Creating an Educational Exchange Using Practical Learning Materials

Haley Hauptfeld, Sophiya Litovchick, Linda Puzey

Worcester Polytechnic Institute

"The teaching is abstract, but the students need practical learning." – E. Smith, Community Member and Retired Teacher

Historically, designing for development is a method used to aid a developing area. Unfortunately, it often conducted by those who lack awareness about the issues they are trying to solve. A major factor which leads to design for development is the assumed poverty of a certain area, which is usually defined by Western standards.[1] These standards do not account for the unique culture of the area. Additionally, development work is historically led by academics, engineers, and scientists who have never experienced or lived in their area of focus. This results in inappropriate solutions to the problems discovered by the developers[2]. These solutions can also be skewed to benefit the developers and misinterpret the true problems at hand. In retrospect, historical development projects can be described as abstract.

Instead, design must be practical, hands-on, and immersive. Co-design is a method which focuses on working alongside a community to ensure that the needs of the people are met. When utilized properly, it creates a mutual exchange of knowledge between all involved parties. Co-design works to find an appropriate solution for the problem. There may not be a clear, concise solution. Instead, the correct solution is defined as one that best serves the community and considers the current situation as well as community feedback. This

method is highly based on communication and collaboration during every step of the design process.

The Teaching and Learning Materials Development Project, which began in 2019, is an ongoing collaboration between Worcester Polytechnic Institute (WPI) and teachers at the Presbyterian Primary School in Dwenase, Ghana. Before this project began, the school's classrooms had few physical materials that students could interact. Studies show that students absorb information better when they physically engage with their environment and schoolwork.[3] In Dwenase, the teaching methods were primarily based on abstract ideas. The teachers did not have materials to give the students and were unable to create an immersive learning experience. This made it difficult for younger students to understand and process the curriculum.

The solution to this problem was creating Teaching and Learning Materials (TLMs), which are physical tools that aid the teachers with their lessons. This builds a better educational foundation for students. Additionally, due to the financial constraints of living in a rural Ghanaian community, the TLMs produced were low cost and created from locally available resources. However, this project went beyond the physical deliverable. It established an authentic partnership with the teachers that encouraged the use of their own creativity to improve their classrooms. Through observation and participation, the group was able to gain information about the community. This resulted in the ability to utilize the existing learning and teaching styles to create TLMs that supported interactive classrooms. Holding design sessions and having conversations with the primary school teachers led to a practical partnership where we were able to take the abstract curriculum and create practical tools for students. This formed an educational exchange that built a foundation for cross-cultural development between the WPI students and the primary school teachers.

Co-Designing for Development

"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."
– Don A. Norman, The Design of Everyday Things

Co-design is an integral theme in our project. Before we arrived in Ghana, we learned about the numerous problems that can occur when people and organizations design for development. For example, a robotics company based in Silicon Valley, called Zipline, developed medical delivery drones to be used in areas such as Rwanda and Ghana. Since 2016, these drones have been delivering medical supplies, such as blood, to remote areas in developing countries. At first, this project seemed like an impressive solution to some of the healthcare issues in Rwanda and Ghana.[4] However, medical professionals in Ghanaian communities have described Zipline drones as a "high tech vanity project" because they do not address the underlying problems that are just as important as delivering medical supplies. For example, the drones do not address the issue of infrastructure or certified staffing of health centers.[5] Developing better roads would make it easier to deliver medical supplies such as blood. It would also solve other problems, such as shortening the time it takes for people to travel to hospitals and delivering staple goods. Additionally, in more rural areas, staff members may not be trained or may not have all the equipment necessary to administer the medicine provided. Addressing these problems would bring a higher quality

of life and would naturally decrease the need for medical supplies. Zipline did not address these underlying problems because they were more focused on a simple, short-term solution. They wanted a payoff that would only take a few years, rather than one that might occur decades from now. This project found an expedient solution before properly defining the actual problems of Rwanda and Ghana. This solution was inappropriate for those communities because the designers never defined the true problem.

