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Mr. Marx

Research Science

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WT Research Science Design Proposal

Project Abstract:

Currently, over one billion people worldwide live in homes with dirt flooring.[2] Not only an issue of home aesthetics and dirtiness, dirt floors actually are one of the world's most significant causes of disease.[3] Even though many people are living in these unsanitary conditions, nobody has yet invented an affordable and effective replacement for dirt floors. The goal of our project is to do just this, hopefully giving people around the world an affordable flooring solution that will significantly reduce their chances of getting sick. The general idea of our product is a system of floating tiles that are placed on top of the dirt floor, creating a barrier between homeowner's feet and the floor. Hopefully, our solution will provide more sanitary living conditions for many people worldwide.

Background and Significance:

General Background

According to the World Bank, currently 10% of the world's population lives under what is defined as extreme poverty- earning less than $1.90 per day. These people often live in poor living conditions, with bad sanitation and malnourishment making it

easier for them to get sick.[9] One major contributor to this bad sanitation caused by poverty is the dirt floors that many poor people live on. These floors transmit diseases to people living on them, making sickness in houses with these floors much more widespread. Diseases are transmitted from floors both by dust kicked up from them, which spreads pathogens into the air, and by muddy puddles on the floors, which can contain diseased mosquitoes.[5] The prevalence of dirt flooring is a major, worldwide sanitation problem that needs to be solved.

Overall Need

Over the summer I (Eli) spent 2 weeks in the Dominican Republic. While I was there, my group and I were able to help a small community near the city of Puerto Plata (Northwest Dominican Republic). When I was walking around the community and looking in the family's homes there were several things that I noticed that really caught my eye. One of these things is that the majority of the homes had no flooring, and the floors inside the homes were just dirt. The select few homes that didn't have dirt floors had cement floors instead, something that you don't see in homes around us in the United States. Having just worked extremely hard the preceding mornings on manually mixing and laying cement to create a basketball court for the community, I knew just how labor intensive and exhausting it would be to do this inside the homes. With that being said, I understood the financial situation of the community, and it was not great. It is very expensive to purchase lots of bags of cement, and it also takes time to mix and lay that cement; time that you could be trying to make a living. This brought me back to the alternative option; the idea of the dirt floors. These floors make it nearly impossible

for your feet to remain clean of bacteria and other diseases living in the soil, not to mention that you are cooking and eating with all of these bacterias surrounding you. After all, there is no way to clean a dirt floor. With there being no easy access to healthcare, and this being a community filled with children I saw this as an extreme issue. People would be getting sick from living in their own homes, and there really isn't an affordable or efficient way to solve that problem. The only other option would be to cement the floors which poses many issues of its own.

Upon returning home, with the issue still on my mind, Kevin and I began to research deeper into the issue. The information that we found further backed up my thoughts, and in fact, we found that dirt floors are not only an issue in the Dominican Republic, but also in other third-world countries. As we mentioned before, over one billion people worldwide do not have access to adequate flooring,[3] and this problem has many negative health effects. A 2007 World Bank study found that, the replacement of dirt floors was linked to large reductions in diarrhea and parasitic infections: by 49 percent and 78 percent respectively. The study also found that replacing dirt floors lead to an increase of cognitive development, from 36 percent to 96 percent.[2] These statistics convinced us that inadequate flooring was a serious problem, so we set about what solutions have already been created to replace dirt floors.

Current Status

A number of current solutions exist that are designed to replace dirt floors, but they are all flawed in some way. The most common replacement for dirt floors in developing countries is concrete. Concrete is usually used because it is cheaper than

most other flooring options, and is relatively easy to install.[5] While concrete is able to prevent the illness that is associated with living on a dirt floor, concrete floors still have many problems that make them an unsustainable solution. First of all, concrete floors are still prohibitively expensive for poor people living in developing countries, as a full concrete floor for a small house can cost up to two months of a family's salary.[6] In addition to their high price, concrete floors are not very durable- they chip easily if anything is dropped on them. The process of repairing a concrete floor is time-consuming, and requires special materials and tools that people in third-world countries do not have access to. All of these problems combine to make concrete an inadequate flooring solution for developing countries.

