The Simplistic Grid

Team 2
Tucker Wheeler, Ali Wallace, Rachel Lee, Kevin Aguirre
EDSGN 100 Sec. 25
Dr. Ritter
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**Problem Statement (Greenhouse Grid)**

Over the last 4 years, Penn State’s HESE (Humanitarian Engineering and Social Entrepreneurship) program has been refining the design for a low-cost greenhouse for a small-scale farmers which enables them to move from subsistence to sustainability. Our design objectives for this project, using only simple tools such as rope or wire, a level, and a measuring tape, were 1) to define an efficient method for measuring how level the ground is, and 2) to define the process so a 6m x 6m square area can be marked with 16 posts to form the frame of the greenhouse. The goal of the project is to completely mark the grid in 10min or less.

**Concept Development Summary**

We began the process of designing our first prototype by conducting research on the area of the world that we were targeting for our project. In this case, we were designing a greenhouse for Kenya. What we found out about Kenya is that electricity is not readily available; however, construction materials and labor can be found easily and at a small expense. Kenya has scarce natural resources like water, forests, but has an abundance of minerals. We also learned that communication with our clients in Kenya would be difficult since there are a total of 62 different languages spoken across the country. We transformed what we learned about Kenya into guidelines for how our project should be designed. The desired features we came up with for our design are as follows; the foundation needs to be level, the posts need to be equally spaced and square, laying out the posts needs to take 10 minutes or less, the design should be under $10, the materials need to be accessible, and the design plan should be simple.

![Picture #1: Our first sketch of our design plan.](image-url)
# Test Report Summary for Prototype #1

<table>
<thead>
<tr>
<th>User Need/ Feature/ Requirement</th>
<th>Description of Test</th>
<th>What is “pass”?</th>
<th>Materials/ tools needed to run tests</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>Use a level to determine if ground is flat and even on average. Location: on grass area outside of Hammond.</td>
<td>If the bubble is relatively centered</td>
<td>Level</td>
<td>We placed the level on the styrofoam and found it to be level. When placed on the ground, the bubble was in the center of the two lines, indicating it was level (see picture 1) PASS</td>
</tr>
<tr>
<td>Equal Spacing/ Square</td>
<td>Measure diagonals of the grid.</td>
<td>Diagonals are even length</td>
<td>Tape measure</td>
<td>We measured the diagonal of one pole to another to ensure the grid was square and even in length. On our prototype, both measured 8.5 inches. When we tested outside, both diagonals measured 50.9 inches (see picture 2 and 3) PASS</td>
</tr>
<tr>
<td>Less than 6 minutes (so there is room for extra time in the full scale)</td>
<td>Time yourself when constructing the grid using a stopwatch</td>
<td>if it takes under 6 minutes</td>
<td>Stopwatch</td>
<td>We started timing when the first pole was placed and stopped when the last one was placed. We completed the grid in 6 minutes and 39 seconds (see picture 4) PASS</td>
</tr>
<tr>
<td>Low cost</td>
<td>Add up expenses to ensure we spent under $10</td>
<td>If expenses are under $10</td>
<td>Calculator</td>
<td>The strings and poles are provided, so the only thing needed to be purchased was the protractor. This could easily be purchased for under $10. PASS</td>
</tr>
<tr>
<td>Accessibility of materials</td>
<td>Do background research to determine availability of materials</td>
<td>If materials are accessible</td>
<td>Internet</td>
<td>Most materials we need are already provided; the only thing needed outside of this is the protractor. Therefore, the materials are very accessible. PASS</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------------------------------------------------------</td>
<td>-----------------------------</td>
<td>----------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Simple</td>
<td>Gauge complexity of process by explaining it to others and seeing if they understand</td>
<td>If others understand the process</td>
<td>Peers, prototype, and directions</td>
<td>We did not have time or the materials needed to conduct this test. We need to write formal directions in the future to determine if we will pass. FAIL</td>
</tr>
</tbody>
</table>

Picture #1 How the level should look.  Picture #2 The prototype is 8.5 inches across.

Picture #3
Our first test was 50.9 inches across the diagonal.  Picture #4
Using the string to map out our grid.
**Prototype #1 Summary**

Our tests on our first prototype revealed promising results. The leveling test proved easy. By making use of a simple level we were able to confirm that our miniature prototype was indeed level. We tested the dimensions of the grid by measuring the diagonals. If the grid was perfectly square the diagonal distances from opposite corners should be equal. Our diagonal measurements turned out to be only ⅛ of an inch off. We found this satisfactory. As far as our timing goes, we were able to mark out the grid and place all the posts in 6 minutes and 39 seconds which is well below the time limit of 10 minutes. What this means is that we can add some more complicated procedures into our prototype to improve the accuracy of the design without having to worry about going over the time limit.

Some of our tests did not require a physical examination of the prototype. For example, the accessibility of the materials is another important design requirement but it is something we researched before construction began on our prototype. By consulting our research, and by looking over the materials we confirmed that our design would be low cost. The only materials required for laying out the framework would be the lumber, a level, string, and a tape measure. We never got a chance to test the simplicity of our design so we have no data to draw a conclusion from this test. Overall the tests seemed to back up our design, however, there is still room for improvement.

**Concept Refinement Statement**

The Design Thinking Workshop and Prototype #1 testing allowed us to evaluate our design and make improvements. We thought about what would make the process easier and more efficient, which lead us to the conclusion of marking the string used. By measuring out the distance between posts and marking these distances on the string, we were able to simply place the posts where the marks were when constructing the grid, cutting down both time and effort. We also decided testing our idea at a scale of 6ft by 6ft would give us more accurate timing for the real design. Another change we made was sketching our process to have other people look at it to see if it was easily understood. These upgrades made the second prototype a large improvement from the first.

