of Controllers on Stand

For Figure 1, there was a 51.3% preference to use wood. This was initially our plan, so we decided to utilize wood as our primary material of construction. Further, the team felt as though the wood would help balance out the aesthetic of one's desk a bit more. Gamers tend to lean more to rustic pieces in order to balance out the high technological look of their gaming spaces.

Figure 2 showed that 87.2% of gamers preferred a dark finish to the headset. This correlated with the fact that most gaming equipment is a dark color. Gamers tend to go for dark equipment in order to ensure the longevity of appearance for the equipment and to protect the equipment from getting a worn look over time.

Among the respondents, 44% demonstrated a preference for the headstand to hold both controllers and a headset as seen by Figure 3. Although 44% is not the overall majority, 46% of respondents said that they would only use the product as a headset stand with 5% saying they would only use it for a controller stand. The other 5% were those that said they would not use a headset stand. The team felt the product would be bolstered if it could do both, which would in turn capture the needs of most gamers no matter how they intend to use it.

Figure 4 showed that 38% of people wanted the stand to have one controller and another 43% wanted the stand to hold two controllers with additional data that shows some would prefer no controllers and some with 3 controllers. As discussed later, it was seen that two controllers could fit on the headstand, so the team proceeded with allowing for two controllers to sit on the stand.

The data given on the wire management portion of the project showed that over 50% of people wanted 1-3 spindles on the product. When arriving at product development, a way was not seen to add the spindles to the design while also continuing to minimize the amount of desk space taken up by the product. The team also sees a high trend towards wireless headsets, so the spindle was taken off the table. Additionally, the last question on the survey offered no further advice to the product than the solutions that product was already trying to solve. There was mention of adding a wireless charging hole, but this was seen to not work with the current design as the wood would split trying to add those large holes on the product.

All in all, the market research gave the team an opportunity to see what the gaming market called for. This led into our initial prototype design and followed up with a Market Analysis to see who would purchase the product as well as determining if our product would be profitable.

PROJECT SCOPE

The scope of the project involved the creation of a headset and controller stand from initial prototype to full-scale manufacturing production process. The stand would be made from wood, screws, and nails, and the stand would be finished with a dark wood finish such as a walnut stain. The fall semester would center around the prototype creation of the stand, and the spring semester would center around the manufacturing production creation. The prototype creation would be the finalizing of an official design that would be put into a manufacturing process. The manufacturing production creation would be the formation of a continuous layout manufacturing operation that could potentially mass produce the stand.

PROTOTYPE

The first prototype of the headset and controller stand was a bulky and rough design aimed at fulfilling the storage portion of the problem statement. The initial design is shown in Figure 5. The base was 11-2/100 inches by 9-9/20 inches. The height was approximately 7-87/100 inches, which was varied because of the two stops affixed to the headset resting area. Moreover, the stops were discarded early into the prototype phase as they were not a feasible addition. The dimensions of the design were arbitrary when creating the Creo® file seen in Figure 5. The importance of the design at that stage was to take the idea of the stand and create a hypothetical prototype design in terms of appearance. The material chosen for the design was dimensional lumber found at stores such as Home Depot®. The attachments used were nails from a nail gun. To further describe the design, the design was segmented into different portions. There were five main pieces of the design, which was the base, back pillar, connector, controller hooks, and front pillar. The back pillar and front pillar were initially designed to be attached directly to the base with the use of nails. The connector was designed to be attached to both pillars using nails. The controller hooks were designed to be attached to the connector with the use of nails. This initial design was a baseline for the following iterations.

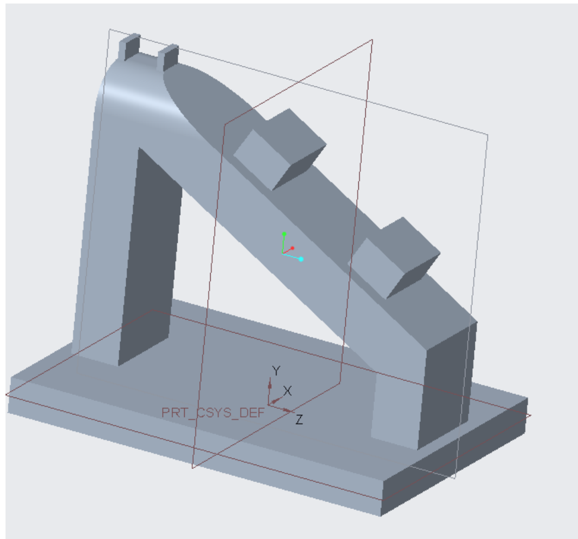

Figure 5: Creo for Initial Prototype

Once the Creo design was altered to adhere to dimensional lumber sizing, the design's dimensions were changed. The base was changed to be 10 inches long by 3-1/2 inches wide by 1-1/2 inches in thickness. A 2" by 4" piece of dimensional lumber was used to create the base. The back pillar was changed to be 7 inches tall and offset 1/2 inches from the back of the base. Also, the back pillar was 1-1/2 inches by 1-1/2 inches in width and thickness. These dimensions are the actual dimensions of the back pillar. The back pillar was made by a 2" by 2" nominal sized piece of dimensional lumber. The connector and front pillar pieces were arbitrary dimensions as the initial building of the prototype eliminated the front pillar from the design. The elimination of the front pillar came from inability to manufacture a piece that could attach properly to the connector. Figure 6 illustrates the final parts used for the prototype. After fixing this design mistake, the connector was cut with angles to allow for connection to the back pillar and base. The angle and dimensions were created on the factory floor and were not noted as the goal of this initial prototype was to create a physical product out of wood. However, the connector was made with a 1-1/2" by 2" piece of dimensional lumber. The controller prongs also used this piece of lumber and were 1-1/2" long and offset 4 inches from one another.

