Paper 1 Background and Cultural Context

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1: Introduction

In partnership with local primary school teachers, we will co-design Ghanaian Teaching and Learning Materials to enhance the educational experience of students in Akyem Dwenase. The final products will be sustainable because the designs will make use of locally available resources. Teaching and Learning Materials (TLMs) are standard tools used for primary school education throughout Ghana. In Akyem Dwenase, a rural community in the Eastern Region of Ghana, there are not enough TLMs to adequately supply the teachers and primary school students. The teachers have expressed the need for these materials. Providing TLMs to primary schools will help create a strong foundation and improve the quality of education for the students.

There are many challenges that arise when working in an unfamiliar culture and location. We will be designing TLMs to supplement existing lesson plans and curriculum. All of our designs must be able to work with current teaching methods. Another major challenge will be the physical construction of the TLMs in Dwenase. The key to co-designing useful TLMs will be observing the responses of the teachers and students to our prototypes. The teachers will be able to provide better insight on the proposed TLMs than we could assess in our time there. We want to put a lot of emphasis on working with the teachers in Dwenase while in Ghana. The group will first begin designing TLMs by focusing on activity based design methods, as well as referencing the general curriculum guides available through Ghana's National Council for Curriculum & Assessment.

2: Cultural Context

In order to design relevant and long lasting TLMs, we need to look into various design practices and put them in context of Ghanaian culture, history, and educational goals. We will make the TLMs are useful to teachers and students by ensuring that the tools align with the policies and principles of Ghanaian government and education. We will also look into case studies and various foreign aid programs that have already been employed. This background will allow us to learn from the successes and failures of various development projects and efforts in Ghana.

2.1: Governmental Goals

Providing a quality education for all students is a major goal of the Ghanaian government. Support of this effort can be seen through the allocation of the annual budget. In 2017, about 20% of Ghana's total budget went towards education, which is a significantly higher percentage than most western countries (Roser, 2017).



Figure 1: Percentage of Ghanain education funds

In addition to spending a significant portion of the budget on the education system, the current President, Akufo-Addo, aims to create free education for all students from preschool to high school (Akufo-Addo, 2019b). He has also expressed the need for Ghana to end any dependency on foreign aid in order to build a country that can sustain itself using their own resources (Akufo-Addo, 2019a). Understanding how the Ghanaian government allocates money to its education system allows us to examine why there is a lack of TLMs in Dwenase.

Throughout the 2000s, most of the educational reform in Ghana had been focused on the northern regions. However, there exist schools in all regions of Ghana that are in need of educational reform. Most issues arise from a lack of funding. For example, 15% of Eastern school districts have sub-par Per Child Expenditures (PCEs). PCEs describe the amount of money that schools spend on each individual child. Part of the reason that many school districts are struggling is because the Ministry of Education (MoE) only provides funding for teacher's

salaries, construction of new schools, and some textbooks. All other resources are expected to be paid for by the parents. In areas of high poverty, parents cannot afford these costs, causing students to lack access to learning materials. This diminishes the quality of the students' education (World Bank, 2010). Due to underfunding of rural schools, such as the one in Dwenase, we must also keep the cost of the TLMs low to allow the school to afford them without becoming dependent on outside resources. Having a good conception of governmental goals is important when crafting tools for education. However, it is also imperative that one considers the cultural context, specifically the culture and lifestyle of the local community.

2.2: Historical Development

Throughout our project, we must immerse ourselves culture and lifestyle of the local community. We need to critically consider how we design our project with the local community without imposing Western ideals. The United States has imposed Western ideals on many other countries through development projects in the past and it has failed many times. One such failure happened when the United States attempted to 'modernize' the Philippines by teaching them the U.S. form of democratic government. The modernization attempt failed due to the cultural differences between the two nations. Latham explains, "in the first elections for a Philippine assembly in 1907, the franchise was so sharply limited by literacy and tax requirements that only 3 percent of the population was able to vote" (Latham, 2011, p. 15). This prevents the majority of the population from having a chance to voice their opinion and undermines the entire idea of what the U.S was imposing in the first place. This shows us how we must listen to the people of Dwenase when co-designing the TLMs.

It is also important to learn about the culture of the people we are working with. It is imperative that we do this to gain respect for a different culture, as it will aid our ability to work towards a common goal. Before we even begin creating these materials, we need to consider the types of lessons and content of the lessons in which these materials are used. We must work closely with the school teachers, as well as the students, to find solutions that will work sustainably.

3: Design Process

Our project group is not the first to provide aid to communities in Africa. Thus, it is important that we investigate older projects and learn from their failures and successes. These projects are always done under the guise of good intentions, but are often met with unintended consequences. Problems tend to arise from a lack of understanding of local culture, along with ignorance from those enacting the projects. We will create a development process that will focus on understanding and working with the local community to mitigate negative outcomes. We will focus on human centered co-design with the community in Dwenase to ensure that our influence will leave a lasting and locally sustainable impact.

