Co-designing Community Infrastructure

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Figure 1: Entrance to the health center in Dwenase, Ghana (Photo Credit: Robert Krueger).

Putting the Community in Community Infrastructure

Development engineering is a new field that incorporates people of many disciplines, in our case engineering students and faculty along with local experts and resident community members, to work collaboratively and solve complex issues. A design is a plan for the creation of a solution (Ye, 2016), and the process of design can be defined as "the placing and patterning of any act towards a desired goal" (Papanek, 2019). In development, effective design is accomplished by embracing local culture rather than imposing one's own culture and beliefs.

The lack of effective design in development can be traced back to colonial practices from as early as the fifteenth century. Colonizing nations, who viewed indigenous practices as inferior, would travel to "underdeveloped" places such as West Africa, eradicate local knowledge, and force their values and culture on to the local people (Iweriebor, 2002). Each had their own administrative system that can be described as foreign, authoritarian, and bureaucratic to the African people (Iweriebor, 2002). As a result, most of the preexisting culture and political systems in Africa were disrupted and replaced (Mavhunga, 2017).

This failure to understand the culture resulted in a lack of faith in local knowledge and technology from both external and internal actors. Local experts with the ability to design their own solutions often rely on help from external experts, who design new solutions that fail to utilize time-tested local knowledge. Even today, many well-intended projects fail because the end users are not consulted, and, therefore, the deliverables do not fit the needs of the people they are designed to serve. For example, a project to bring solar energy capabilities to the village of Bishop Kodji in Lagos, Nigeria provided energy, but stopped working after about three months. The project was initially repaired, but over time the local maintenance workers stopped fixing the system (Okereke, 2017). Why did the solar energy project fail? When working on the project the developers did not take into consideration the number of people to be supplied with power, suitable locations for the planned solar parks, or how the power from the project should be connected to the grid. When the people of Bishop Kodji reached out to the project managers

for help, no one came to their aid (Okereke, 2017). It is obvious that the developers of these projects had good intentions, but something was missing in their design process that led to the failure of the project. Looking back on the failures in Bishop Kodji, every issue could have been foreseen if the developers had included local experts that knew the village and its people. The traditional design team includes well educated technical experts, and would never consider local knowledge to be that of experts. These developers recognize their faults. Because of this, design processes have been evolving and growing to improve upon the failures of the past. By researching these failed projects, we learned the importance of co-design in finding effective solutions. As engineers, we have designing experience, but we lack the cultural understanding and knowledge of the local residents. For this project, we combined our experience with that of the people of Dwenase. As a result, we became "facilitators in the creation of ideas, not technological experts" (Krueger, 2020).

In this role, we hope to work with the community to demonstrate how they can design their own solutions using their own expertise. By involving them in the entire process, including brainstorming potential ideas and testing prototypes, we demonstrated how an iterative co-design and co-creation process can produce appropriate solutions to complex problems. We hope this community-developed design technique will amplify what works well in the design process, so that this process can be confidently replicated. "It's not about the product. It's about breaking down barriers." (Soboyejo, 2020).

While working in an environment with which we were unfamiliar, we often encountered surprises and setbacks. For instance, we expected digging a trench to take weeks, but it was completed in one day. Conversely, we planned on receiving our gravel shipment in a matter of weeks, but it took months to arrive, and our community feedback forum was delayed for a week because of an extended power outage. However, delays can be expected with any project. The obstacles associated with human interaction were much harder to predict. For instance, we initially planned on having a dirt surface to the road, but changed this to a gravel surface after many community members mentioned they preferred the appearance. Our technical design had neglected aesthetics. We were able to fix this issue by including community feedback in the

design process, but the feedback also yielded unanticipated results. Local experts would often agree with whatever we proposed, despite the fact that they had their own good ideas, making it more difficult to utilize local technology. We hope by learning from and sharing these experiences, we can lead the way to more successful projects in the future.

The World Designs Us

Figure 2: Community members working together on the road to the Dwenase Health Center.