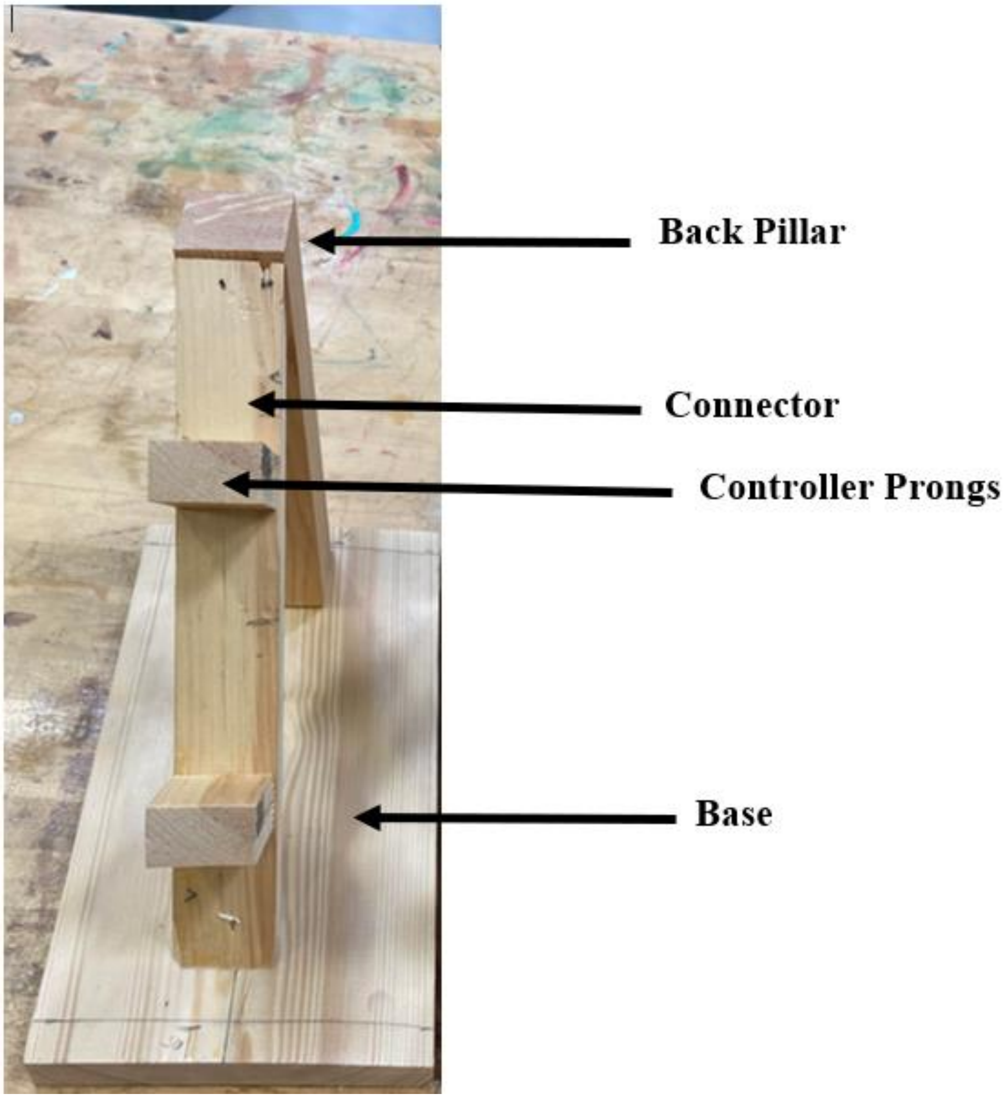

Figure 6: Stand Parts Guide

The tooling and attachments used in the creation of the initial prototype was a vertical bandsaw to cut the wood the proper length, a miter saw to cut the connector's angles, and a nail gun to attach the various pieces together. The initial prototype is shown in Figure 7.

Figure 7: Initial Prototype

After completion of the physical prototype, the errors in creating and designing the initial prototype were addressed. The first issue was the dimensioning of the connector piece. To fix this problem, the design was recreated and is seen in Figure 8.

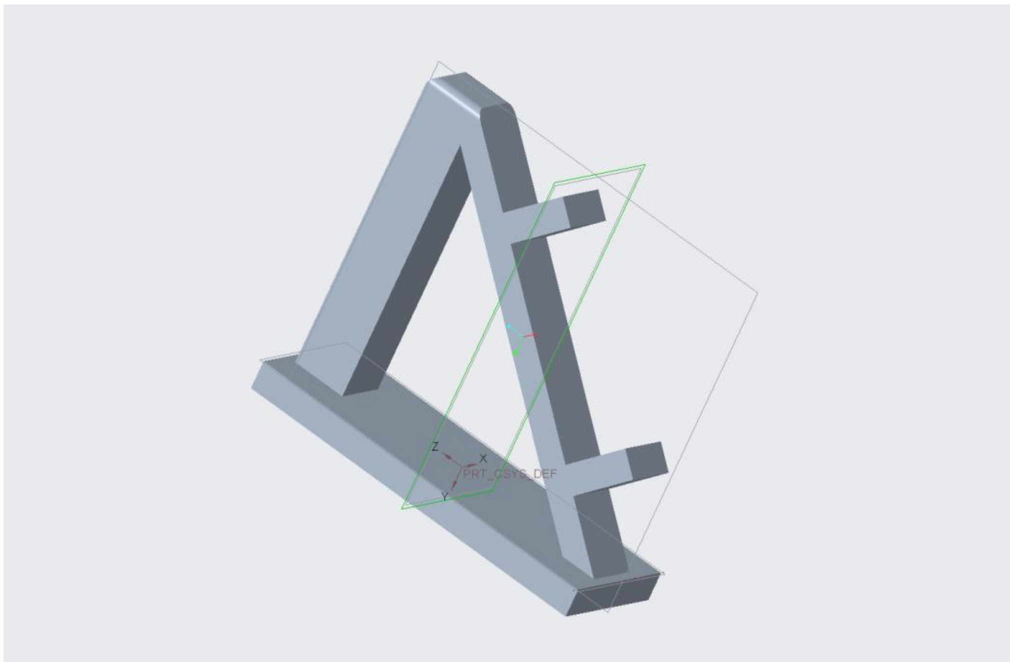

Figure 8: Final Creo Prototype

The overall dimensions of the new design were 10 inches by 8 inches by 3-1/2 inches. The connector was dimensioned to be 11-11/32 inches long and contain 45° angles on each end of the part. The dimensional lumber used for the new connector was a 1" by 2" piece of dimensional lumber. The sizing of the connector piece allowed for a 1/4-inch offset of both the connector piece to the front edge and back pillar to the back edge.

Another error experienced when creating the initial prototype was the height of the back pillar. Once the initial prototype was completed, headsets and controllers were added to see the feasibility of the design. When sizing the prototype, the back pillar was not tall enough to safely store most headphones. The back pillar was increased to 8 inches tall as a result and made of 2” by 2” dimensional lumber. The headphones were not the only problem with sizing the initial prototype as the controller prongs were unevenly spaced on the connector piece. The stops allowed the controllers to be held, but the placing and display of the controllers was unappealing. Accordingly, the controller stops were dimensioned themselves and on the connector piece. The new dimensions of the connector piece were 1-1/2 inches in length and made from 1” by 2” dimensional lumber. Also, the prongs were offset 3 inches from the front edge or back edge depending on the prong.