3.1: Problem Definition

In order to create teaching and learning materials that will be relevant to the community, we first need to understand the correct problem. Not fully understanding the problem can lead to solutions that do not provide proper aid, or cause further complications. For example, the PlayPump was a development project that found a solution before properly defining the problem for each location that it was installed in. The concept of the PlayPump is simple: merry-go-rounds that pump water for the community as children play with it. After a few PlayPumps were installed in some initial locations, the device was presented and marketed as a success. This caused many people, including celebrities, to send monetary aid to implement the project across multiple countries within Africa. This project seemed prosperous until many of the pumps stopped working. Slowly, the communities where these pumps had been installed stopped using them. This was due to a wide variety of issues; children would become disinterested in the device, no one was able to service the pump, and the water would suddenly stop. In the article, The PlayPump: What Went Wrong?, Stellar states that "I would contend that in many cases, the problem with PlayPump is that it was addressing the wrong problem" (Stellar, 2019). The creator of the PlayPump should have been asking the communities why they didn't have water, and what barriers they faced when obtaining water. Additionally, the designers of the PlayPump did not consider what would happen if they placed the device in an entirely different community. We are

combatting the issues that are presented by the PlayPump by using the concepts of human centered design and co-design.

To achieve our human centered design goals, we will employ the double diamond model of design described by Norman in his book, *The Design of Everyday Things*. As seen in Figure 2, Norman's method consists of a two-step process. The first 'diamond' examines a general problem statement with additional research and questions that widen the perspective on a problem, which will produce the correct problem. The second 'diamond' uses the same method to create numerous solutions and prototypes to help produce the best possible solution. The PlayPump realized the right problem for its original location through research and insights, but failed to deliver a solution that worked for other communities. The solution was generalized in an attempt to sell the product across several countries in Africa. Learning from the PlayPump, we will co-design TLMs to address the specific issues that the community faces. We will be ensuring that our methods are highly human centered using the double diamond model of design. This method makes us consider all possible solutions and problems, which will allow us to be informed when working with Dwenase (Norman, 2013).



Double Diamond DESIGN PROCESS

Figure 2: Double diamond model of design

3.2: Unintended Consequences

Although we will be rigorously working to understand the community in Dwenase, there are always unintended consequences that arise when working on a project. A great example of unintended consequences is the Tanzania water project. The result of the project was bringing the people of Tanzania a sustainable water source. However, many young girls in Tanzania were no longer able to get an education because of the long distances needed to get clean water for their families. Additionally, this project created many open water sources that allowed for mosquito growth and led to the introduction of new diseases. In general, foreign designers are often not able to foresee environmental or lifestyle consequences that come out of a project. One small or big change can cause a ripple effect that reaches an entire population. That is why working directly with local communities is paramount. However, the nature of unforeseen consequences is that they are unpredictable. Thus, we must first work alongside the community to prevent any issues that arise during the project (Murphy, 2014).

Predicting issues that may arise when designing the teaching and learning materials will allow us to be proactive. One possible issue is that the TLMs designed will not work with the students learning styles and will not aid in a better understanding of the material. Another foreseeable issue is the loss of TLMs. Many students are already losing materials like pencils that are harder to find in the rural community. Afterwards, the students get reprimanded by their parents. If our materials are easy to recreate and inexpensive, we will be able to ease the burden of losing materials. By tackling the known consequences, we will be able to alleviate some of the unpredictable ones and have a better foundation for dealing with them as they arise.

The failure of the Playpump and the Tanzania water project was due to a lack of communication with local authorities and communities, as well as a misunderstanding of the core problem. They were only solving a side effect of a problem and inadvertently created more issues for the people living in these countries. One example of a group that does a good job of understanding and listening to consumers is IDEO, a design contractor famous for their creativity. To showcase this

creativity, they took on the challenge to redesign the shopping cart. First, in order to understand all the uses and current problems of the shopping cart, the team broke off to talk to a multitude of "shopping cart experts" defined by people who worked at grocery stores, and people who used the shopping carts. Second, the group had brainstorming sessions that produced many seemingly crazy ideas. Finally, the group was broken into teams and each team had to create their own practical prototypes (IDEO Shopping Cart, 20019). This is a good example of human centered design because it used input from shopping cart experts and did not deflect any ideas until the prototyping phase. We will be employing a very similar process in Dwenase. We will also work with the teachers and make sure we have a continuous feedback loop throughout the entire project.

