Greenhouse Foundation Spacing-Tool

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Team 4
Mission statement: Our product is intended to help layout the foundation of the greenhouse. By using a diamond shaped arrangement of PVC pipe, the builders may quickly and effortlessly implant the rebar that will act as the foundation of the greenhouse. The benefits of our design is that it is quick, light, durable, and long lasting. This ensures the long-term success of the greenhouse and the surrounding communities. Our key business goals are to keep the final design under $50 and convenient for the consumer to use. Our primary market is to the HESE organization for them to use when building greenhouses in Africa. Our secondary market is to any other individuals or groups building greenhouses in any part of the world. Our foundation template is not limited to use only in Africa. We are assuming that our product will work as intended and that we have considered all possible consequences and environmental risks that might affect our design. We are also assuming that the carpenter and local workers will understand how to assemble our tool every time they use it. The stakeholders of this project include the consumer, in this case HESE, material manufacturers and retailers, and marketing team.

Concept development summary: Describe the methods used to develop your prototype 1

- Describe the process the team used to collect ideas and information about the region of the world that the greenhouse is to be used (societal, economic, history). What did your team learn (i.e., from the context research assignment)?
- What were the desired features for prototype #1?
- Include early sketches of your design ideas, if available.

We utilized the worksheets that our professor gave us to consider all factors that went into the prototype such as durability, cost and portability. After brainstorming a few sketchy ideas, we decided to pursue this one with the PVC pipes as a template for the grid. In order to gather information about the greenhouse region, we did extensive research on the climate, societal and political status of Kenya: a country where greenhouses will potentially be built. We also interviewed the HESE representative for details about the areas that the greenhouses are built. For instance, in Kenya, there is a wet season and a dry season that divide up the year. There is also a huge elevation and climate difference in various parts of Kenya. We took these into strong consideration when thinking about what materials we could use that could survive these conditions.

Ideally, we wanted to use a light, yet durable material, and PVC instantly came to mind. Portability was also one of the major concerns, so instead of a way to lay out the entire grid in one device, we thought that if we made a template for part of the grid that we could shift around to complete the grid would allow for portability and ease of setup.

Test Report Summary for Prototype #1. All data should be shown in spreadsheets/tables. Include pictures (with a label such as “Figure 1: Drop test example”) and tables (with label such as “Table 1: Summary of Prototype #1 testing). Make it clear where Prototype #1 was tested. All pictures and tables must be discussed and referred to in the report text.

Our first prototype was tested outside the Hammond building on the lawn. We chose this spot because it would allow us to somehow simulate the conditions of the ground that the spacing tool would be exposed to in the country of Kenya.
<table>
<thead>
<tr>
<th>Test Type</th>
<th>Pass/Fail</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>1:50</td>
<td>When we set up the grid it took us only 1 minute and 50 seconds to lay out the whole grid which is significantly less than the maximum time allotted making this design extremely time effective.</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Barely Failed</td>
<td>After setting the grid up we measured how far away each pole was to see our accuracy. The measurements showed we were barely over the allotted range for miscalculation.</td>
</tr>
<tr>
<td>Durability</td>
<td>Failed</td>
<td>To test the durability of our first prototype with simulated the wear and tear if would go through. After dropping our prototype on the ground from about five feet, one of the arms broke off thus causing the prototype to fail the test.</td>
</tr>
</tbody>
</table>

First prototype made of wood  
Setting up the grid  
Durability test failure

- **Concept refinement summary:** Describe the methods used to develop your prototype 2.  
  - Describe how you used Prototype #1 development and testing to guide development of Prototype #2.  
  - Did you change any of the desired features?
Include any updated sketches of your new prototype ideas, as needed.

Our first prototype was made of wood as we did not have pvc at our disposal due to cost issues. For prototype 1, our main goal was to simply test out the concept of our design. Although we tried to make measurements as accurate as possible, drilling holes in wood was still kind of inaccurate. The concept of the prototype worked, but the durability of the wood glue that held the piece together was very poor. We knew we wouldn’t have this problem with a pvc prototype, so that’s what we decided to do for the second prototype. In addition, we made the decision to make a pvc prototype as well because no matter how well we tested the wood prototype, it still wouldn’t behave the same as pvc. Otherwise, our design with a 4 way joint in the middle with holes drilled on the ends of the legs still remained the same.