While concrete is the most common type of flooring that replaces dirt, some other solutions have been created that aim to be better alternatives to concrete. One of these flooring solutions is called EarthEnable. EarthEnable is a type of earthen floor, similar to concrete. The first step in laying an earthen floor is placing a layer of laterite, a type of rock, to provide a dry layer to lay the floor on. After the laterite layer is created, a mixture of sand and clay is spread over the top of it, forming the middle layer of the floor. Finally, a special type of oil is spread over the top of the mixture, making it more durable, waterproof, and easy-to-clean.[8] Earthen floors like the ones that EarthEnable provides have many advantages over concrete floors. One major advantage that they have is their durability, thanks to their oil coating. This coating prevents them from being damaged easily, so they no longer can chip like concrete. In addition to their heightened durability, EarthEnable's floors are also significantly cheaper than concrete

floors. According to their website, earthen floors are up to 75% cheaper than concrete floors.[6] While this price decrease is certainly noteworthy, it may not be enough to make these floors totally affordable. EarthEnable admits that "...[Our floors are] not affordable to most of our customers up front, but over the course of the floor's life (10-15 years), is certainly affordable."[6] This excerpt shows that an earthen floor is still a significant investment for most poor families, which means that cheaper options should be available. Another significant disadvantage of these floors is how labor-intensive they are to create. Like those made from concrete, earthen floors require multiple steps and specialized tools, making it difficult for anyone who does not have a mason in their area to get one installed. Even if people had the tools and materials to make the floors themselves, they may not have enough time to create them, as laying an earthen floor is a fairly time-consuming process and would conflict with any jobs that they do. Earthen floors also have to be redone with oil every few years to stay durable, which adds to their price in the long run.[1] The many disadvantages of earthen floors show that while they may be a better solution than concrete floors, they still could be improved on.

Problem to be Solved

As shown previously, having dirt floors inside of family homes is a major issue, and one that doesn't currently have an ideal solution. The abundant amount of homes in third-world countries that have dirt floors are causing the homeowners an array of related diseases, some ultimately leading to death. For this issue at hand, there are several routes that could be taken in order to create a solution. For example we could create a cheaper form of cement or cheaper shoes to keep the people's feet off the dirt.

For our project, Kevin and I will approach the problem by coming up with a tile system to cover the dirt and floor the houses.

Design Objectives:

Inspired Project: Snap in Tile System http://www.snapstone.com/

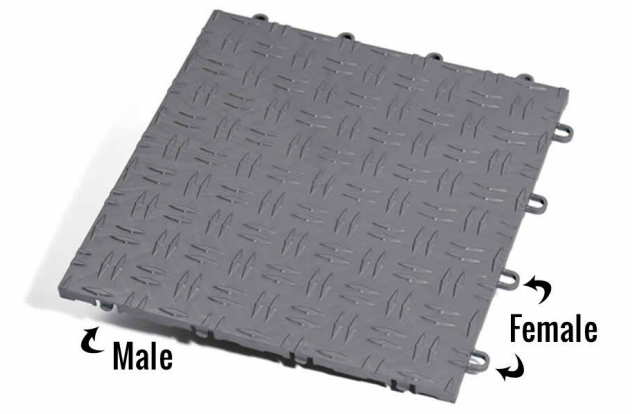
Image on the Left Below:

http://diy.sndimg.com/content/dam/images/diy/fullset/2007/2/13/0/dbtr412_1ff.jpg.rend.hgtvcom.1280.960.suffix/1420599414099.jpeg

Image on the Right Below:

http://auto-auctions.info/wp-content/uploads/2015/12/snap-together-tile-and-diamond-grid-loc-tiles-snap-together-garage-floor-tiles-29.jpg

The goal of our project is create an interlocking tile system that can go over dirt floors that is cheap, durable, and protects people from obtaining diseases that come from the dirt. One product that inspired this design is the SnapStone flooring system. SnapStone is a floating tile system that can be placed over an existing floor and locks together, without the use of grout.[10] We like SnapStone as a solution to this problem for a



couple of reasons. One reason is that it is easily replaceable. If one tile gets broken, or chipped, another can be added in its place (unlike cement). Another reason is the longevity that comes along with a tile system like this. Because of the durability and ability to have one tile at a time be replaced, the tile system will be able to last much longer than other solutions - such as cement. While it is a nice product, there are a few problems with SnapStone that make it incompatible with being an affordable floor solution. First of all, SnapStone is fairly expensive flooring solution, costing about $5 per square foot.[10] While this price may not seem extremely expensive to us, for people worldwide living in poverty, this price is far too high. Another disadvantage of the system is the fact that SnapStone tiles must be placed over an existing floor. Since our product is intended for people living on dirt floors, SnapStone would not work for our purposes.