In the 1400s, European colonizers invaded Africa to exploit the abundance of natural resources. Along with this, they brought western European rationality which subjugated African forms of knowledge, science, and innovation. As a result, most of the preexisting African culture and political systems were disrupted. The African societies fought the European imperialists for years to maintain control, but by 1900 the majority of Africa had been colonized. Many of these European powers decided to enforce their own policies in the newly colonized areas. Much of the cultures were also lost through forced assimilation and colonials pushing their own ideology to try and "civilize" these societies (Iweriebor, 2002). The effects of this can still be seen in how modern development projects have been conceived and implemented.

Developed nations, such as the United States, were considered a model for the "future". The progression from 'traditional' society to a 'modern' society is known as modernization, and it began in Ghana in the late 1940's and early 1950's. "Imposed modernization" is the process of

forcing the so-called superior practices of western society on local cultures. However, modern views often clashed with the existing way of life and were not sustainable in the long term. This outdated attitude can be seen in development projects in Africa where engineers and designers do not include the local people in design decisions. Instead decisions were made by Europeans using methods that work for Europe, but may not apply to communities in Africa. For example, Norway's development agency attempted to bring infrastructure to one of east Africa's poorest countries, Kenya. Their project was to develop a fish freezing facility on the shores of lake Turkana, a body of water teeming with fish. They believed that building this factory would greatly increase the income of the people in the area, and more development projects would soon follow. What they didn't understand is that the people of Turkana are pastoral, they rely on their livestock for food and income. Even with a lake full of fish, in Turkana if you are a fisherman you are poor, it is seen as a last resort. Soon after its development, the facility closed. The Norwegean developers saw a problem, and gave it a very "black and white" solution. There was no thought given to whether the people of Turkana would actually adopt this new way of life and run the factory. This is one of the main problems when the traditional "western" design methods are applied to solve problems around the world.

Social design involves elements and practices that traditional design methods do not consider. It expands what is considered an expert in the design process, allowing knowledge and ideas to be critiqued by the community and the creation of a solution that is appropriate for the area. "We have to recognize the knowledges held by people that are embedded in place and as relevant as our own 'expert' knowledge."(Krueger, Telliel, & al...). Empathy and understanding are the keys to social design. Taking social design one step further, we arrive at cross-cultural co-design. The goal of this process is to learn about the culture and community you are going to work with and design the project with the people it will be for. Becoming a part of the community and working with them gives you the unique opportunity to leave behind more than just your physical project. It creates a sense of pride and ownership within the people and inspires them to create sustainable solutions to their problems with their knowledge and skills .

Keeping cross-cultural co-design in mind, we created our own design process. Our process was iterative and revolved around community collaboration. By working with the people of Dwenase, we were able to learn with them and work hand in hand to define the problem and the solution. This helped to ensure that the correct problem is solved with the best solution possible and it can be maintained. Our process began with exploring local designs, then brainstorming with local experts, building and testing prototypes, getting feedback from the community, and then back to exploring local designs until the project is complete. This process was open to change once arriving in Ghana. As we've learned, "We design the world, and the world designs us."(Escobar, 2018). The world designs us because of its material nature. We act on it in ways that are effective; this is design. While we thought we were designing with the community, the community was also designing us and reshaping our own preconceived beliefs. Living with the people and experiencing the culture has shown us what co-design really means, and we have created invaluable friendships throughout this process.