3.3: Activity Centered Design

Before our time in Dwenase, we will utilize activity based design. Activity based design looks at common activities and questions, and how and why these activities are done. Our 'activity' is the general curriculum taught in primary schools. We are making assumptions based on the Ghanaian Primary School lesson plan and creating designs on subjects that the lesson plan puts high emphasis on. This will allow us to create meaningful designs before coming to the community. It is important that we keep in mind once was get to Dwenase, we might find very different methods of teaching, which we will have to adapt to.

3.4: Human Centered Design

Understanding the shortcomings of past design projects is only part of a comprehensive design process. That is why we will be using human centered design once we arrive in Dwenase. The method allows us to keep our designs in alignment with desires, needs, and capabilities of those who will be using the design. To ensure this will happen, we will use the iterative design process, along with the concept of the double diamond model of design. The iterative process is built on the four principles of observation, ideation, prototyping, and testing. When completed in repeated succession, this can bring about a high level of interaction between designers and users (Norman, 2013).



Figure 3: The iterative design process

Observation is built on the principle of applied ethnography. Ethnography is the study of people in their natural environments to account for the local culture. Don Norman states "Don't take a shortcut and stay home... what you'll learn is seldom an accurate reflection of the target population or of the ways in which the proposed product will actually be used." (Norman, 2013). This is one of the reasons why we will be traveling to Ghana and working with the teachers in Dwenase directly before creating TLMs. In many past development projects brought to Africa, the solution is merely an imported product that doesn't take into account local culture or engage the local community in the problem definition. This is important to our project because we will be working in an environment that is unfamiliar to us. In order to understand the needs and desires of the teachers and classroom, we must make direct observations. We will be doing this by visiting the classroom and observing the teacher and student dynamics, as well as analyzing the TLMs they currently use and how they use them. We will also be conversing with teachers and asking questions about their needs for creating the optimal learning experience. Also, we need to consider that it is the students who benefit most from the use of TLMs. Thus, we will also be observing and interacting with students outside the classroom environment.

Ideation is the second step in the iterative design process. Using the double diamond model of design, we will be creating a problem definition along with the teachers in Dwenase. This allows us to engage the community in defining their own needs and desires. Then, we will move onto possible solutions where we will keep all design options open by generating numerous ideas

without setting creative constraints. We will be using the knowledge gained from observing the classroom and talking with teachers to create designs based on gaps in curriculum. First, we will create concepts alongside teachers and then put these concepts into drawings. Once we have started the brainstorming process, we will present our TLM drafts. As stated earlier, having a wide variety of TLM drafts will allow us to better understand our problems and find the proper solution.

The next steps we will enact will be prototyping and testing. Prototyping will include both modeling our designs on our own or working with local artisans to build these designs. We will want to create multiple prototypes for each TLM. By having multiple types of each TLM, we will be able to test these inside the classroom and observe which prototypes work best with the teachers and students. We want the testing phase to be as natural as possible, so we will be testing TLMs with our team in the classroom. In addition to this, teachers will use the TLMs without our team in the classroom. It is crucial that teachers must be able to use the TLMs once we have left Dwenase. Therefore, it is important we get feedback from them when the TLMs are used in the setting most similar to a usual classroom environment.

The iterative process described above is highly human centered because it incorporates direct feedback from the community and culture where the designs will be applied. However, while we are not in Dwenase, it is considerably harder to make direct observations and gain feedback. Until we are in Ghana, we will be using activity centered design. This type of design has also been described by Don Norman to be best used for when direct observation is impossible. He argues that this happens most often when the design is for a very broad activity, such as driving a car. The direct observation of every culture and society that has cars would be impossible (Norman, 2013). In our case, we cannot currently observe the culture of classrooms in Dwenase, but we are able to view resources and lesson plans that are often used in Ghanaian primary schools (NaCCA, 2019). We will create materials that complement these lesson plans as our draft concepts.

4: Conclusion

Based on our research, we've developed multiple potential design drafts that we could modify and co-design with primary school teachers in Dwenase. Currently, these designs are created based on only activity-centered design. However, we plan to make them human centered design-oriented when we are able to work more closely and communicate with the teachers of Dwenase.

Creating TLMs alongside the teachers in Dwenase means we must work with another community that is not familiar to us and provides many cultural differences and communication barriers. In Ghana, we will be working with the community and modify our TLMs alongside the teachers to focus more on human centered design. We are focusing on the basic skills that primary school students need. By keeping in mind all the background and contextual research, as well as the failures and successes of past development projects, we are creating a path for a successful co-design project with the primary school teacher in Dwenase.

Paper 2 Technical Considerations

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1: Introduction

It is crucial to have access to education along with quality learning supplies when forming a foundation for children around the world. A major goal of the Ghanaian Government and the town of Dwenase, a rural community in Ghana, is education. Although the Ghanaian government spends a high percentage of their budget on education, the World Bank tells us that 15% of the Eastern Primary School Districts do not have proper funding (World Bank, 2010). Lack of educational funding is a major issue in the community of Dwenase. This is especially evident in the lack of classroom supplies available to the teachers and students. Teachers are originally trained to use specific Teaching and Learning Materials (TLMs) for their classrooms, but once they arrive in rural communities these materials are not available. Our team, in partnership with primary school teachers, will be co-designing Teaching and Learning Materials to enhance the educational experience of the students in Dwenase. The TLMs produced will be created with locally available resources to ensure they are sustainable.