To adapt SnapStone for use by poorer people, a number of changes need to be made to it. First, a number of steps need to be taken to reduce the cost of the product. The first of these- not selling our tiles at a profit- does not require any significant design work. SnapStone is a business, so they sell their product at a significantly higher cost than what it cost to produce. Since the aim of our project is to help people, we would just sell it to cover our costs (or it would be given through donations) to give customers the cheapest floors possible. The cost of the floors could also be reduced by changing the material that the tiles are made out of. Currently, SnapStone tiles utilize porcelain, which is fairly expensive. Instead, the entire tile could be made out of plastic, significantly reducing its price or a system can be created that any tile can be used. We

also could just make the bases of the tiles out of plastic, and allow users to insert any type of tile they want into the plastic cases, which would be cheaper than requiring the use of porcelain. Hopefully, making these changes to Snapstone would create a flooring system that is viable and affordable alternative to dirt floors for people living in poverty.

Challenges and Concerns:

One of the challenges that we will face during this process is creating a system that can work in any house, not with specific dimensions. Many of the houses that have dirt floors (mostly in third world countries) are not dimensioned in any standard way; they even may or may not have leveled walls and floors. This is going to bring up some concerns because we want our system to be effective and usable for all houses in need, no matter the shape or condition. We may be able to talk to a local flooring company to ask them for their thoughts, find out more about flooring systems as a whole, and talk about ways that we could try to solve this issue.

Another possible issue with our flooring system involves making it impervious to water. Making a tile system directly on top of the dirt that is waterproof would be very challenging, as the cracks between the tiles allow water to flow through. This transfer of water would defeat the purpose of the floors, as germs from the ground could still flow up and onto the floor. Usually, floors are grouted to make them waterproof; however, grouting is an expensive and laborious process that poorer people do not have the ability to perform. Instead, we would need to use a different method of making the tiles waterproof, possibly a sheet of plastic laid between the tiles and the ground.

One final problem that we will face is coming up with an effective design that is also very affordable. Right now, there are some solutions to the dirt floor issue, but they are very expensive for the people in poverty that need the floors. Although we are not making these floor in an attempt to make a profit, we will still need to pay for the up front cost of the materials. We can try to fundraise and gain donations in order to pay for the costs, but we ultimately want a low cost that, if necessary, the families in need can obtain them for this flooring for their houses, without spending their entire salary on it. We will have to be deliberate with our material and design decisions in an attempt to keep the costs low.

Deliverables:

- Final Product
    - Fully constructed floor that can cover at least a small area
        - Made up of tiling- either fully plastic, or partially plastic with the ability to insert user-chosen tile
        - Is secured down in some way, potentially to the wall
        - Comes with tarp to prevent water from getting through
- Testing
    - Small scale dirt floor with wood to simulate the walls of the houses.
        - Start with very small floor (only four tiles) and gradually work up to bigger ones
        - Can be used to make a realistic representation of our product- with tiles, tarp, and securing method

    - Test both all-plastic and customizable tiles to see which work better for our purpose
    - Waterproof Testing
        - Elevate floor in some way, without tarp, and see how much water can pass through
        - If it turns out that the floor can actually repel water, we will not need to use tarps, making the floors cheaper
- STEM Symposium
    - We will present our project at the WT STEM Symposium, probably with the aid of a trifold board
    - We will bring samples of tile for people to see

Progress:

Since first beginning this project, we have made a lot of progress, especially in terms of the physical product prototype. The first design consisted of a “plus” shaped contraption, having slots to hold down the tiles and an array of spikes on the bottom to keep them secured in the dirt (Images 1-4). After printing this design, we encountered several issues.

First, the pieces had too much bulk, making them inefficient, impractical, and aesthetically displeasing. We decided to slim down this same design, taking off material from all sides, while still maintaining the same overall concept.

After producing many prints, and undergoing many tests, we found that this design, although doing its job correctly and well, did not have a bright future in terms of

being the final designed prototype. We made the decision to scrap that design, and move towards our newer model.

In our new model, we wanted to minimize the material usage, compact the design, and make it overall more efficient, practical and aesthetically pleasing. Our first attempt of the design, although thorough in concept, was much too small (in terms of edge to hold the tiles, corner piece, and clasp) and was too long as we didn't take in account the middle pieces (Images 5-7).

The idea for the clasping system was to have a "T" shaped male end slide into a corresponding track. The male "T" would be on a plus-shaped mount, which would be located at the common vertex of four tiles. The long pieces were designed to fit between two tiles, overhanging both of them to keep them in place (Images 8 & 9).

While this new design had potential, it had many problems which held it back from working effectively. We found that making this system work well on a very small scale was nearly impossible. The short parts of the "T" were too small for the printer to create, so they came out as horizontal lines, leading to failure. The long pieces were also too long for the tiles we used, making the system ineffective for tiling an entire floor. Finally, the areas of plastic that overhung the tiles were too small, so the tiles weren't actually secure and could move around. Due to this failure, we began designing a newer version of the system to solve these issues.