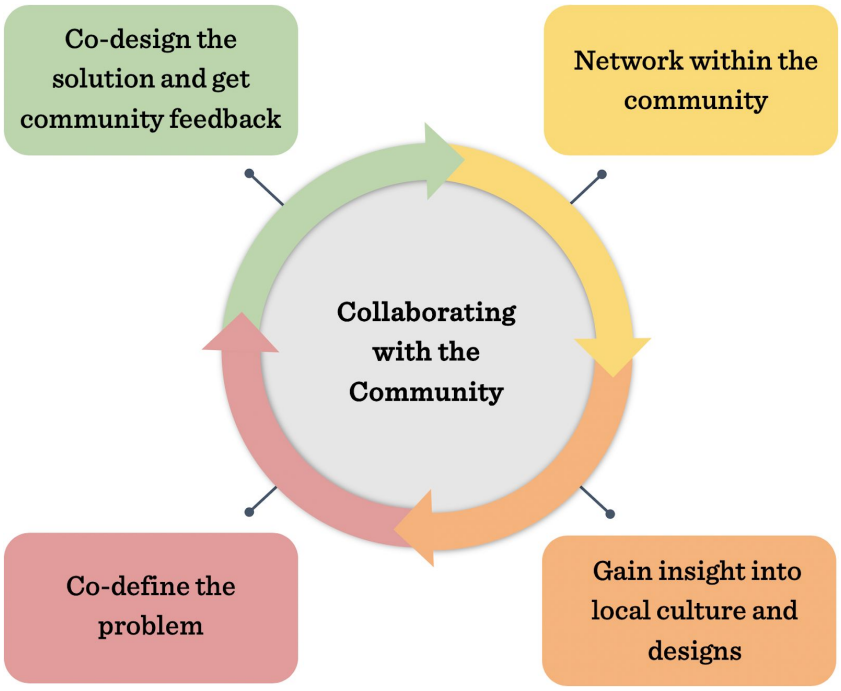

Figure 3: Graphic of our design process.

Co-define then Co-design

In the Eastern Region of Ghana there is an average of 1665 mm of rain per year, most of which comes during the rainy season which runs between April and July and then again from September to December (Kibi climate, 2019). In the town of Dwenase, this rain water floods the place in front of the local health center, which prevents car access and makes walking difficult. Once the rainy season ends, the road is filled with puddles that become ideal breeding grounds for malaria-carrying mosquitos (Opoku, Ansa-Asare & Amoako, 2009).

Figure 4: Road runoff flooding the parking lot (Photo Credit: Gloria, Director of the Health Center).

Through the course of our project we worked with the students and community of Dwenase to develop an improved drainage system around the local health center. However, before we could co-design a solution, we had to co-define the problem. Prior to arriving in Ghana, we thought the flooding was caused by a lack of slope across the parking lot. We researched drainage techniques and came to a potential “solution” for our seemingly 2D issue. Our original idea was

to re-grade the road so that water would flow out of the parking lot towards the drains. This required few materials. However, we soon found out this would not be enough.

As soon as we spoke with the health center workers, we realized the true problem was that the health center parking lot is at a lower grade than the road. Water comes into the lot from the rest of town instead of draining to the nearby river. We were not present during the rainy season, so we relied on local knowledge and experience to co-define the problem. Had we defined the problem solely based on our own knowledge, which was based on aerial views from google maps and close-up pictures of the health center lot, we would have designed a solution that did not solve the problem.

Instead, we created a design with the community to reduce flooding during the rainy season and puddles during the dry season, while still taking into account the needs and priorities of the community. We utilized both our own knowledge and the resident's expertise and communal labor days. During this community service, we saw the power of this community working together firsthand. As Gideon, one of the residents, said: "Ghanaians work with their strength; Americans work with their pockets." (Gideon, 2020).

Our interactions with the Agricultural Chief best exemplified this mindset. He asked us to mark up a trench from the front of the health center to the river, which was several hundred feet away. We were initially hesitant because this would involve moving tons of hard clay using only pickaxes and shovels, but we trusted the local knowledge and went through with the plan. By noon the next day, the community had dug a 100-foot-long section of trench. Before this, we had assumed we would need heavy machinery to accomplish something this large and therefore had limited our potential solutions. We had been designed by our experience, where public works are completed by corporations with government contracts that pay for plenty of materials and equipment. We were working with our pockets while they were working with their strength.

In addition to learning what was possible, we also learned what was necessary from our community interactions. Our preliminary designs focused mainly on accessibility. We had a

separate walking path from the road because we anticipated a lot of car traffic. We also placed the parking lot on the right side because that left more room for vehicles to park, and we intended to raise that side to slope the entire lot to the left. Our final design includes neither of these.