2: Technical Design

While the TLMs need to have a meaningful impact on students, it is also important to design tools that will work for an extended period. These materials will also need to be very cheap and easy to create so that the community can sustain these materials for continual use. In an attempt to encompass the general concept of well crafted and long-lasting designs, we will lay out some of the major design considerations

2.1: Local Materials

Our area of focus will be in a rural village in the Eastern Region of Ghana. Most of the available resources are building or repurposed materials. Most likely there will be a lot of wood, such as Teak and Mahogany, scrap metal, and cloth. On a smaller scale, it may be possible to utilize animal hides, string or floss, markers, and beads. There is also an abundance of repurposed materials such as bottle caps from plastic water bottles, old plastic bottles, and other packaging supplies. The majority of TLM assembly will be done using nails but there will also be small

quantities of Elmer's glue or tape. We will also be able to ask local artisans to aid us in creating these materials.

Due to the abundance of wood in Dwenase, most of the TLMs will either be fully or partially created out of wood. One of the biggest considerations when dealing with wood is that it is a natural material and has grain, or pattern of wood growth. Depending on the type of wood our designs will need to adapt to the gain to avoid splintering. Different techniques need to be utilized when working with wood (CDMG, n.d.). For example, when attaching two pieces with screws, the holes will need to be pre-drilled to make sure that the wood remains flat. Other techniques will be commonly used by the local artisans. The group will need to stay in contact with artisans and have them aid our designs to make sure they are feasible. They may also be able to help us ensure that these designs durable.

2.1: Low-Level Design Considerations

In Dwenase, the same level of precision that can be achieved with automated machine tools will not be possible as most things are handcrafted. For this reason, our designs should avoid having tight fits, and instead take advantage of clearance sizes and tolerances. A clearance size, or tolerance, is a size that measures slightly larger than the necessary size. Having a tolerance allows for some level of error when constructing a product. Depending on the accuracy of the equipment being used and the level of expertise of the person making the product, the amount of clearance needed will vary. There are some standards given to suggest the amount of clearance that should be used. We will be adding about a 10% tolerance to all of our TLM plans when building to ensure that all the pieces will fit together even if they are not cut or formed perfectly (Sigmetrix, 2017).

When possible, we should avoid constructing right corners, which are undesirable because they cause a weak spot. The area at the corner receives a lot of pressure from both sides, and is more likely to snap. Since the TLMs will be going through continual use, having an unstable design will not allow the tool to last long (Hudak, n.d.). To avoid this, we will be creating fillets and

chamfers. Fillets are rounded corners, while chamfers are a symmetrical sloping edges that can be used to replace a right corner. These are two of the most common ways that designers avoid right corners. The one that we choose will depend on the particular designs. When using wood, fillets are typically created by sanding down the corners to produce the curve. Chamfers can be produced by simply cutting out the desired shape.

2.2: Measurement System

The metric system is used in Ghana. To ensure that the TLM designs can be easily made by local artisans, we will need to make sure that we use the metric system, instead of the imperial system (The New York Times, 1975).

3: Safety Standards

When building TLMs, a major consideration is safety. We will be following various international toy safety standards to ensure all of the TLMs are appropriate and can be used by students without the possibility of endangerment.

3.1: Physical Safety

All children's toys must be visibly clean. This is especially important for our group's considerations, as we will be using a lot of refurbished materials such as bottle caps, or old containers. There should be no small toys or easily detachable objects if the TLMs will be used by children under the age of 3. All toys, and TLMs, must be free or any sharp edges or objects. This includes ensuring that all of our wooden pieces are smoothed or finished in such a way that children cannot get any splinters. This also must include ensuring that if there are any metal pieces, screws, or bolts, they must not be exposed. If they must be slightly exposed, edges and points are smoothed out to be rid of sharp edges and burs. Screws and bolts are recommended to be finished with domed or hemispherical ends to protect children, as seen in Figure 1. Since there is the possibility of using string or leather, the materials will need to be strung tight enough not to tangle a child or snap and hurt a child (Standard Consumer Safety Specification for Toy Safety, 2017).



Domed ends, with and without small flat in the center

Figure 1: Prefered ends for screws and bolts

3.2: Use and Abuse Testing

Each TLM created is intended to be long-lasting. Thus, they must withstand continual use by teachers and students over the course of many uses per-day for as long as possible. Knowing this, we will perform simple use and abuse tests. We are mostly working with primary school students, so we will focus on the oldest age group described in Table 1 (Smith, 2002).