Another error was the size of the base. The base in the initial prototype was oversized and unappealing. The base, in following prototypes, was downsized to 1” by 4” that was cut 10 inches long. The position of the back pillar and connector on the base was to be offset from the edges to be aligned in the middle of the base. Moreover, the back pillar and connector were both 1-5/8” in width, and the middle of each part was placed at 1-3/4” from either side edge of the base. These offsets for both parts allowed the final prototype to be centered properly. The final prototype design can be seen in Figure 9.

Figure 9: Final Prototype Design

Aside from design errors, attachment and tooling errors were found in the creation of the initial prototype. The initial prototype utilized nails from a nail gun to attach all the components of the overall design. However, these nails struggled to maintain a strong connection between the parts. Also, the nails split and deformed the wood when attaching the parts. The attachments were changed to screws to obtain a stronger connection. Two different sized screws were used to connect the parts. Two #2-1" screws were used to connect the controller prongs to the connector, and one #6-1-5/8" screw was used to connect the back pillar to the base. Two more #2-1" screws were used to connect the connector to both the base and the back pillar.

With the change in attachment and design, tooling was revisited. The change to screws created the need for a drill. The vertical bandsaw was substituted for a miter saw as it was a cheaper alternative while maintaining the quality needed to create a satisfactory final prototype. Since the miter saw could make angular cuts, it was used for the cutting of all parts, both in length and angle. Also, the design changes gave a basis to improve the aesthetics and feel of the eventual final prototype. The aesthetics were improved by sanding the individual parts by hand. After sanding the individual parts, the wood was stained with a walnut stain. The stain gave a dark wood finish to the final prototype. The stain used was MINWAX®'s penetrating dark stain. Krylon®'s polyurethane coating was added to the production to improve finish. With all the changes to the errors found from the initial prototype and subsequent creations of the final prototype, a final prototype as seen in Figure 10 was created.

Figure 10: Final Prototype Design

MARKET ANAYLSIS

With the scope of market complete and early prototypes done, it was time to do a market analysis for our product. This was to give us a better idea of how many stands that we could sell as well as the expected capacity to build. Furthermore, this gave the opportunity to determine whether mass scale production would be profitable. The survey was responded by 130 individuals, and the findings showed that mass scale production should be considered. The full survey can be seen in Survey 2.

Survey 2: Market Analysis Survey

1. What is your age?
   Short Answer
2. How do you Identify?
   a. Male b. Female c. Other/Prefer Not to Share
3. Please select the demographic you most consider yourself:
   a. Grade School (Middle or High School) b. College Student c. Adult
4. How often (if ever) do you play video games?
   a. 6-7 days a week b. 3-5 days a week c. 1-2 days a week
   d. A few times a month e. Never
5. Do you own any video game consoles?
   a. Yes b. No
6. As seen in the picture below (Figure 10), how much do you think this product should be worth at retail (US $)?
   Short answer
7. How likely are you to purchase this product?
   a. Not Buy b. Possibly buy c. Buy

The survey started out by asking the age of each respondent as well as how often they play video games along with the number of consoles owned. Of the 133 respondents, 63.8% were college students with the others surveyed being in grade school and adults. Although the feedback from adults and individuals still in grade school was useful, the team decided to proceed to only analyze the data of the 83 college students since they made up over half of the participants and allowed for better research focus.

The 83 college students were 53% male and 47% female with 70.9% of the college students playing video games at least a few times a month. Of the 58 that do play video games, 47 of them own at least one gaming console and equipment for which our headset and controller headset would be used for, which showed that the customer ratio was 56.7%.

This further showed the demographics of collegiate gamers, and a picture of our prototype shown in Figure 10 was shown to those taking the survey. At this point, they were prompted to provide feedback on what they think the price should be, and the average price was $23.48 for those that were college students that owned gaming consoles. This was a positive as we planned to market the product at a $25.00 price point.

This group of college students that do have gaming consoles were then asked whether they would not purchase, possibly purchase, or purchase the product to determine if they were respectively detractors, passive, or a promoter. It was found that 53% were detractors, 32% were passive, and 15% were promoters. Although this is not ideal, it did show that 7 out of the 47 students surveyed that could be potential customers would buy the controller and headset stand, and this can be viewed as 8.4% of college students would buy the product. Since the company is still pre-revenue, the group only accounted for those that were promoters to determine the number of projected customers at the colleges in Mississippi.

PROJECTED MARKET

The team found the number of students at each University in Mississippi ("Biggest Colleges in Mississippi" 1). The customer ratio of 57% combined with the sales ratio of 8.4% showed that the total number of projected collegiate customers in the state of Mississippi was 4707 people. Table 1 breaks this down further.

Table 1: Projected College Student Market

College Student in MS	Number of Students	Customer Ratio	Customer Base	Sales Ratio	Projected Customers
University of Mississippi	20274	57%	11480	8.40%	968
Mississippi State University	22201	57%	12572	8.40%	1060
Southern Mississippi University	14509	57%	8216	8.40%	693
Jackson State University	9811	57%	5556	8.40%	469
Hinds Community College	9941	57%	5629	8.40%	475
Mississippi Gulf Coast Community College	8860	57%	5017	8.40%	423
Northwest Mississippi Community College	7097	57%	4019	8.40%	339
Itawamba Community College	5871	57%	3325	8.40%	280
Total	98564		55813		4708

The 4,708 customers were used in our financials to determine the profitability of our product in our first year. It is worth noting that Mississippi is among the lowest in the nation when it comes to people 15 years or older who play video games (Ingraham 1) with it only being roughly 3-7%. This further supported using 4,708 as our projected customers since we only considered projected consumers from one state when the group hopes to push this out nationwide. Additional research needs to be done to determine the national projected customers along with projected income when the company is scaled to that size.

MANUFACTURING

With the final prototype and design completed, a manufacturing process was designed to ensure mass production of the headset and controller stand. The first step was to sort through the various activities and operations of the production of the prototype. The first step simultaneously included setting the operations in order. There were three main activities to the process, which were setting up, cutting, finishing, and attaching.

