Greenhouse Grid Final Report

By Group 7:
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Mission statement:

Our product provides the customers with a quick and easy assembly of a greenhouse grid. The product is a reusable, premeasured, right, isosceles triangle that is made of a cheap, weather resistant, durable plastic. The product will be used to determine steak placement in greenhouse frame construction and needs very little training to use. The product uses a premeasured system so as long as the customer uses the tool properly, the time of measuring a grid will be greatly reduced and the task will be much less tedious. This product is aimed at customers in developing countries with harsh growing conditions but could also be marketed to people in developed countries to use to set up their own greenhouse/shed. The stakeholders of the product are the customer, the retailer, and the producer of the product. We plan to introduce the product in the second quarter of 2015.

Concept Development Summary:

Our group researched the area of Kenya and discovered that there was an unemployment rate of 40%, forcing many of the natives to harvest their own crops. However, another issue arrived in that only 9% of the land is arable. We took this into consideration, brainstorming how we could develop a system of gridding out a greenhouse in the fastest time possible. The gridding tool had to be durable in order to maximize use, as well as portable so the workers could carry their other items required for the job. For the first prototype, our goal was to develop the basic design of the tool, and worry about scaling in later designs. After discussions and presentations of our sketches (shown below), we considered a right angle that could be continuously flipped to create the 6x6 meter grid.
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<tr>
<td>Durability test</td>
<td>In this test, we tried to account for human error. We simulated if a person were to drop the prototype on the way to or from the job site. This test proved to us that we needed a more durable design for prototype #2.</td>
<td>This test proved to be a complete failure. The corner piece split into two the very first time we dropped it from approximately four feet off the ground.</td>
<td>Create a supportive arm that runs from one end of the corner piece to the other. This will make the prototype much stronger so that the users will not have to repurchase the product.</td>
<td>The product will be used multiple times by the workers who design the greenhouse grid, hence the product needs to be durable and not break easily, and hence the test we performed signifies this, as they might end up dropping/pulling the product apart.</td>
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<tr>
<td>Waterproof</td>
<td>Since our prototype was made of wood it is not waterproof as wood warps with the exposure to water. The Gorilla glue we used to glue the wood together is waterproof, so we will continue to use it on the next prototype.</td>
<td>The warping would change the length of holes making our product useless. Hence it failed our test</td>
<td>Our next prototype will be made from PVC pipe, a plastic that does not warp due to water damage.</td>
<td>The places where the prototype will be used might be wet, or dirty; the product should be able to withstand such conditions.</td>
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<tr>
<td>Accuracy</td>
<td>New measurements will have to be taken because our holes do not have an error of +/- ¼ inch. Our prototype was off on one side by 2 inches as we forgot to take into account that the length of the sides change when combining the wood frame together.</td>
<td>The prototype failed to create accurate holes</td>
<td>The prototype 2 should be made more accurately, it should have almost zero error.</td>
<td>It is very important that the holes are at an accurate distance from each other, as this will help in making a perfect grid.</td>
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<td><strong>Time to build the greenhouse</strong></td>
<td>Each group member attempted to grid out the greenhouse by marking a piece of cardboard with a pencil. The grid is supposed to be made in under 10 minutes and on an average each group member did it in under 8 minutes.</td>
<td>The grid had to be created in less than 10 minutes, which it very well did, hence prototype 1 passed this test extremely well.</td>
<td>The next prototype should be as quick as prototype 1. The main idea behind making a sample pre-made grid is to be able to make the greenhouse grid in under 10 minutes. Hence this test proves that the grid can be made in under 8 minutes.</td>
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<td><strong>Portability and weight</strong></td>
<td>The prototype 1 was extremely heavy since it was made of wood. The weight of the product came to be about 3 kilograms.</td>
<td>Even though this prototype is not the full size, it was pretty heavy since it was made up of wood.</td>
<td>Wood is a much heavier material than PVC pipe so the next prototype will be made of PVC pipe. The user of the product will either use a small vehicle or walk to the site of the greenhouse, hence the product needs to be very light and extremely portable as well, which our test prove it.</td>
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*Pre drop test: The prototype was dropped from approximately 4 feet high.*

*Post drop test: proves to be an absolute failure. The prototype is in two pieces*
Concept Refinement Summary:

Our first prototype was not durable nor portable according to our tests, making this the concern for our next prototype. Our next design was made out of PVC instead of wood making it extremely durable and more resistant to water. With the addition of connector pieces, the prototype could be broken down making transportation much easier. Another way to increase the durability of the corner piece was the addition of a third pipe that turned the right angle into a triangle. This would prevent the right angle from being flimsy and decrease the possibility of damage.
# Prototype 2 - Testing Report