Co-design seeks to counter the errors made by previous generations of development designers. Co-design is a process where the designer works closely with the community to facilitate a solution to a problem. The designer does not work with customers, but rather collaborators. To achieve co-design, our project group developed methods based on Norman's description of human centered design. We referenced his double diamond model of design that consists of a two-step process, seen in Figure 1.[6]
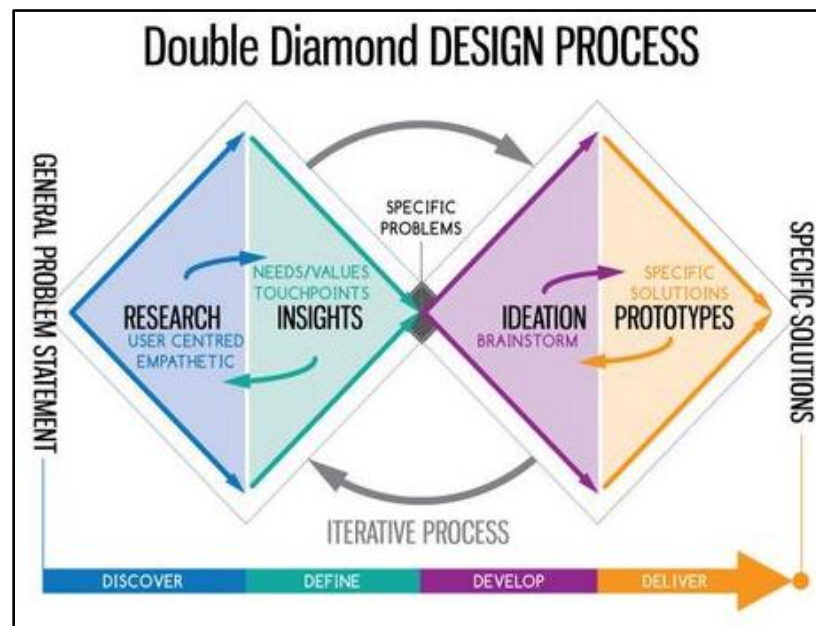

Figure 1

The first 'diamond' examines a general problem statement with additional research and questions that widen perspectives, which in turn, identifies the correct problem. The second 'diamond' uses the same method to create numerous ideas and prototypes to help produce the best possible solution.[7] The Zipline medical delivery drones focused on a high-tech solution to a low-tech problem. As the drones gained more attention, it became clear that

underlying problems were not being addressed. Zipline used a flashy solution because that was easier and gained more traction in Western societies rather than attempting to solve more complex problems in African nations. Learning from the Zipline drones, we employed co-design to address the specific issues of the community in Dwenase, Ghana.

Using techniques from co-design allowed us to keep our ideas in alignment with the needs and capabilities of those who will be using the design. We used an iterative process that's 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 partners. In order to foment this close interaction, we worked directly with the primary school teachers in Dwenase.

We created a development design process that focused on understanding and working with the local community. Using the design methods that we studied led us to develop our own seen in Figure 2.
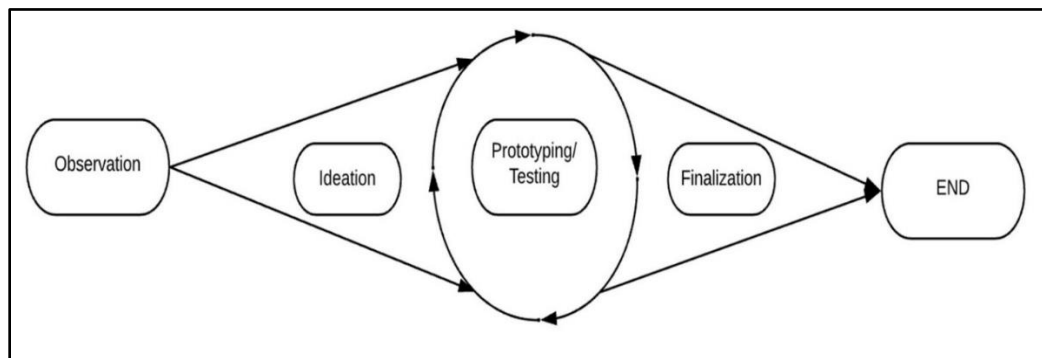

Figure 2

Originally, our process began with observation to broaden our scope of knowledge about the educational system in Dwenase. Observation included informal conversations, classroom observations, and general activities with the community which would allow the community to be comfortable expressing their ideas to us. This was also done in order to add to the knowledge base that we have about the problem. Afterwards, we moved to ideation, which involved developing numerous potential designs alongside our collaborators. Originally, our focus was prototyping and testing. The plan was to develop multiple prototypes of TLMs for the teachers to test out in their classrooms and have them pick the ones that worked most

effectively. Our process ended with the finalization of the TLMs. This process was intended to be immersive because we worked with the primary school teachers, rather than for them. However, during our time in Ghana, we modified this process often based on the information we learned while co-designing with the community.