In the cutting activity, each of the four-part types (connector, back pillar, base, controller prongs) were cut to proper lengths and angles. Table 2 shows the dimensional lumber used for each of the pieces along with their length.

Table 2: Dimensions of Parts

Part	**Dimensional Lumber**	**Length of Part**
Base	1” x 4”	10 inches
Back Pillar	2” x 2”	8 inches
Connector	1” x 2”	11-11/32 inches
Controller Prongs (x2)	1” x 2”	1-1/2 inches

Two more cuts were made on the connector piece to apply the appropriate angle of 45° to each side. The order of cutting was created into an organized, linear fashion. Setting up was intertwined throughout the cutting activity. Operation 1 was creating a stop for the base part using a piece of scrap wood and clamp on the miter saw. Operation 2 was utilizing the miter saw and stop to cut the base to 10 inches long from the 1” by 4” dimensional lumber. As the process of building the stand required certain pre-works such as sanding and staining, Operation 2 and all other cutting operations were done in a batch and queue method. Operation 3 was taking the stop and altering the positioning to allow for the cutting of the front pillar. Operation 4 was cutting the front pillar 8 inches long from the 2" by 2" dimensional lumber. Operation 5 was altering the stop to allow for the cutting of the connector. Operation 6 was cutting the connector 11-11/32 inches long from the 1" by 2" dimensional lumber. Operation 7 was altering the stop to allow for the cutting of the controller prongs. Operation 8 was cutting the controller prongs 1-1/2 inches long from the 1" by 2" dimensional lumber. Special care was taken to cut two times the normal amount of parts as there are two prongs per unit. Operation 9 was changing the set-up of the miter saw to accommodate the 45° angle cuts on the connector. The miter saw used in the process had angle ticks on its machine, which were used to properly set-up the angle. Operation 10 was cutting these angles on both sides. Moreover, Operation 10 involved two cuts for each connector. Once these ten operations were completed, the cutting activity was completed. Table 3 shows these operations.

Table 3: Set-up and Cutting Operations

Operation	**Machine/Tooling**	**Activity (Description)**
1	Wood Stop/Clamp	Set-up (Base)
2	Miter Saw	Cutting (Base)
3	Wood Stop/Clamp	Set-up (Back Pillar)
4	Miter Saw	Cutting (Back Pillar)
5	Wood Stop/Clamp	Set-up (Connector)
6	Miter Saw	Cutting (Connector)
7	Wood Stop/Clamp	Set-up (Prongs)

Table 3 Continued

Operation	Machine/Tooling	Activity (Description)
8	Miter Saw	Cutting (Prongs)
9	Miter Saw	Set-up (Angle)
10	Miter Saw	Cutting (Angle x2)

After cutting all the pieces, the finishing activity was organized and performed. The finishing activity contained the sanding and staining portion of the process. Operation 11 was setting up the table to have the wood, brushes, and paper towels ready for sanding and staining. Operation 12-15 was sanding the bases, back pillars, connectors, and controller prongs with the belt sander. Operation 16 was staining all the parts with the walnut stain. Table 4 shows these operations.

Table 4: Set-up and Finishing Operations

Operation	Machine/Tooling	Activity (Description)
11	Table	Set-up (Finishing)
12	Belt Sander	Finishing (Base)
13	Belt Sander	Finishing (Back Pillar)
14	Belt Sander	Finishing (Connector)
15	Belt Sander	Finishing (Prongs)
16	Brushes/Paper Towels/Stain	Finishing (All Parts)

Once the pre-work of cutting and attaching were done, the attaching operations were started. Operation 17 was drilling one #6-1-⅝" screw into the base and back pillar to connect them. Operation 18 was screwing the controller prongs to the connector using two #2-1" screws, one for each prong. Operation 19 was attaching the connector to the base with a #2-1" screw. Operation 20 was drilling the connector to the back pillar.

Operation 20 concluded the overall process of building the headset and controller stand. Table 5 shows these operations.

Table 5: Attaching Operations

Operation	Machine/Tooling	Activity (Description)
17	Drill/#6-1-5/8" Screw (1)	Attaching (Base to Back Pillar)
18	Drill/#2-1" Screw (2)	Attaching (Prongs to Connector)
19	Drill/#2-1" Screw (1)	Attaching (Connector to Base)
20	Drill/#2-1" Screw (1)	Attaching (Connector to Base)

With operations clearly sorted and set in order, the process was shined, or evaluated. When beginning preliminary manufacturing runs, many errors in assembly arose. The errors all stemmed from inconsistencies from attaching the parts together. Moreover, one finished product would differ greatly from another finished product. These discrepancies between finished products caused a temporary revisit to the prototype or building phase. This revisit provided different design modifications to the product. The first change in the design modification was to shorten the base to 9-1/2 inches, which deleted the ½-inch offset for both the connector and back pillar. This change meant that both parts would now be flushed with either the front or back edge of the base depending on the part. Table 6 illustrates the new dimensions for the design.

Table 6: Updated and Final Dimensions of Parts

Part	Dimensional Lumber	Length of Part
Base	1" x 4"	9-1/2 inches
Back Pillar	2" x 2"	8 inches

Table 6 Continued

Part	Dimensional Lumber	Length of Part
Connector	1” x 2”	11-11/32 inches
Controller Prongs (x2)	1” x 2”	1-1/2 inches

The other change to the design was to use nails for the connection of the connector to both the back pillar and base. This operation was tried earlier in the prototype phase, but it did not work well because of improperly sized nails and operating error of the nail gun. The reintroduction of nails into the design allowed consistency to the connection of connector to both base and back pillar. Two 1” nails were used for each connection point on the connector. These nails were administered with a nail gun. These changes were the only changes made before beginning the initial phase of the manufacturing process. Table 7 shows the fixed operations for attaching the parts of the stand.

Table 7: Fixed Attaching Operations

Operation	Machine/Tooling	Activity (Description)
17	Drill/#6-1-5/8” Screw (1)	Attaching (Base to Back Pillar)
18	Drill/#2-1” Screw (2)	Attaching (Prongs to Connector)
19	Nail Gun/1” Nail (2)	Attaching (Connector to Base)
20	Nail Gun/1” Nail (2)	Attaching (Connector to Base)

The initial phase of the manufacturing process began with the need for jigs or guidelines as many errors arose in the prototype phase from inconsistent finished product iterations. One product iteration would be perfectly created, but the next product iteration would be offset in some capacity. The errors arose whenever the parts were screwed or nailed together. The result was the creation of three jigs to guarantee the accuracy of the product. The first jig (Jig 1), as seen in Figure 11, created was for the connection of the base and back pillar.