Table 1: Use and abuse test by age group

	Impact	Flexure	Torque	Tension	Compression
18 Months of Age or Less (16 CFR § 1500.51)	10 drops from 4.5 ft ± 0.5 in	120° Arc 30 Cycles 10 lb ± 0.5 lb	2 lbf-in ± 0.2 lbf-in	10 lb ± 0.5 lb	20 lb ± 0.5 lb
Over 18 but Not Over 36 Months of Age (16 CFR § 1500.52)	4 drops from 3 ft ± 0.5 in	120° Arc 30 Cycles 15 lb ± 0.5 lb	3 lbf-in ± 0.2 lbf-in	15 lb ± 0.5 lb	25 lb ± 0.5 lb
Over 36 but Not Over 96 Months of Age (16 CFR § 1500.53)	4 drops from 3 ft ± 0.5 in	120° Arc 30 Cycles 15 lb ± 0.5 lb	4 lbf-in ± 0.2 lbf-in	15 lb ± 0.5 lb	30 lb ± 0.5 lb

3.3: Age Appropriateness

Since we are working with the primary school, we expect a range of ages. The TLMs must be topical and helpful for multiple grade levels and across multiple subjects. To achieve this, we need to ensure that the TLMs created are appropriate based on the ages of the students. This can be done with multiple methods such as observing student interactions with the TLMs, teacher and parental feedback, basing the classification on the physical size, and constraints of students using these materials (Standard Consumer Safety Specification for Toy Safety, 2017).

4: Structured Interviews

It is very difficult to learn information without talking to people who are experts in their subjects. That is why it is important to perform interviews with the teachers or community members of Dwenase. Specifically, we will be conducting structured interviews. A structured interview consists of asking the same questions in the same order for every person interviewed. We must consider who we are interviewing before we start coming up with questions. We must employ different questions and tactics based on who we are collaborating with. The questions themselves must be appropriate for the people we are interviewing.

First, we must create questions specifically for teachers. Since there is no literature on how to conduct interviews with teachers from Ghana we can adapt guidelines from general teacher interviews. However, we are aware that they may need to be modified as we get feedback and begin to run interviews in Ghana. It is important to prepare ourselves and learn about who we are interviewing before we conduct the interview. Second, the questions must be made respectful and engaging. It is of great importance that we abide by Ghanaian cultural values and practices to show respect. Lastly, we need to follow up on our interviews. People can change their minds or new things come up as they process what was asked during an interview on their own time. Our interviews should have multiple points of communication so we can continue learning from the teachers we are collaborating with and gain a strong relationship (Tooms, 2004). We have developed some initial questions for teachers. However, we are aware that these questions are

subject to change before using them in Ghana because we have not met the teachers yet. These initial questions are:

- Where did you receive training to become a teacher?
- What are some key differences between the training you received and the style of teaching you currently have?
- What is the largest difficulty you have with teaching in a rural area?
- How long have you been a teacher in Dwenase?
 - If you've been teaching in this area for a long time, what were some of the best classes that you've had, and why do you think they were successful?
 What are some of the worst classes you've had, and why do you think they were not as successful as others?
 - If you've been teaching in this area for a short time, what do you hope to focus on, in terms of your teaching style?
- Currently, how strictly do you follow the curriculum that you were trained to teach?
- After co-developing these TLMs for Dwenase primary school education, how strictly do you plan on following the curriculum that you were trained to teach?
- How much do you struggle with keeping the student's attention?
- What have you done in the past to keep the attention of students? What techniques have worked, and which ones have failed?
- What are some of your student's most common interests?

In the later weeks of our project, we will also be interviewing young students. These interviews will be broad and will only focus on the students' reactions to new TLMs while we test different designs. Based on the information we heard during our preparatory course, the kids will treat us as a 'box of kittens', meaning that these interviews will be harder to conduct. There are a few tactics we can try to employ to make this process easier. The first of these is to make the interview engaging. Children generally have shorter attention spans. Grabbing their attention

early during the interview will make it easier to gain information. We can do this by playing simple games or asking questions of personal interest to grab their attention. We must also watch out for students changing their perceptions to please us. If we give them a prototype of a TLM, we don't want to skew their opinions based on our presence. A way to work around this is to have the teachers perform some basic interviews with only a few questions when our group is not there. Another important aspect of interviewing young students is to ask them open-ended questions. It is easier for a child to express themselves when the question allows for interpretation, and the child can provide any response (Vasquez, 2000).

