HESE Greenhouse Grid
Team Alpha
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Mission Statement

The tarp grid is a durable, portable, and efficient way to place rebar during the construction of greenhouses. This product will decrease the time in which greenhouses can be constructed and increase the accuracy when positioning the rebar in the beginning steps of construction. Beta testing will occur during the summer of 2015, and implemented in the field by fall 2015. When on the market it is expected to replace all the other methods of laying rebar for under a fifty dollars. The marketing strategy for the tarp will be to target the specialized workers and organizations currently building greenhouses in Sub-Saharan Africa. This product will also be made available to non-professionals who have a practical use for it. The stakeholders include: HESE, any manufactures involved, the people native to the area who will be benefitting from the greenhouses, and the investors who help provide funding. These groups have the most to lose if the project fails. To be successful we have outlined a few assumptions. First, the natives will accept the project and use it as intended. Second, the materials for prototyping, building, and assembling the product will arrive on time. Next, the weather will not change unrealistically from the research conducted. Lastly, it will not cause any damage to the surrounding environment. In conclusion, the tarp grid will not only be profitable, but productive to the people using it.

Concept Development Summary

To create our first prototype, we started with brainstorming. We first needed to know what conditions our product would be working under and the location. We chose to place our product in Rwanda. In order to understand the restraints we would be working under, we had to do a lot of research on Rwanda. From our research, we found that Rwanda had two rainy seasons, from March to May and October to November. We also knew that it had a very hot climate as well. From this information, we knew we would have to create a prototype and final product that would be able to withstand all of these seasons. We planned for a very durable
prototype. We also learned that a lot of civilians of Rwanda farm for a living. We knew that we would have to create a product that was self-sustaining, therefore the people could depend on it for a long time. Finally, we found that a large percentage of Rwandans could read and write, however, there was still a great percentage of people who weren't educated. Therefore, our product needed to be simple, easy to put together and take apart, use, and fix. It was important that we researched the country our product would be in so that we could create a prototype and overall product that would work the most efficiently in the environment.

From all of the research we conducted on Rwanda, we created a list of our most desirable features for our prototype. We wanted our first prototype to be durable, portable, accurate, cheap, simple, and easy to repair. We figured that all of these requirements would be the most appropriate for the environment we would be working with in. After we made our features, we created three ideas and used the Design Selection Matrix to decide which design would be the best fit for our first prototype. Our three ideas were a tarp, a rope ladder, and a hinged square. We decided to go with the tarp. We then started to work in the lab to make our first prototype. When we finished, we created a testing report to evaluate the product and decide whether it was going to meet all of our requirements.

Figure 1

First ideas and sketches
## Testing Report 1

### Test Results Summary:

<table>
<thead>
<tr>
<th>goal</th>
<th>metric</th>
<th>results</th>
<th>notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>portability</td>
<td>lightweight</td>
<td>less than 2 kg</td>
<td>1 pound</td>
</tr>
<tr>
<td>accuracy</td>
<td>small margin of error</td>
<td>less than 1 cm off the mark</td>
<td>1.2 cm</td>
</tr>
<tr>
<td>assembly</td>
<td>quickly assembled</td>
<td>assembled in less than ten minutes</td>
<td>2 minutes to mark with pencil</td>
</tr>
<tr>
<td>durability</td>
<td>withstand heat, water and, dropping</td>
<td>no significant effect after dripping water on it, using a hairdryer on it (simulating a hot dry day), and dropping it</td>
<td>No water damage, no damage from the heat, no damage from dropping it</td>
</tr>
<tr>
<td>price</td>
<td>affordable</td>
<td>less than fifty dollars</td>
<td>20 dollars</td>
</tr>
<tr>
<td>simplicity</td>
<td>easy to assemble and repair</td>
<td>less than 2 moving parts, parts are able to be found in the local area,</td>
<td>One part, easy to figure out how to set up and lay out</td>
</tr>
</tbody>
</table>
Tested Criteria:

- Portability: Mass is important so that the product is portable and easy to use. The product will be reused many times so it must be portable. The method of using this in creating a grid also involves repeatedly picking it up and setting it back down (see User Guides page 16)
- Accuracy: Accuracy is obviously crucial for the final product. The purpose of the project is to lay out an accurate grid. Without accuracy, the greenhouse could not be successfully built.
- Assembly time: The goal of the product is to greatly reduce the amount of time it currently takes to create a grid layout. The product therefore should be able to be used in a relatively short amount of time.
- Durability: The product is going to be reused many times over. This could involve being exposed to extreme heat, wet or moist environments, and being repeatedly dropped.
- Price: In designing for BOP price is always a significant factor because the potential customers need to be able to afford it. So it’s important to keep costs down wherever possible
- Simplicity: The product must be easy to implement and easy to repair.