Figure 5: Preliminary designs.

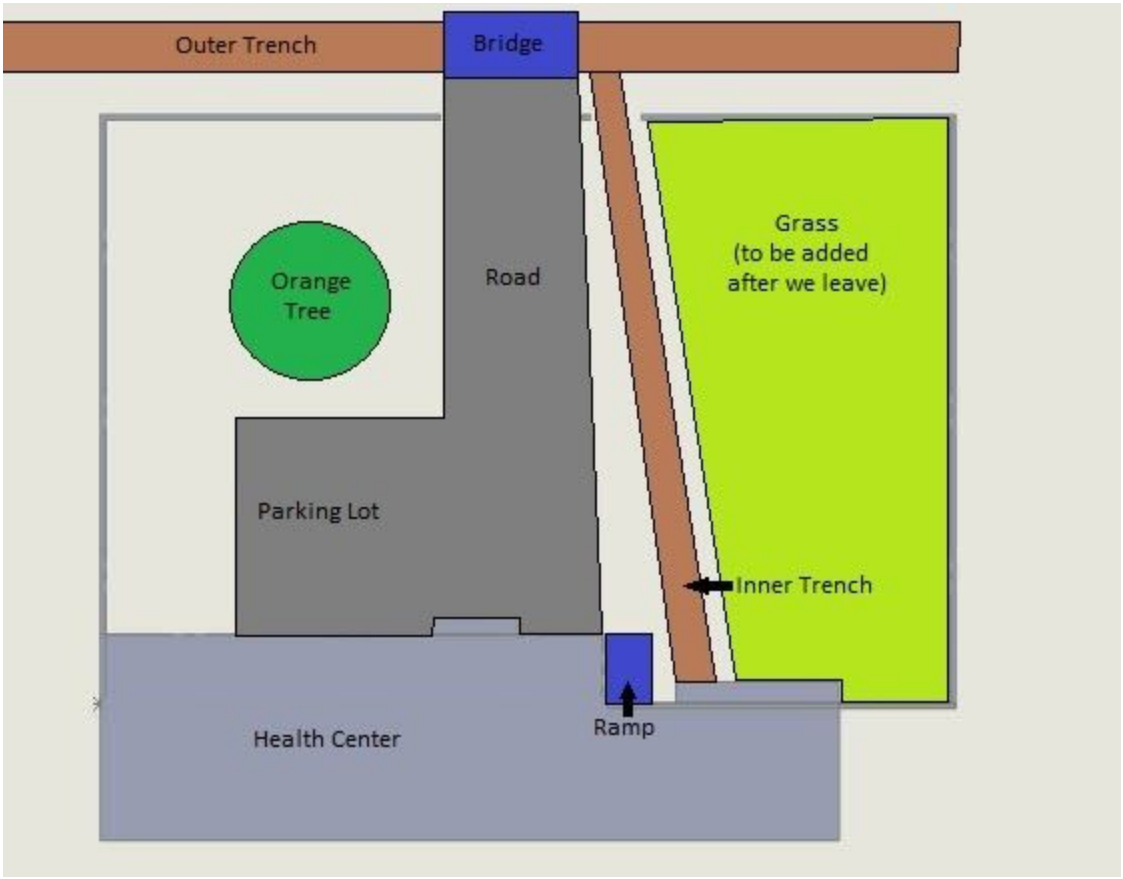

Figure 6: Final Design.

We quickly realized during our daily walks into Dwenase that owning a car is rare. Most people walk or take taxis if they need transportation, meaning that a large parking lot was not necessary. In fact, drivers often refuse to enter the health center lot during the rainy season due to flooding. During our conversations with the residents of Dwenase about their priorities regarding the health center, the majority said they would be fine walking on the road. In contrast, every person we interviewed said the water from the main road was a major problem with accessing the health center. Because of this, our final design sacrificed the walking path and large parking lot to make room for an inner trench.