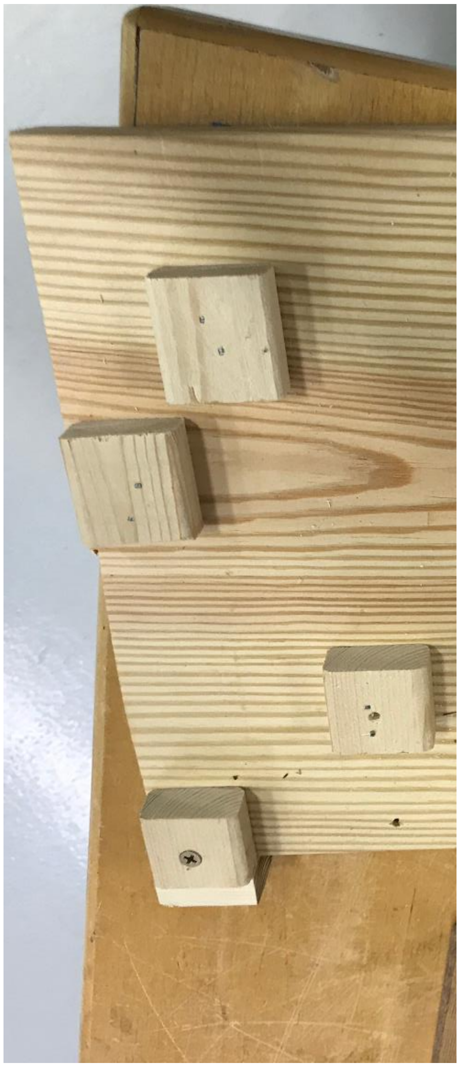

Figure 11: Jig 1 for the Connection of the Base and Back Pillar

Figure 12 shows Jig 1 in use. Demonstrated in the figure, the base is flushed to the end of the base with the use of the stops to hold the back pillar and base in place. Another feature of Jig 1 was the placement of the back pillar compared to the side edge of the base. Jig 1 was planed from its original size to 1" which allowed for the back pillar to sit exactly in the middle of the base. To use the jig, the operator placed the back pillar into the hold and placed the base on the edge of Jig 1.

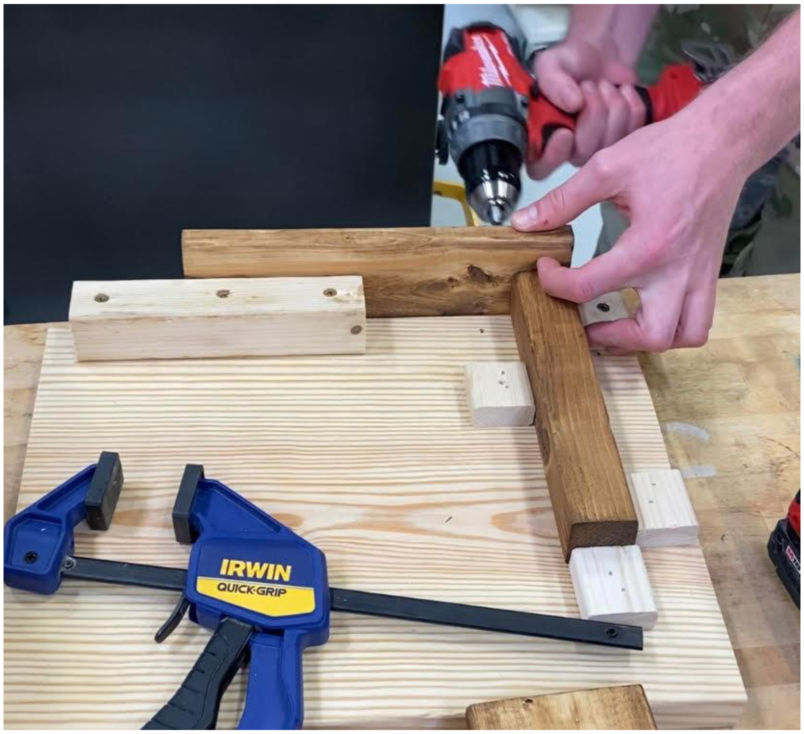

Figure 12: Jig 1 in Use

The second jig (Jig 2) was for the connection of the connector to the controller prongs. Figure 13 shows Jig 2, and Figure 14 shows Jig 2 in use. The features of Jig 2 were the various stops to properly orient the connector and controller prongs. In Figure

14, the connector was oriented to have the long end facing away from the operator. Also, the stops were spaced properly to have the prongs aligned with our design specifications.

Figure 13: Jig 2 for the Connector and Controller Prongs

Figure 14: Jig 2 in Use

The last jig created was Jig 3. Jig 3 was attached to the same piece of wood as Jig 1. Figure 15 shows the whole apparatus of both jigs on the same piece of wood. The reasoning for this placement will be described in detail later, but Jig 3 consisted of a clamp and wood components. Figure 16 shows Jig 3's wood portion, and Figure 17 shows Jig 3 in use with all components. The features of this jig were centered around the proper attachment of the connector to the base and back pillar. The connector was attached to the back pillar with the nail gun, and the clamp held the connector flush with the back pillar as seen in Figure 17. The other feature of Jig 3 was the wood component that allowed the operator to flush the connector with the edge of the base when connecting them. After all these jigs were created, the operations ordering was shifted due to some errors and changes made from the jigs.