5: Understanding How To Make An Idea Stick

Another important technical consideration is the study of learning. To develop effective TLMs, we must understand how people learn, and what makes concepts stick inside someone's mind. In Malcolm Gladwell's *The Tipping Point*, the author discusses what makes some ideas favored in comparison to other ideas that are both trying to achieve the same goal. An example that resonates with our project is the popularity of the following children's TV shows: *Sesame Street* and *Blues Clues*. Gladwell discusses how these shows wildly succeeded because they used certain techniques that made children want to learn. We can use these techniques and apply them to our TLMs (Gladwell, 2014).

5.1: Mutual Exclusivity

For example, we must consider the principle of mutual exclusivity. "This means that small children have difficulty believing that any one object can have two different names" (Gladwell, 2014, p. 115). One of the few episodes of *Sesame Street* that failed was when the writers gave Big Bird a new name, "Roy". This confused the children because they had to assign another label to Big Bird, which complicated their understanding of the information that *Sesame Street* was trying to teach them. We can use the principle of mutual exclusivity in our project by making our TLMs very specific. Each physical TLM that we design should have one purpose. For example, one TLM should not be used to teach multiplication and fractions.

5.2: The James Earl Jones Effect

Also, we must be aware of the James Earl Jones effect. Essentially, this is just learning through repetition. *Blues Clues* was a success because Nickelodeon ran the same episode five days in a row for a week, and then moved onto a new episode in the following week (Gladwell, 2014, p. 125). When co-designing our TLMs, we must consider that repetition is an integral part of the learning process. Therefore, students will most likely use the TLMs over and over again. The design must be able to retain constant use.

5.3: The Stickiness Factor

There are many considerations when contemplating how to make an idea stick in someone's head. Gladwell brings up several other techniques in his book, such as temporal narratives, audience engagement, etc. Essentially, "the lesson of stickiness is the same. There is a simple way to package information that, under the right circumstances, can make it irresistible. All you have to do is find it" (Gladwell, 2014, p. 132). We just need to find a way to co-design TLMs that will make basic primary school concepts stick in the heads of the students.

6: Potential TLM Designs

Based on our analysis of the Teacher Resource Pack, we have laid out multiple designs that can be incorporated into the curriculum. These designs are specifically created to be easy to put together and use minimal amounts of materials. The goal of each design is to be assembled alongside the students in Dwenase. Our current set of tools deals with the concept of numeracy, which is taught in all of the primary school grades.

6.1: Abacus

The first design is an abacus. Abacuses have been used to teach math for thousands of years. With this design, we are hoping to aid teachers when teaching addition and subtraction. The abacus can be constructed with a simple wooden frame. The dowels can be constructed from wood. However, they can also be strung with thick string or leather. To represent numbers, we will use traditional beads. Many artisans create and sell beads in Ghana, as it is a staple of their local culture. The exact beads can be chosen by the students to form a greater connection with their materials.



Design 1: Abacus

6.2: Multiplication Tool

Our second design is a multiplication block. The block will be constructed on a wooden base with slots drilled into it for placing bottle caps. These blocks can be carved by local artisans and the bottle caps will be collected by the group. The block will contain a total of 144 slots with 12 on each side. A student can place the two numbers they want to multiply on each side, and fill in the square they create. By counting the total bottle caps, the students can visualize multiplication. By the end of their primary school education, students are expected to know multiplication up to 12x12, and this board accounts for these guidelines.



Design 2: Multiplication Tool

6.3: Kente Cloth Fractions

A third TLM is a fraction tool. It will utilize pieces of Kente cloth on top of wooden blocks that can be slotted together. Kente cloth comes in a variety of different patterns and is locally made. We will use different patterns to represent fractions. Each pattern will symbolize one whole and we will make varying amounts of blocks for each pattern. By using a local cloth they are all familiar with, it will incorporate their own culture into their understanding of math.



Design 3: Kente Fractions

6.4: Measuring Cups

Our final numeracy tool is a set of measuring cups. The cups will be made out of old clear container bottles that will be cut to represent different metric sizes. The containers can be made from old plastic water bottles or jugs. Each cup will be sanitized and the edges of these plastic bottles will be melted using a lighter to rid the tools of any sharp edges. By pouring water into these cups, students will be able to visual more complicated addition, subtraction, and fractional concepts.

Paper 3 Ethnography and Methodology

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1: Introduction

Ethnography is the study of research and development from the perspective of a philosopher. This is an important concept to consider when working with a new community to achieve a common goal. The goal of our project is to work in partnership with local primary school teachers to co-design Ghanaian Teaching and Learning Materials (TLMs). This will help enhance the educational experience of the students in Akyem Dwenase. The TLMs will be sustainable because the designs will be based on locally available resources.

2: Analysis of Ethnography

It is important to bring ethnography into design because the central concepts that define ethnography shape the purpose of design. In *On Ethnography*, the author states that research design "is best understood not as practical planning, but as a theoretical and epistemological thought-process which gradually transforms a vague idea into an actual sociological problem" (Williams, 2018). It is important to understand the underlying impact that research has on the actual project. A complete problem is formed from the various issues that are affecting the community that is studied. In our project, we are studying and working with the community in Dwenase. It is imperative that we recognize the biases we carry into the project and our assumptions that we bring to Ghana.