Test Report Summary for Prototype #2. All data should be shown in spreadsheets/tables. Include pictures (with a label such as “Figure 1: Drop test example”) and tables (with label such as “Table 1: Summary of Prototype #2 testing). Make it clear where Prototype #2 was tested. All pictures and tables must be discussed and referred to in the report text.

Prototype 2 was tested in the same place as prototype 1. We used the lawn outside of Hammond building because it was the best simulation of Kenya’s ground we could have.

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Pass/Fail</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Passed, 3:50</td>
<td>Using the pvc prototype to set up the grid took a little longer than the wood prototype due to having to put the pvc pipes together. However, the pvc pipe prototype was still time effective in setting up the grid.</td>
</tr>
<tr>
<td>Accuracy</td>
<td>BarelyPassed</td>
<td>Within the allotted margin by .02 centimeters.</td>
</tr>
<tr>
<td>Durability</td>
<td>Passed</td>
<td>The PVC was dropped repeatedly and went through simulated wear and tear expected of it to go through.</td>
</tr>
</tbody>
</table>

Cost analysis:
- For Greenhouse gridding teams: Could the Prototype #2 design be built for full-size greenhouse gridding and meet the price goal of $50 in materials? What is the estimated price of your final prototype? What is the expected price of the final product (with your material choices, etc.) given a goal of 250 greenhouses manufactured per year? Justify your answers.
Our prototype #2 could be built full-size and still fit within the cost constraint. The total cost for all of the materials (not including the tools needed to actually make the prototype) would be approximately $15. This information is based off of PVC pricing information from lowes.com. The 4-way tee joint will cost approximately $3. Additionally, the actual PVC pipes in total will cost about $12. These values will hold true for the final prototype, as PVC is our desired material. We feel that this is the most cost-efficient material that would provide the most durable product to manufacture 250 greenhouses.

**User Guides:**
- Greenhouse teams: Laying out the grid for the greenhouse structure or correcting the joint wearing problem is a process, but the construction worker may be unable to read or write. Provide an illustrated guide which shows the greenhouse gridding or joint protection process.
  - How to use the frame

  We designed the frame to be very simple to use. To get it ready for use, follow these steps:
  1.) Gather the pieces and get them in an x-shape.
  2.) Push each rod into a separate opening of the joint, making sure that the side with the hole remains facing outward.
  3.) Make sure all of the rods are tightly secured by the joint
  4.) Place the frame on the ground in the desired location
  5.) Place rebar in the holes at the end of the rods
  6.) Pick up the frame and translate it so that 2 of the rods are in 2 of the holes
  7.) Place the frame back down
  8.) Place 2 rods in the open holes
  9.) Repeat until grid is completed
  10.) Disassemble
  - NOTE: if rods are stuck, twist and pull when trying to remove from joint

**Re-design ideas/thoughts.**
- Summarize the feedback from the HESE students/general public obtained during the DEM Showcase.
What suggestions for redesign or testing do you suggest to the HESE students if they started with your team’s prototype #2 and were building a prototype #3? Be specific. What is your “dream” prototype #3?

The HESE feedback was overall positive, and the students said that we have a good idea, but their primary concern was in regards to the PVC. They think that PVC is not an environmentally friendly enough material and that we should look into alternatives. We discussed this as a group, and we collectively decided that despite this, PVC was still our best option. Given the price budget, there is a very limited number of materials that we can choose from. Other options would either be too expensive, not mobile, or not durable enough. We felt that PVC had a nice balance of the three while still being able to accurately and quickly do its job. Additionally, the low cost can help cover the potentially high cost of importing the material.

Our suggestion for making another prototype would just be to measure more accurately. Overall, the frame is very easy to construct. The whole process involves measuring out the proper lengths, measuring holes, and then cutting them to those values. Human error is the only potential problem with construction, but that can easily be minimized with diligence. Our “dream” prototype #3 would simply be the same as our prototype #2 with even more precise measurements.

Reminder: list any sources of information or references used in your report, such as costing information, etc. To not list references is plagiarism…

Works Cited