Figure 1

This figure is demonstrates how durable our prototype is. We used a hair dryer to prove that our prototype could withstand extreme heat, such as 160 degrees Fahrenheit.
Figure 2

This figure demonstrates how durable our prototype is. We folded the prototype six times into a small square.

Figure 3

This figure shows our accuracy test. We used our prototype to mark where the holes would be placed and we measured the holes to test the product’s accuracy.
Observation Summary:

We performed all of our testing in the lab. From our testing, we learned that our prototype might not be the best design for our final project. We realized that although of product was durable and all one piece, it was going to be very hard to find the right material to make it cost efficient. We also realized that the tarp wasn't that accurate. It is hard to make perfect holes on a tarp that gets wrinkled and we figured it might tear or lose accuracy after a while. If our holes tore, the entire product would be ruined and the greenhouse would be inaccurate.

Redesign for prototype 2:

For prototype 2, we will work on making a product that is more accurate and more durable. For this design, we don’t want to make something that resembles a tarp. Instead, we will create a prototype that is made out of some kind of hard material, such as plywood. We will use hinges to fold the new design, that way it will still portable. Also, for this prototype we will make sure our measurements are perfect, that way accuracy is within our standards.

Concept Refinement Summary

After we created our first prototype, we realized we needed to make some changes. We followed similar steps for creating our second prototype. We created some sketches of the changes we wanted to make. We decided that our first design would be too expensive. We wanted to change our design from a tarp to some kind of waterproof and durable wood. We used prototype one’s imperfections and restrictions to create an idea for our second prototype. We had two sketches that we liked. One was a kite-shaped outline and one was a square. We
decided to go with the square design because it was less complex. For prototype two, we had the same desired features. We wanted the product to be durable, portable, accurate, cheap, simple and easy to repair. One feature we were not able to accomplish was the weight restriction. Our second prototype would be somewhere between 20 and 30 pounds, which was heavier than our first prototype. This meant that it would not stay within our weight restrictions. For our second prototype, we performed the same tests to make sure it would stick to all of our desired features. We made significant changes in our material and design so that we could meet almost every requirement. Without our first prototype, we would not have known what kind of changes to make and improve on so that our product could be almost perfect.
## Testing Report 2

### Test Results Summary:

<table>
<thead>
<tr>
<th>goal</th>
<th>metric</th>
<th>results</th>
<th>notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>portability</td>
<td>lightweight</td>
<td>less than 2 kg</td>
<td>2.1 pounds, 0.95 kg</td>
</tr>
<tr>
<td>accuracy</td>
<td>small margin of error</td>
<td>less than 1 cm off the mark</td>
<td>.125 inches .318 cm</td>
</tr>
<tr>
<td>assembly</td>
<td>quickly assembled</td>
<td>assembled in less than 10 minutes</td>
<td>6 minutes 30 seconds</td>
</tr>
</tbody>
</table>
| durability        | withstand heat, water and, dropping | no significant effect after dripping water on it, using a hairdryer on it (simulating a hot dry day), and dropping it | Water: distorted and weakened the cardboard  
Hairdryer: No effect  
Drop: dented the corners | The tests measure the material strength of the product. It’s important to keep in mind that the final product will be made of wood which will better withstand these tests than cardboard. |
| price             | Affordable                    | less than 50 dollars    | 40-45 dollars                                                        | 35 dollars for wood, 5 to 10 dollars for hinges and handles. |
| simplicity        | easy to assemble and repair   | less than 2 moving parts, parts are able to be found in the local area, | one moving part (hinge) and made of simple hardware and wood       | The real product will be the same design and just as simple to set up and understand |