When practicing ethnography, it is important to understand the difference between induction and deduction, and incorporate both methods into our research design. Induction is the process of finding empirical data to form a general theory about a topic. Deduction begins with a general idea, and uses empirical data to prove a theory that was already formed. It is important to use both of these concepts in our research because "ethnographic research design is flexible, open-ended; it overspills onto the data-collection as well as data-analysis phases" (Williams, 2018). This type of design is exploratory because the biases of the researcher, as well as the content researched, both play a factor in the result of the data. Therefore, induction is needed to gather empirical data, but deduction is an integral part of ethnographic research. There will always be a slight bias in every piece of data that is collected.

2.1: Data Collection

The type of data that we collect will most likely be in the form of interviews. We will conduct structured interviews, in which we will ask questions that we have already developed. We will also conduct unstructured interviews, which will consist of connecting and understanding the community, inside and outside of the classrooms that we are impacting. When we are conducting interviews, it is imperative that we understand "the interview is literally an *interview* or exchange of views between two people, not a one-way conversation" (Mannik McGarry,2017 pg. 72). We are trying to understand a culture that we have never experienced before. "As a competent researcher, you obviously need to be paying attention to what people are saying, but you also must consider how they say it (which is often more important), their facial expression, body language, physical movements, and any other sensory information related to the interview" (Mannik McGarry,2017 pg. 77). It is important to pick up on signals that are not expressed through verbal language. We must consider how people react when we interview them, and base our future actions and questions off of those reactions.

3: Ethnography and the Design Process

The actual work we do in Dwenase will follow a design process that focuses heavily on human centered design. This must be done conjointly with the ethnographic approach described earlier, which allows us to recognize the biases around the questions we ask, as well as what the collected empirical data truly means. During our time in Dwenase, we will be completing certain tasks each week that follow the general guidelines of an iterative and human centered design.

However, the first step to creating the TLMs takes on a different, more activity centered approach. Due to various constraints, our group is unable to have the level of observation necessary to fully implement human centered design and utilize ethnography. Thus, we have been using the Teacher Resource Pack directly from the Ghanaian National Council for Curriculum and Assessment. This document has helped us identify activities that will best be aided by physical learning tools. For example, we will be focusing on math concepts, such as numeracy, which is consistently taught throughout all grades in primary school. These TLMs have been sketched out or created using a computer aided design to be brought to Ghana and presented as possible solutions. However, once we arrive in Ghana we will conduct structured and unstructured interviews with teachers. This will allow us to get more information during observation when we are on location, but still have an understanding of possible TLMs before our arrival.

4: Logistic Schedule

Once we arrive in Ghana, we will switch our methodology to human centered design. It is important to note that all of our weeks will include continual use of the iterative cycle. We will try to focus on one part of the cycle at a time to guide our work. However, we will create a specific list of tasks each week to guide the project towards its completion.

4.1: Preparation

In the fall of 2019, we studied the cultural background of Ghana. We were able to get a copy of the standards for primary school education and determined what specific standards the Ghanaian government puts special emphasis on for their primary school students. We found that a major focus was put on math because the majority of non-textbook TLMs were used for math (Opoku-Asare, 2005). Therefore, we are currently assuming that there is a strong probability that we will want to focus on counting, addition, subtraction, and fractions. However, these are merely assumptions. The true human centered design that we are planning to achieve will not occur until we are physically in Ghana. Based on our current assumptions, we've developed some preliminary designs to address mathematical topics. We shaped these designs using CAD (Computer Aided Design), placing emphasis on how to build things that do not easily break.

This first initial design and research phase will help us be as prepared as possible when we get to Ghana. When we first get there, we need to meet the teachers and establish a partnership. We will wait to show them our designs to ensure that their input is being heard and that we are working as co-designers. Instead, we will observe their classrooms and learn what concepts they cover.

4.2: Week 1

The first week will begin the observation phase. We will hold an introductory meeting that will allow us to begin forming connections with the teachers of Dwenase. We will have an initial interview with the teachers where we can get their perspectives on the curriculum they currently teach. This will allow us to understand where they feel their students have learning gaps, or where they need the TLMs most. Afterwards, we will spend time observing the classroom. Hopefully, we will be able to see how the students are paying attention, and where and when they are confused or begin to lose focus. As foreigners, we will be a distraction to the classroom. It is vital we speak with teachers before observing so we can collect unbiased opinions. We will also spend time getting to know the students. This will allow us to be less foreign to them as the weeks go on and will get them to react to new materials with less bias. We will go about doing this in two ways. We will also hold semi-structured learning with the students, possibly in the form of games. This will encourage more participation amongst the students in later weeks, allowing us to understand their learning processes. We will also connect with the students outside of a classroom environment. For example, we can do this by playing soccer with them in the fields. By connecting with students, we will hopefully be less of a distraction in the classroom.