Figure 15: Jig 1 and Jig 3

Figure 16: Jig 3 for Connector to Back Pillar and Base Connections

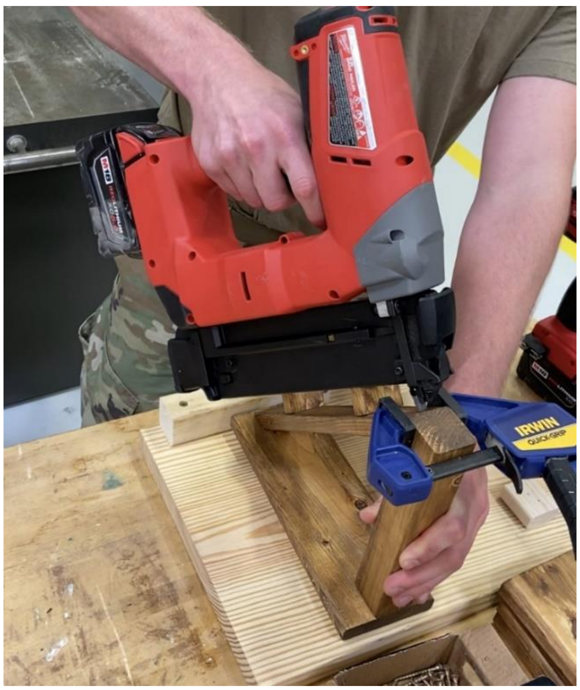

Figure 17: Jig 3 in Use

The first change in operations was the change to Operation 18. During trial runs of Jig 2, it was found that the controller prongs did not securely attach to the connector when using #2-1” screws. The change was to use #8-1-1/2” screws to alleviate this insecure attachment. The second change was to pre-drill every hole that was made. This addition of pre-drilling was essential to ensuring each product iteration was similar in build because the absence of pre-drilled holes caused certain pieces to rotate and become off center, even when using the jigs. The operation numbering was impacted with this change. Also, the use of the nail gun caused the wood to be marked by the nail when connecting the connector to the back pillar and base. The results of these markings caused the addition of three operations to the end of the process to fix these markings before the final product was produced. These changes were added to Table 8, which illustrates the final operation ordering. In all, 25 operations described our process of creating a headset and controller stand.

Table 8: Final Operations Ordering

Operation	Machine/Tooling	Activity (Description)
1	Wood Stop/Clamp	Set-up (Base)
2	Miter Saw	Cutting (Base)
3	Wood Stop/Clamp	Set-up (Back Pillar)
4	Miter Saw	Cutting (Back Pillar)
5	Wood Stop/Clamp	Set-up (Connector)
6	Miter Saw	Cutting (Connector)
7	Wood Stop/Clamp	Set-up (Prongs)
8	Miter Saw	Cutting (Prongs)
9	Miter Saw	Set-up (Angle)
10	Miter Saw	Cutting (Angle x2)
11	Table	Set-up (Finishing)
12	Belt Sander	Finishing (Base)
13	Belt Sander	Finishing (Back Pillar)
14	Belt Sander	Finishing (Connector)
15	Belt Sander	Finishing (Prongs)

Table 8 Continued

Operation	Machine/Tooling	Activity (Description)
16	Brushes/Paper Towels/Stain	Finishing (All Parts)
17	Drill	Attaching (Pre-Drill for 18)
18	Drill/#6-1-5/8” Screw (1)	Attaching (Base to Back Pillar)
19	Drill	Attaching (Pre-Drill for 20)
20	Drill/#8-1-1/2” Screw (2)	Attaching (Prongs to Connector)
21	Nail Gun/1” Nail (2)	Attaching (Connector to Base)
22	Nail Gun/1” Nail (2)	Attaching (Connector to Base)
23	Belt Sander	Finishing (Connector to Back Pillar)
24	Belt Sander	Finishing (Connector to Base)
25	Fine Brush/Paper Towels/Stain	Finishing (Staining Sanded Areas on Connector)

After creating the standardized workflow of operations, the creation of the production layout was performed. This creation caused the team to split the whole process into two different portions, which were the pre-work portion and the assembly portion. In the pre-work portion, Operations 1-16 were performed by two operators. In the assembly portion, Operations 17-25 were performed by two operators. However, these two portions were not done simultaneously. They were done in succession as Operation 16 called for staining the wood which takes time to properly coat and dry. With this realization, the team decided to create a batch and queue method to attack the production timing issues. As such, the assembly portion of the process would be conducted for the first three hours of the shift, and the pre-work portion of the process would be conducted for the final five hours of the traditional eight hour shift to prepare for the next day’s assembly. The ordering of these two portions was dependent on the uneven timespan to complete each portion. The pre-work portion took significantly longer than the assembly portion, and the results were to have one 3-hour period and one 5-hour period. This distinction allowed the team to create two different set-ups for the two portions of the process.

The assembly portion was the first set-up of the working day. For the process layout, the legend for both the assembly and pre-work layout is included in the figures. The workflow of the assembly portion of the process is illustrated in Figure 18.