Our community interactions made it obvious that we were focusing on the wrong issues. We were drawing on our experience from the United States, where many people need on-site parking, and where road works are completed with heavy machinery. By integrating ourselves into the local community, we were able to co-define the problem and utilize the local knowledge and assets. It allowed us to co-design a solution with the local residents that is both appropriate to their situation and replicable in others.

In Theory and Practice

To effectively codesign, collaborators must be willing to share experiences so there can be a free exchange of ideas. In preparation for coming to Dwenase, we primarily researched the technical aspects related to drainage designs and the theory of codesign. With the necessary background knowledge, we needed to gather firsthand accounts on the rainy season conditions. By discussing this issue openly with the community members and encouraging their involvement, our hope is that they will be receptive to us and enthusiastically collaborate with us to create a better road and parking area. We spoke individually with people around town and heard multiple times that "anything you do will help" (Community Members, 2020). Local experts can provide more specifics. The health center staff are familiar with the lack of flood control. In addition, plans to expand the health center have been delayed by several months. Low expectations for seeing changes made as well as the scope of their expertise were made clear.

For this issue of lack of drainage to be completely resolved, both the social problems and cultural impacts must be considered. The staff provided videos of the lot during the rainy season. We can see the quantity of water coming in from the street, and that the stones in front of the health center was their most successful tool to reduce standing water.

Figure 7: The existing stones and drains in front of the health center.

It seems that this has been a recurring issue but using locally sourced materials such as rocks and dirt will allow for long term maintenance. From community discussions and working with the Agricultural Chief and unemployed youth, we can conclude that water flow from the main road is a primary concern. The district engineer as well as community members provided insight into the current drainage methods. These included trench size, slope, and direction as well as the use of carpet grass. These local experts provided insight so the final design will align with the current technology. Involvement in the design process will equip these people with skills to maintain this project as well as conduct similar ones. While the macadam road and parking lot will improve flood mitigation, it is useless unless maintained.

By working with the local students, we hoped that they develop and refine skills that will aid in their future careers. During our two meetings, we created activities about measurement and used different unit systems such as feet and inches. We also explained how calculating area and volume relates to how much material is needed to fill the lot. The teachers stressed that the students had already learned basic concepts, but it was important to convey real world applications. It was challenging to engage the students in a fun way. If we had created activities for the students during our preparation and developed a relationship earlier, perhaps this would have been much more effective. Children are the future and Dwenase's future will only brighten with greater student and community involvement.

Looking Back

Figure 8: The gravel being delivered on the 16th of February, 2020

This project relied on the union of thoughts and ideas of two parties of different backgrounds. With this, inherently, comes challenges. We encountered obstacles in communication, scheduling, and obtaining materials. These challenges required changes in project deadlines and alterations to the co-design process. The initial plan was to hold a community forum, so the entire community had an opportunity to have their voice heard. Health center accessibility and safety would be discussed. Adapting to better incorporate the experiences of those more familiar with the area of work would be the most important part of our process. To draw from Geddes: “While drawing on their own extensive relevant experience, the international experts are

approaching the assignment with no preconceived ideas of what is best for the countries and are open to the opinions and needs of the local stakeholders."(Geddes, 2017).

We approached the community to start this design process. We engaged with people in an open conversation and gained some of their individual knowledge. One of our main points of contact for insight was the health center staff who would have the most first-hand experience with the issues the lot experiences in the rainy season. This provided pertinent information about the sources of the issue, what solutions have helped in the past, and what solutions have been ineffective. The community forum was rescheduled twice then cancelled after a power outage made it impossible to announce over speakers. Since the community forum was not going to be an effective method of co-design, our team went door to door asking for thoughts on how to address the health centers problem. We collected some anecdotes and ideas, but most said something along the lines of anything would be better than what is currently there. Our process of co-design changed from working with the majority of Dwenase's population to working with those with more infrastructure experience.