Tested Criteria:

- **Portability:** Mass is important so that the product is portable and easy to use. The product will be reused many times so it must be portable. The method of using this in creating a grid also involves repeatedly picking it up and setting it back down (see *User Guides* page 16)
- **Accuracy:** Accuracy is obviously crucial for the final product. The purpose of the project is to lay out an accurate grid. Without accuracy, the greenhouse could not be successfully built.
- **Assembly time:** The goal of the product is to greatly reduce the amount of time it currently takes to create a grid layout. The product therefore should be able to be used in a relatively short amount of time.
- **Durability:** The product is going to be reused many times over. This could involve being exposed to extreme heat, wet or moist environments, and being repeatedly dropped.
- **Price:** In designing for BOP price is always a significant factor because the potential customers need to be able to afford it. So it’s important to keep costs down wherever possible
- **Simplicity:** The product must be easy to implement and easy to repair.

*Figure 1*

This figure demonstrates our accuracy test. In this figure we measured where our holes would be placed so we could figure out how accurate the product was.
Figure 2

This figure shows how portable our prototype is. In this picture the prototype was folded up into half its size so that it could be easily transported.

Figure 3

This figure shows how simple our prototype is. It is all one big piece and doesn't need to be assembled.
Observation Summary:

We performed all of our testing in the lab. We learned about the material limitations of cardboard. It was difficult to work with and did not withstand testing well. This showed us that future prototypes should be built using the intended material so that all tests could be carried out meaningfully. We also learned that it’s difficult to make a square have perfect right angles and have equal lengths on all sides. This was a surprise to us because constructing a square seemed so simple and it revealed that there might be difficulties in producing accurate products. We might want to consider a better production process that would be more reliable and accurate. We also observed that our cardboard half scale model was already almost half of the weight requirement. Scaling up and converting to wood would make the product much heavier. This was quite surprising because it felt fairly light. We could reduce the weight by cutting unnecessary sections out (suggestion from Professor Ritter).

Cost Analysis

The original prototype could not be produced under fifty dollars; however, prototype two potentially could. For the design of Prototype two, it requires a little over a meter squared of treated plywood. The material would be purchased at Home Depot which sells Oriented Strand Board that is 7/16 inch thick and four by eight feet squared. This piece of wood can be cut in half, and used for multiple grids. Additionally, it would cost about $8.25 each (Oriented Strand Board). The wood is made without cores or knots therefore it should be fairly durable and not bend. According to Home Depot, it will not warp or bend as easily as plywood as it is treated. It is made from fast growing trees which makes it environmentally friendly because it uses less resources to produce (Oriented Strand Board). We also plan to include handles and two door hinges. Door hinges cost approximately three dollars on average at Home Depot. This brings the
total used to $14.25 leaving $35.75 left in the budget to purchase waterproofing material and handles. A set of two handles can be bought at Amazon for approximately four dollars and the project requires two sets ($8 worth of handles). $13.21 will be used to purchase Thomas’s Multi-Surface Water Seal from Amazon to extend the life of the product by protecting it from the elements. This leaves an excess of about $14.50 in the budget.

Works Cited


Final Design: User Guidelines and Instructions
Re-design ideas/thoughts

Some feedback our group received was to cut out unnecessary material from the design. One requirement that our prototype did not achieve was the weight limit. A suggestion was for us to take out parts from the middle of our design, that way the product would weigh less. This would also reduce the cost of our product because we would be using less material. We also received very positive feedback about our hinges and handles. Our audience felt that these two necessities were a creative way to make the product portable. Even though it may be heavy, the workers can easily transport the grid because of this. Overall, our audience felt that our product was a good design and would be a good way to lay the foundation for greenhouses in Rwanda.

Some suggestions we would make for the HESE students would be to create a prototype that was made out of less material. If we could create a third prototype, we would redesign it to weigh a lot less by cutting out the middle of the board. Our new design would be an outline of a grid, rather than an entire piece of wood. We would also suggest to the HESE students to look into the material more in depth. While plywood could be very durable, it might not last as long as the team might desire. HESE students could figure out a material that will work a lot better for the grid. Overall, our second prototype would need a more work so that the perfect and final product could be created.