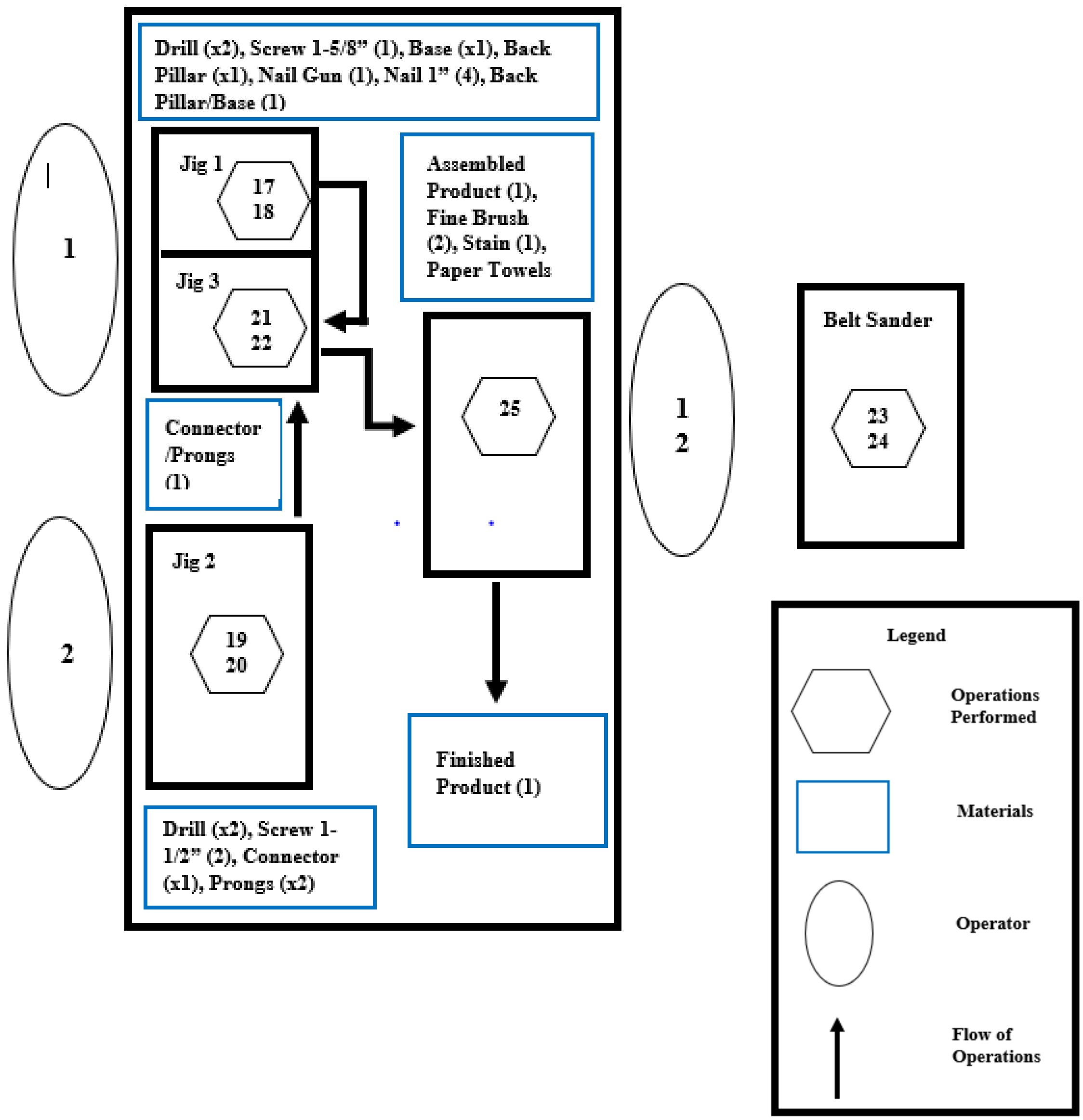

Figure 18: Assembly Portion of Process

The workflow of the pre-work portion of the process is illustrated in Figure 19. In the whole process, there were the same two operators to perform the entirety of the process, and the materials listed are for the creation of one single final product.

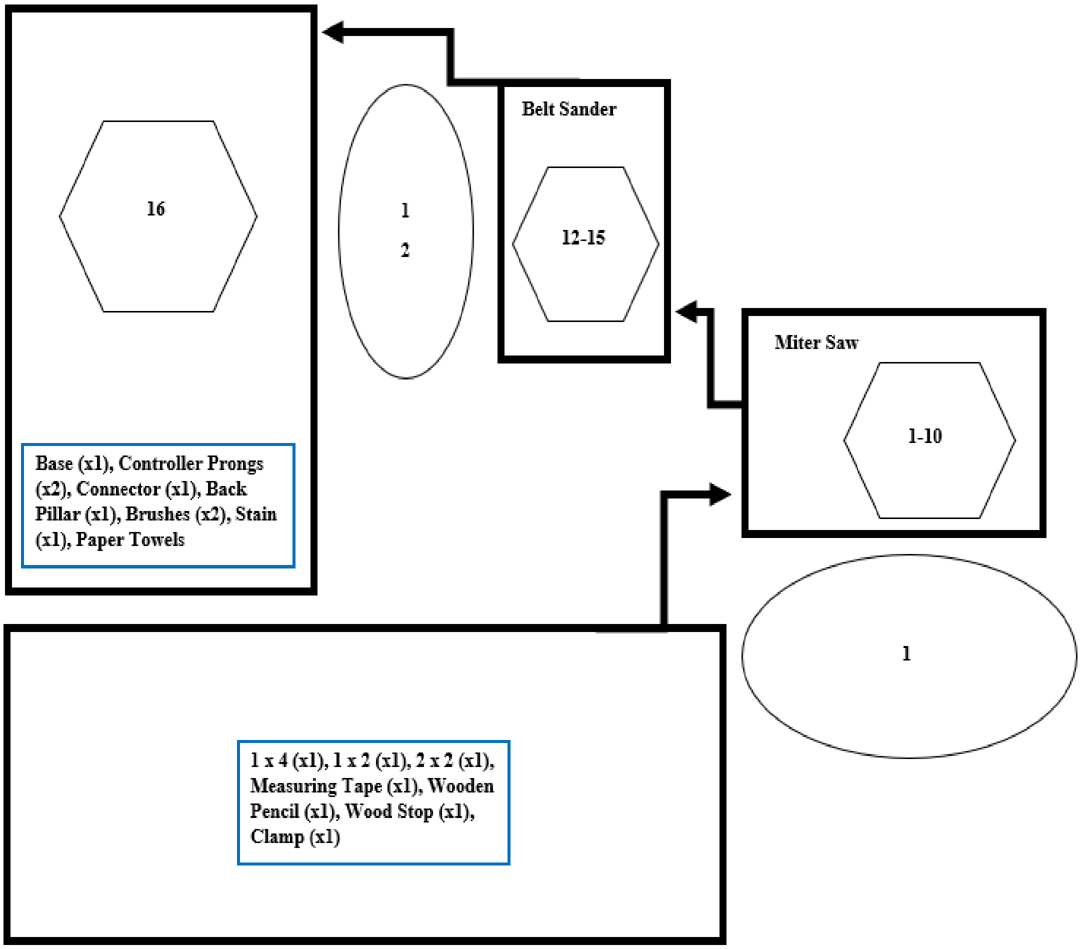

Figure 19: Pre-Work Portion of Process

Further, the assembly process in Figure 18 was designed in nonlinear fashion. The reason for this nonlinear order was dependent on two earlier operations in the process. The process has two subassemblies before the actual final assembly. As such, these two subassemblies converge together on either side to make for ease of the operator and creation. These tasks were performed by the two operators in a batch and queue method with one taking the back pillar subassembly and the other taking the connector subassembly. As mentioned earlier, Jig 1 and 3 were created on the same piece of wood as a result of these two subassemblies. The workflow allowed the two subassemblies to converge onto the final assembly of connector to base and back pillar. This final assembly was conducted by the operator who previously was attaching bases and back pillars. With the completion of this final assembly, the final product was sent to the operator who had conducted the subassembly of connector and controller prongs. The delegation of operators was based on the timing and order of the process. The connector operator was going to finish his work first as the other operator needed his parts to continue with his duties. After the connector operator completed his subassemblies, he moved to the final finishing of the final product. The finishing allowed the nails that partially stuck out of the wood to be grounded out by the belt sander to alleviate any problems with customers handling the stand. From there, the sections that were sanded were re-stained with fine brushes to ensure precision. After the final assembly operator finished all the products, he was to move to staining the final products. Once these finishing tasks were completed, the product was ready to be sold to customers.