One of the purposes for us coming to Dwenase was to work with the students to build interest in STEM and inspire confidence in the skills they have been developing in classes. To achieve this, we aimed to meet with the kids regularly, and teach engaging lessons to show how what they have learned in the classroom can be translated to the real world. The headmaster allowed us to meet with the students once a week to do an activity relevant to their curriculum. Our assumption was that these students would be roughly 15 or 16 years old, however they were younger than anticipated. The students that worked with us were about 11 or 12 years old. This changed our plans for what we would be doing together during these meetings, as well as the amount we would fit into one meeting. Looking back, reaching out to the schoolteachers for the curriculum and typical teaching methods would have aided in creating an engaging lesson for the students.

The timeline changed from what had been originally intended to account for the physical build to be condensed into the latter half of the project duration. Multiple events played a role in this. Attempting to co-design primarily with the community as a whole rather than focusing in on the

local experts, namely the Unity Committee, was a major contributor. While arranging certain meetings it is necessary to follow up with involved parties to ensure plans have not shifted, and events are set to proceed as expected. Not doing so results in confusion and delay. The delay that affected the timeline most was the delivery of gravel. The gravel was essential in starting construction of the macadam road. It arrived during week 5; giving us a condensed timeframe to complete construction. Improved management can expedite and better this cross-cultural co-design process. However, circumstances such as delays in delivery are difficult to avoid. The best way to confront this was to prepare for the material's imminent arrival. Even with all these obstacles, with the help of both the Dwenase community and our small WPI community, the lot was ready for use by the end date of this project.

Looking Forward

Co-design involves a free exchange of ideas between partners. We thought we were co-designing with the community. However, they were co-designing us. This applied to our work and our personal lives. From the start, they had shared their culture with us and we were eager to learn. The school children loved to teach us phrases in Twi. We shared our experiences from home while simultaneously learning about theirs. We compared animals found in the United States compared to Ghana and showed pictures of the different seasons. Many of them had never heard of snow before. It was refreshing after living in Ghana for two months that something so normal to us was so foreign to them. At the end of our time in Dwenase, the community held a send-off party which involved dancing and eating the local food one last time. We could properly say goodbye. Not only did we co-create a solution to the health center drainage system, we learned about our respective cultures and made lifelong friends.

This is the first time anyone in our group has co-designed cross-culturally. By partnering with the community from the beginning, we hoped to have a positive impact on the Dwenase health center and the community overall. Before arriving in Dwenase, we met the King who spoke about Ghanaian culture stating that “In Ghana, everyone looks after one another” (Panin, 2020). We adopted this philosophy as soon as we arrived in Dwenase and it has since fostered a strong sense of community between us and the people we meet. Through the relationships we have formed, we are laying the foundation for future students to co-design with the people of Dwenase. During our visit with the King, he also outlined our overall mission to inspire hope in the community rather than the tangible deliverable. To accomplish this, we worked with local students one day a week and completed activities in order to develop and refine related skills. Our meetings built confidence so similar projects can be completed in the future. We empowered them to apply what they are learning in school to real world problems. We are leaving further recommendations for the community, as seen in the Appendix, and are confident that the

students will play a vital role in carrying them out. Experts design worlds, and the local experts in Dwenase have the power to design their own worlds.

Figure 9: Teaching local students about measurements and how to find area and volume. (Photo credit: Manasse Kabore)

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Figure 10: The new road in use.

Appendix

Future Advice

1. Finish digging the big trench out to the river on both sides of the road.

    a. Make sure it is at least 3 feet away from the telephone pole because erosion may damage the soil underneath.

    b. Slope the trench to the river to make sure the water does not pool.

2. Slope and dig out the existing trenches on the side of the health center lot. Connect them to the larger trench.

    a. Maximize the angle where the trenches will meet in order to prevent erosion and pooling.

3. Move the dirt from the sides of the road so the mud does not fall into the trench.

4. Add gravel on the remainder of the lot to promote drainage.

    a. Discourage people from parking on the dirt until it is covered in gravel to prevent rutting and the formation of dips in the soil which will cause puddles.

5. Add dirt to the left side of the lot if looking at the health center from the road. Once the dirt is added, plant carpet grass to slow the water.

6. Create a ramp to the left side of the stairs in order to improve handicapable access.

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