For our new version, we widened both the long pieces and the plus-shaped pieces, hopefully giving the printer the ability to print the "T"s correctly. We also made the overhanging parts of both mounts stick out farther, which made the tiles more

secure. The lengths of the long pieces were shortened so they could actually be used with our tiles (Image 10).

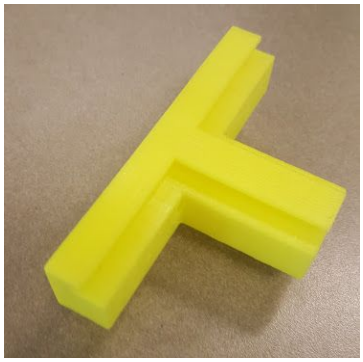
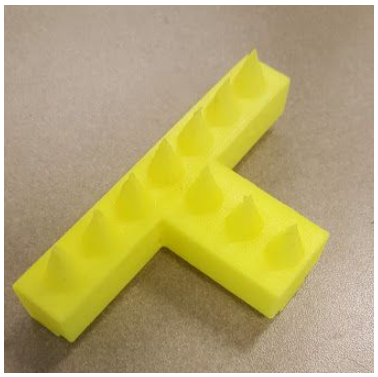
Even after making these new parts, our design had some major issues. The “T” that we had designed to help the pieces stick together was still ineffective, and they could come apart easily. To solve this problem, we realized that we had to make a more fundamental change to the design.

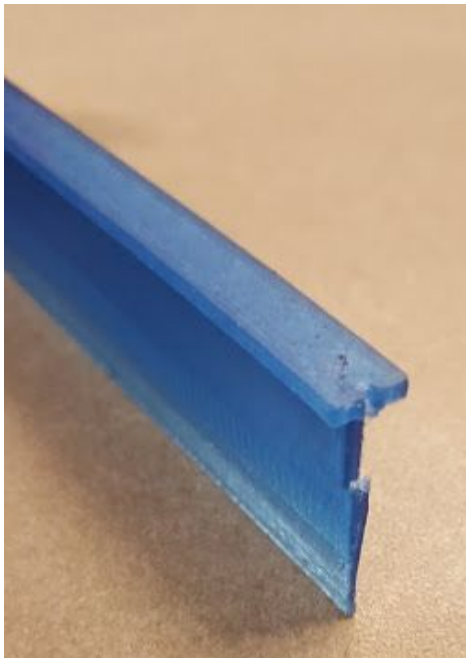
To hold the pieces of our flooring system together more strongly, we changed to a design involving large L-shaped pieces on each part of the system that were designed to lock together. Our first version of this design had the “L” pieces on the outside of both parts (Images 11 & 12).

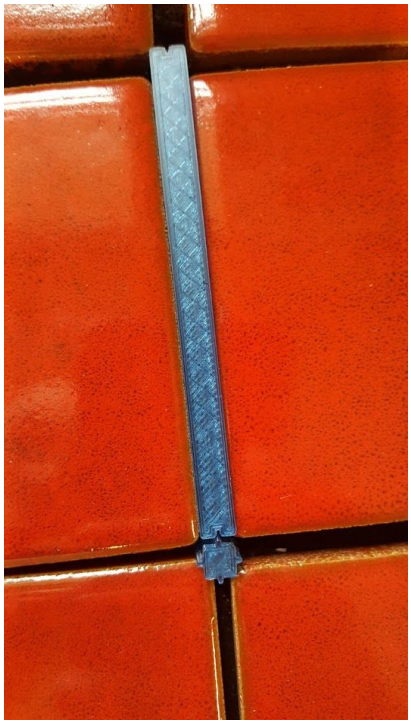
This solution created gaps between pieces of our mounting system, making it ineffective (Image 13). To fix this problem, we recessed the female “L” mounts into the bodies of the long pieces, eliminating the gap (Images 14 & 15).