The pre-work process as seen in Figure 19 was designed in a linear path unlike the assembly process. The first operator began with cutting the parts from the dimensional lumber. The process utilized a wood stop, clamp, measuring tape, and wooden pencil to ensure proper lengths and consistency. The parts were moved to the second table for sanding on the belt sander. The second operator performed this task, and the first operator began to stain the completed parts once they finished cutting all the wood. After the second operator sanded all the parts, the operator would help the first operator continue to stain the parts. The parts were allowed to dry overnight for the next day's assembly process.

The completion of the manufacturing component of the capstone was predicated on a small production run. The production run occurred on March 5, 2020 in front of the capstone supervisor, Mike Gill. The production run included both portions of the process. Each portion was done for the creation of five products, and it was run in the same order as a full upscale process. The production run was accomplished without error, and it concluded the manufacturing aspect of the capstone. Figure 20 shows one of the controller and headset stands produced during the trial run.

Figure 20: Manufacturing Run Finished Product

FINANCIALS

From the market analysis and projected market, the group then produced a projected income statement as seen Table 9**.**

Table 9: Projected Income Statement

Total Sales	$	117,700.00
Total Variable Costs	$	(28,389.24)
Contribution Margin	$	89,310.76
Total Fixed Costs	$	(35,779.00)
Operating Income	$	53,531.76
Noncash Expenses	$	(1,390.00)
Cash Flow	$	52,142.26

The total sales were calculated by using our price point of $25.00 with 4,708 projected customers to give our total sales to be $117,700.00 in our first year. This then led us to find our projected variable cost to determine whether $25.00 was a feasible price point. Table 10 shows the breakdown of the cost of each controller and headset stand to show that each stand has a total variable cost of $6.03 per unit. This shows that without fixed cost and non-cash expenses, the product currently has a 75.9% profit margin.

Table 10: Projected Variable Costs

Targeted Base (# of students)	4,708
Projected Sales Price	$25.00
Projected Variable Costs (per Unit):	
Wood (Including Scrap)	$1.39
Screws	$0.50
Glue	$0.07
Stain	$1.00

Table 10 Continued

Projected Variable Costs (per Unit):	
Varnish	$1.00
Price Rate Labor per Unit*	$2.07
Total Variable Cost	$6.03

The fixed costs were taken as the lease on warehouse, marketing cost, and tooling cost. These came out to a total of $35,779.00 per a year as shown in Table 11. For the lease on the warehouse, a 5,000 square foot warehouse in Corinth, MS at Interchange Business Park was found that would cost approximately $18,000 per year. The drills were the Milwaukee Cordless High-Torque Impact Wrench, and the nail guns were Milwaukee Gauge Brad Nailer. A Milwaukee cordless dual bevel sliding compound miter saw was used to cut the wood. The drum sander chosen was a Grizzly Drum Sander. All prices were obtained from their respective company's website.

Table 11: Projected Fixed Cost

Lease on Warehouse	$	18,000.00
Projected Marketing Costs (Subjective)	$	15,000.00
Total Tool Cost (not including rental)	$	2,779.00
Total Fixed Costs	$	35,779.00

The noncash expenses seen in Table 12 are for the nail guns, sander, and table saw. This total depreciation winds up being $1,390 under the assumption that these pieces of equipment have a two-year depreciation.

Table 12: Project Noncash Expenses

Nail Guns	$	279.00
Sander	$	313 .00
Drills	$	299.00
Table Saw	$	499.00
Total Noncash Expenses	$	(1,390.00)

When it is all said and done, the company is cash flow positive in its first year with $52,142. Although this is not much profit, a large upside to this is that we are in fact cash flow positive in our first year of business. This $52,142 should be used to reinvest into the company to maintain the equipment along with potential purchase of table saws.

FURTHER MANUFACTURING CONSIDERATIONS

Although the two-week period on the manufacturing floor provided quality information, it was clear that more time was needed to explore more methods of manufacturing. This was noticed from the time that we started until we finished. The time constraint did not allow the group to test different types of wood, production re-work, and add-ons to the product.

Early in the production runs, it was seen that the quality of wood throughout the planks was inconsistent. This caused certain components of the stand to not come out to meet the outlined specifications. The group would have liked to try varying types of dimensional lumber to help with quality control. When moving to full scale production, this would need to be analyzed further.

An upscaled production process for the controller and headset stand would focus on the upgrading of equipment. The first steps needed would include purchasing a warehouse large enough to store two different sections of our process, which were and are the pre-work and assembly portions. The pre-work section would utilize hand-held paint sprayers to improve the staining aspect. Also, the pre-work section would be shorter because the quality of the wood would allow for less pre-work such as sanding. If staining the wood was necessary, belt sanders would be used to perform final touches on the pieces before staining with the sprayers. The pre-work section would have paint booths to allow operators to easily apply the stain in a controlled environment. Moreover, the pre-work section would involve cutting the wood with CNC table saws to improve standardization among parts. Assembly lines would push these pieces of wood through the saws. In the assembly portion of the process, automatic industrial nailers and drillers would be used to improve connection points. The parts would be properly oriented to allow the industrial equipment to make quick and precise connections. More operators would be needed as well to operate these machines and perform the process. Aside from the addition of new equipment and operators, the workday would consist of the same schedule as created in the manufacturing portion of the project.

There were also other features such as charging port holes that we also wanted to investigate their integration into the product. From the market testing done, it did show that there was desire for holes for charging cables. Although the group wanted to do this, the purchased wood would split when getting drilled for the hole. Future models of the controller and headset stand should incorporate feeds for charging cables.

With each of these changes, it is also important to test the profitability of those changes. These are important to keep in mind when moving to mass production and how they impact the overall net present value of the company.

CONCLUSION

From a broken headset and an idea, a senior capstone project was born. The headset and controller stand was a year-long woodworking project that combined the world of video games and academia.

The two primary goals of this CME Senior Capstone project were to satisfy the customer's needs in functionality and aesthetics. Moreover, the project was a great success in combining these two goals and creating a final product that delivered on these goals. The sleek design created allowed for the storage of video game controllers and headsets without taking excessive amounts of space. The wood, after sanding and staining, was a perfect material to use as it fit well in most modern households in terms of aesthetics. To complete the stand, lean manufacturing principles of kaizen and 5S's were used.

The role of lean manufacturing in the process was essential to its completion. Lean manufacturing was used at every step of the process from prototype to manufacturing to finances. These tools gave a philosophy to the team as how to approach the project and its completion.

The culmination of the project was the completion of manufacturing five stands. After this step, the CME Senior Capstone Project was finished, and the education provided by the CME during the last four years was obtained.

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