**Test Report Summary for Prototype #2**

Location: Grass area outside of Hammond

<table>
<thead>
<tr>
<th>User Need/Feature/Requirement</th>
<th>Describe Test</th>
<th>What is “pass”?</th>
<th>Materials/tools needed to run tests</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>Place a large level</td>
<td>If the bubble is level</td>
<td>Level</td>
<td>Upon placing the level on</td>
</tr>
</tbody>
</table>
on the ground to determine if it is flat and even, testing multiple places around the area of the grid centered between the lines of the level the ground in multiple places, we saw that the bubble was between the two lines, indicating the ground was level. PASS

<table>
<thead>
<tr>
<th>Equal Spacing/Square</th>
<th>Measure opposite corners (diagonals) of the grid to determine equal spacing and use a large protractor to determine that the grid is square</th>
<th>The margin or error for the diagonals is 2 inches and for the corners is 4 degrees.</th>
<th>Tape measure and protractor</th>
<th>We measured the diagonal of one pole to the other, and one diagonal measured to be 102.4 inches while the other measured to be 101.6 inches. This shows that our grid was very close to be equal in spacing. When using the protractor, the angles varied from 90 degrees by less than 3 degrees, indicating our grid was square. PASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 minutes or less</td>
<td>Use a stopwatch to time how long it takes to construct the grid</td>
<td>Takes under 10 minutes to complete the grid</td>
<td>Stopwatch</td>
<td>We began timing when the first pole was placed into the ground, and we stopped when the last pole was placed. We were able to complete the grid in 6 minutes and 29 seconds. PASS</td>
</tr>
<tr>
<td>Low cost</td>
<td>Add up the cost of materials to ensure we spent under $10</td>
<td>If expenses are under $10</td>
<td>Calculator</td>
<td>Since the poles, strings, and level are given to us, the only material needed to be purchased is the protractor. This material could easily be purchased for under $10. PASS</td>
</tr>
<tr>
<td>Accessibility of materials</td>
<td>Conduct background research of the</td>
<td>If materials are accessible</td>
<td>Internet</td>
<td>A majority of the materials we need are already provided, so the</td>
</tr>
</tbody>
</table>
area to see what materials are readily available for use

only thing we need to obtain is a protractor. This is an easily available material. PASS

| Simple | Determine if the process is easy for others to understand by explaining it to 5 different people and gauging their reaction | If others understand the process by either stating they do or don’t. | Peers | We explained the process to each of our roommates and one classmate. Each person understood the idea and process behind it, allowing us to conclude that our process was able to be carried out by others. PASS |

Marking the posts.    Creating the 90 degree angle.
Prototype #2 Summary

The results of our second prototype and testing proved that our design works well. The level was an accurate and easy way to determine if the ground was level. Measuring the diagonals of the grid allowed us to determine if the spacing was equal between each post, and after viewing our measurements, it was clear that our spacing was almost equal because the measurements varied by less than one inch, and were less than one inch apart. By using a large protractor, we were able to determine if the corners of our grid were square. Upon testing, we found that the corners were less than 3 degrees from the desired 90 degrees, allowing us to determine that our grid was square. We were able to determine if our process took under 10 minutes by timing ourselves using a stopwatch; we were able to construct the grid in 6 minutes and 29 seconds, which is well below 10 minutes. When determining if the materials needed are under $10, we conducted research of the price of the materials needed to be purchased, where we confirmed that our materials had an overall price that was lower than $10. We used the internet to see if the materials we needed were readily available; we confirmed that they were. Finally, we determined if our design could be understood by others through the process of explaining it to 5 peers and testing their understanding. All those who we explained it to understood the process and claimed they could carry it out themselves, allowing us to conclude that our prototype was simple enough for others to understand.

Thus far, the results of our prototype are very accurate and indicate efficiency. There was very little variation in our measurements, and we exceeded all requirements. These results allow us to conclude that our prototype in successful.

Cost Analysis (under $10)

- Protractor ($1.41)
According to the DEM project outline, we already have rope/wire, a level, and a measuring tape; therefore, the only thing we would need to buy is a protractor. Buying a cheap small protractor from Staples would be the best option because a lot can be transported at one time and they can be easily replaced if lost or broken. This also saves an extra $8 in the budget.
User Guides:

Our Design Plan

1. Make sure the ground is level
2. The first marking is made in the corner of the laid out ground
3. From that marking, 2 strings that are marked at 2 meters 4 times per string. The strings are on either side of the protractor next to the first marking.
4. Markings are placed on the ground at the place of the marks on the string.
5. From either one of the left open sides the string is placed again and markings are made. This makes the outside frame of the grid.
6. The strings can be used horizontally through the middle to complete the rest of the markings.

**Redesign ideas/thoughts**

After the showcase where we had to present our project, we summarized what the judges and HESE students told us in reference to our design. They stated that most of our design process was rather similar to what they did back in Africa. They questioned whether or not using a protractor would be the most efficient way to frame the grid. But overall it was a good design process that met the requirements necessary to perform. Although we passed all of our tests, there’s always room for improvement so we could think of a more efficient way to mark the posts so the time would shortened. We could ask more people if they understood our design. Our dream design would be to use all of Kenya’s resources to maximum efficiency with low timing and simplicity.

If the HESE students adopted our second prototype as their design plan we would suggest that they build the prototype at the full scale and in African conditions. One of the things we learned from our second prototype was that measuring out the posts takes longer on a larger scale. Furthermore, their experience with the culture, economic situation, and setting in Africa is more refined than ours and may allow them to make improvements to our design that we could not have foreseen. Ideally, we would like our design to be performed the best possible way.