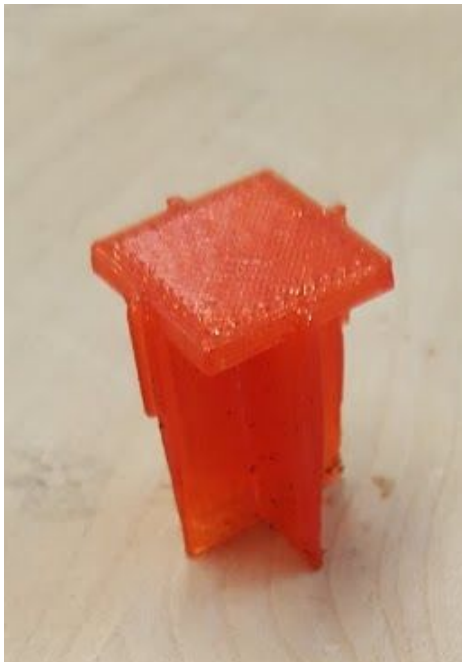
These mounts worked well, but we still had some concerns about durability. We found that the L-shaped connectors on the plus-shaped pieces had a tendency to break off. To combat this issue, we made the “L” mounts much wider, increasing their durability. We also added triangular supports to the top of the plus-shaped pieces, giving the L-shaped connectors more support (Image 17). We then added cutouts into the longer pieces to account for these supports (Image 16). With us being suffice with this current design, we will be moving into further testing to, hopefully, perfect our product (Image 18).

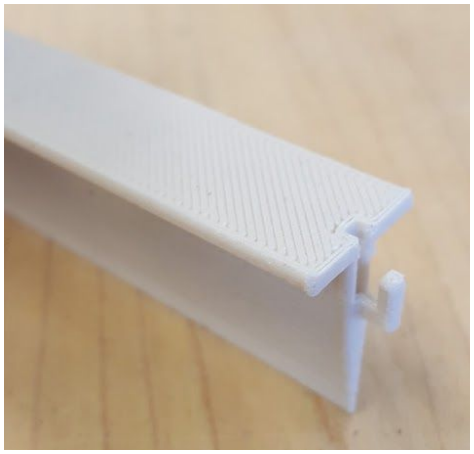
Pictures

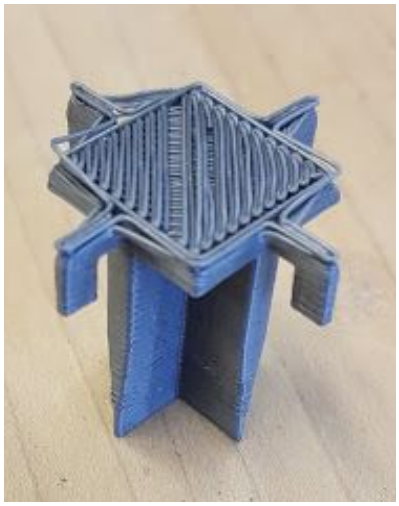
Picture Number	Picture Name	Picture
1	Original “T” Mount Top	
2	Original “T” Mount Bottom	
3	Original Plus Mount Top	

4	Original Plus Mount Bottom	
5	Thin Mount V1 (Long Piece)	

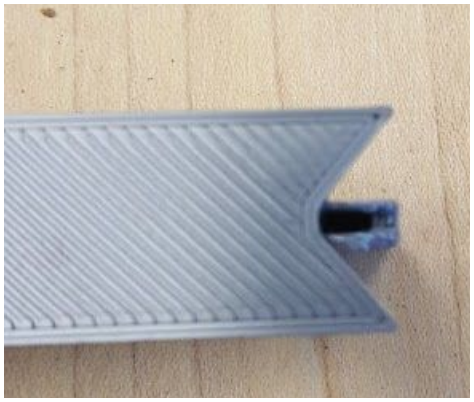
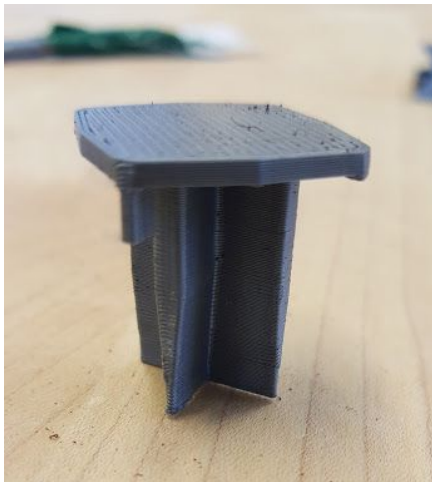
6	Thin Mount V1 (Short Piece)	
7	Thin Mount V1 (Assembly)	

8	Thin Mount V2 (Long Piece)	
9	Thin Mount V2 (Short Piece)	

10	Thin Mount V2 (Assembly)	
11	Thin Mount V3 (Long Piece)	

12	Thin Mount V3 (Short Piece)	
13	Thin Mount V3 (Assembly)	

14	Thin Mount V4 (Long Piece)	
15	Thin Mount V4 (Assembly)	

16	Thin Mount V5 (Long Piece)	
17	Thin Mount V5 (Short Piece)	

18	V6 Perfect Fitting Pieces	

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