<table>
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<tr>
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<tr>
<td>Durability test</td>
<td>The PVC helps in durability since the synthetic material is much more flexible, is hard to crack, and does not splinter. We dropped it from three feet and five feet and the product remained unharmed.</td>
<td>Since the PVC grid did not break, and remained strong, it passed our test extremely well.</td>
<td>We added a supportive arm, which made the durability test a success. We also altered the material of the product from wood to plastic PVC pipe.</td>
<td>The product will be used multiple times by the workers who design the greenhouse grid, hence the product needs to be durable and not break easily, and hence the test we performed signifies this, as they might end up dropping/pulling the product apart.</td>
</tr>
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<td>Portability</td>
<td>The whole product was weighed and it weighed in at about 2kg, which is very light and also since the product was collapsible, it can be carried by one person really easily for a long period of time, this too has was tested.</td>
<td>The maximum weight we wanted our product to be was 3 Kg, since the product was around 2kg and was extremely portable, it passed the test easily.</td>
<td>We switched the material of the product from wood to plastic PVC pipe. This made the product much lighter and easier to handle. We also made the product collapsible. Instead of having two meter triangle that is awkward to carry, we have a 1 meter triangle and two 1 meter pieces of pipe that fit tightly into the others.</td>
<td>The user of the product will either use a small vehicle or walk to the site of the greenhouse, hence the product needs to be very light and extremely portable as well, which our test prove it.</td>
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<tr>
<td><strong>Accuracy</strong></td>
<td></td>
<td><strong>Time to build the greenhouse</strong></td>
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<td>Using pencil marks to simulate the nailing of rebar, we measured the distance between the holes. The accuracy of those holes were within ± ¼ inch.</td>
<td>Even though we wanted our product to have 100 percent accuracy, it had some error, which can be acceptable.</td>
<td>Our group measured the time taken to grid out half of the greenhouse due to limited constraints of the classroom. After three trials, the testing results show as follows for two people to mark out the grid, the average time was about 3 minutes.</td>
<td>The grid had to be created in less than 10 minutes, which it very well did, hence prototype 2 passed this test extremely well.</td>
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<td>The prototype 2 was made accurate by making sure the holes were made at exact distances from each other.</td>
<td>The prototype 2 was the actual dimensions of the grid, making the time test more accurate.</td>
<td>The main idea behind making a sample pre-made grid is to be able to make the greenhouse grid in under 10 minutes. Hence this test proves that the grid can be made in under 8 minutes.</td>
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<td>It is very important that the holes are at an accurate distance from each other, as this will help in making a perfect grid.</td>
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<td><strong>Cost</strong></td>
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<tr>
<td>We estimated the rough cost of the materials of our product we plan to produce:</td>
<td>PVC is a very cheap material. We are still $37 below the budget, making it a very affordable product for citizens of developing countries.</td>
<td>We adopted PVC instead of wood, hence helping in reducing our costs.</td>
<td>The product should be cheap for the consumer to buy, only then will the consumer actually adopt the premade grid system. Our product which is way less than 50 dollars helps the buyer to buy the grid and save money and time.</td>
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<td>5 meters of 3/4 inch pvc pipe: $7</td>
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<td>PVC pipe couplings: $5</td>
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<td>Total cost of product: $13</td>
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</table>
We can see from here that the prototype is easily portable and also can be carried by only one person.

Time to build the grid with the help of the prototype is less than 10 minutes.

The prototype is accurate as well.

The prototype is extremely durable as well because of the PVC pipes.
Cost analysis

Cost of pipe – $4.20

Cost of coupler- 90 degree 27¢
- 2x 45 degree 1.56
- 2x 180 degree 54¢

Total cost = 6.60

The reason the cost of our product is so low is the materials used are already mass produced and readily available. The goal was to design a product a product under 50$ and the product far surpasses that mark, making it a very reasonable purchase for people of developing countries.

Cost References

http://www.homedepot.com/p/JM-eagle-3-4-in-x-10-ft-PVC-Schedule-40-Plain-End-Pipe-57471/202280935?N=5yc1vZbu5Z1z0x2cw


User Guidelines
The product comes disassembled for easier transportation and storage. The user must first assemble the product before it can be used.

STEP 1: Assembly
Assemble the product by linking the coupling on the corner of the triangular pipe to the end of the loose pipes as shown in the figure on the right. The holes on the end of the pipe should be oriented up.

STEP 2: Placement of Stakes
Place first three stakes through the holes as shown.
STEP 3: Reposition
Reposition the product so that two of the three holes are filled with a stake and one hole is open.

STEP 4: Stake Placement
Place a stake through the open hole.

STEP 5: Repeat
Always reposition product so two of the three holes are filled with a stake this ensures accurate placement and an all-around accurate grid.
Redesign Ideas

The HESE students gave us some feedback like:

* Make the corner joint (Right triangular piece) also detachable to make it more portable.

* Color code the model so that it is easier to explain.

* Make the dimensions more accurate (For example, more accuracy when the PVC pipes are connected).

* Make the holes more precisely (size of holes at the ends).

In prototype 3, we would suggest the following improvements:

* Add another diagonal support to make it more durable and sturdy.

* Spray paint the pipes and give proper color codes to them.

* Cut off the extra top part of the joints (connectors) so that they can be flipped and used easily and also it becomes easier to put the stakes.

* Instead of sticking the diagonal support, use another 45 degree joint so that it doesn’t come off.

Works cited

Greenhouse picture

https://cms.psu.edu/section/default.asp?id=201415SPUP___REDSGN100_022