We will also find and talk to local artisans in our first week. We will be looking to understand what materials will be available to us when crafting TLMs and how much work artisans will be able to do with us. The first week will focus on the ethnographic approach. We will collect not only empirical data, but also an understanding on how we will begin to define and develop the TLMs.

4.3: Week 2

In the second week, we will be focusing on the concept of ideation. We will be honing in on the first part of the double diamond model of design, where we will be working to define the problem. This will be done by using all of our observations and brainstorming with the teachers to develop effective TLMs. We will need to decide if we want to focus on certain factors, such as

a specific age group and school subject. We will also determine if creating TLMs based on the Ghanaian curriculum will be beneficial for Dwenase. We will first ask teachers what they believe is missing from their classrooms and what tools they would want to use. We will also begin brainstorming designs by drafting images based on what the teachers are asking for. Only after we have begun drafting ideas with local teachers, we will show our initial designs that we created at WPI this past fall. This will allow them to showcase their own opinions and truly engage the local community in the problem definition and solution. We will also start taking these ideas to any local artisans we met in the first week. Thus, we can begin identifying what designs are too complicated for the group to prototype. As we begin to make more detailed drawings of each TLM, we will also start gathering materials we will need to build these tools. This will help us ensure that all designs are possible to reproduce locally.

4.4: Week 3

The third week will focus on prototyping. We will mostly be working with artisans to physically create the TLMs. We will create one prototype of each design that is chosen by the teachers, while continuing to suggest ideas on any improvements we can make to these prototypes. We will also try to visit the classroom often. This will ensure that we continue fostering connections with the teachers and students. This will also ensure that we can check in with them incase they have more opinions they would like to share. We do not expect the school to halt their education for our project team. We want to make sure our team is easily accessible to them by continuing classroom visits. We will attempt to begin presenting TLM concepts towards the end of this week.

4.5: Week 4 and 5

Going into week four and five, we will focus on prototyping and testing. Although we will be constantly practicing observation and ideation each week, weeks 4 and 5 are especially iterative. We will be creating new TLM prototypes one at a time to let each design have an independent test period. We will ask the teachers to introduce a TLM to the class and teach the lesson incorporating the TLM. We will then ask them if we can observe the initial part of the lesson.

Then, we will leave the classroom. This will allow students to explore the tools without any apprehension about our observations. We will also ask the teachers to keep notes on how the students reacted and how easy it was for them to teach using the TLM. After we test a TLM, we will have a small discussion with the teachers and students to see how they enjoyed and gained value from the tool. This will let us have some empirical data that can help us decide which TLMs were best for the classroom.

4.6: Week 6 and 7

In week six and seven, we will focus on finalizing designs and wrapping up the project in a meaningful way. We aim to create a set of TLMs that will be impactful and long-lasting. Working with teachers, we will pick the designs that best fit their current teaching styles. Using these TLMs, we will create a set of instructions on how to make them, including specific artisans, tools, and materials that will be needed. We will leave this set of instructions with the teachers. We will also walk through the process of making a single iteration of the TLMs with the teachers, so that they will have been exposed to the whole design process and will be able to repair or replicate these TLMs if they break.

We will then prepare the more complicated aspects of each design and collect enough materials to create these designs. We will set up a workshop with the students so that they can help put the TLMs together. This will help foster a relationship between the students and their materials. They will be more eager to use them and will get more value from the materials. We will also set up some time to analyze how our group worked with the school. It is imperative that we document any successes and failures we faced, so that future teams can learn from our work. We want to work with the teachers on a set of tasks that they would like completed next, such as expanding TLMs to different subjects or grade levels. We would also spend a few days observing the classroom with the final set of TLMs. This will allow us to identify any unforeseen consequences.

Ultimately, we want to produce an effective set of teaching materials that both the teachers and students can gain value from, as well as a concise set of instructions on how to create these materials. We will also be paving the way for any future projects that work with the school, including expanding TLMs or aiding with any other educational concerns expressed by the teachers of Dwenase. We will finish our time in Ghana by presenting out project in Accra on February 27th and 28th.

5: Conclusion

The main goal of our project is to work with the community as much as we can to enhance the educational experience of primary school students through the use of TLMs. It is important to bring ethnography into our design because we are working with a local community. We want to conduct interviews to learn what design suits them best. It is very important that we humble ourselves before the community, learn to start conversations correctly, and earn their trust before interviewing them. Starting a good conversation is the first step to gain trust. Ultimately we can create a suitable problem definition and solution, and create a sustainable set of TLMs to aid the primary school.

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