Overcoming the Computer Aided Design Paradigm

"What are the first words you're going to say to the community?" – Professor Robert Krueger

Computer Aided Design (CAD), well known in the engineering community, is the process of using computers and software to develop or modify a design. Engineers often use this tool to complete their work faster. In fact, CAD was created with the purpose of increasing a designer's efficiency. Therefore, we assumed that CAD would serve this purpose for our project. However, it had the opposite effect. Before arriving in Ghana, we created potential TLM prototypes using CAD. After engaging with the community, we realized that this was not the most effective way to form designs. We found that ideation with the primary school teachers always worked better with physical tools, such as pen and paper. This occurred because CAD is unavailable in the teacher's environment. Teachers do not have proper practice with CAD. Thus, it is inconvenient for them to use it because a rural primary school does not have the same resources as an engineering school. Therefore, we realigned our approach to suit the environment that we were working in.

Instead of bringing in a computer and showing them digital renderings of TLM prototypes, we made sketches on paper and supplemented with paper prototypes. This gave the teachers the opportunity to have the same level of interaction with the designs as we did. They were able to instantaneously give feedback on the designs by modifying prototypes and editing the drawings. Our method allowed us to work in 'real time' the same way CAD allows an engineering community to work in 'real time'. Additionally, this prompted more discussion about the designs as teachers would explain their reasoning behind every change. This led to a better understanding of why they wanted each TLM and how they would use it in their classrooms. This change in our approach aided us by forming a better understanding of the concepts behind each TLM from the perspective of both ourselves, as well as the primary school teachers. We were able to extend the limits of co-design by only using tools and methods that all participants were comfortable with. This allowed a shared understanding of basic concepts which allowed more in-depth discussion and analysis of the problems presented by the school curriculum and lack of materials.

As our approach changed, we also recognized that an integral aspect of our project is that we are working in the same area that we seek change in. We are not simply crafting TLMs and shipping them to the destination that they are needed. This remote method proved to be impossible during the preparatory part of the project. The group would spend a lot of time speculating on questions that would be answered in minutes once given the opportunity to observe or talk to the Dwenase community. For example, before traveling to Ghana, we had assumed that there would be sets of pre-made TLMs that already existed as part of the Ghanaian education system. However, after we arrived in Ghana, we realized that the Ghanaian Education Service (GES) does not provide such sets. Instead, GES expects teachers to be creative using their given environment. Unless we had physically visited classrooms and communicated with teachers, we would not have known this. This experience changed a major aspect of our project because we initially focused on re-imagining existing learning tools in a resourceful way. Yet, as we physically worked in Ghana, we realized that we needed to start at the most basic level. We worked alongside the teachers to analyze the GES curriculum and find areas in which the students of Dwenase

struggled. We also observed classrooms and realized that students enjoyed group activities and participated more when they were not singled out. A lot of the tools we saw before arriving in Ghana were highly individualized and would not fully engage the students of Dwenase. Therefore, by co-designing with our collaborators directly in their environment we were able to have a higher level of empathy and understanding. Being in the field aided us in co-creating TLMs that fit the GES curriculum and aided students at the primary school rather than copying Western learning methods.

One final consideration that had us change our initial approach was the budget. The headmaster of the primary school informed us that financial aid comes in the form of a capitation grant from the government which is only 10 GH¢ (~$2 USD) per year for each enrolled student for the 2018-2019 school year.[8] One assumption that we had before arriving in Ghana is the potential use of local artisans to help us craft TLMs. However, after recognizing the size of the budget, we found that we could not financially sustain artisan-made materials. We changed our approach by doing research on the local shops of Apinamang, and Dwenase. We compared price points at different stores to find the least expensive materials in order to best inform our partners about the available resources. We also collected leftover materials from our peers and community members for free. We acted as intermediates to kick start various other collection efforts. Techers began asking students to bring in old water bottles and repurposed old cardboard boxes from their neighbors. Then, in collaboration with the primary school teachers, we brainstormed how these materials could be crafted to form effective TLMs.

In order to work most effectively alongside our partners, we had to adapt our pre-conceived notions based on what we had observed. This requires flexibility and patience. We could no longer rely solely on what we had learned before arriving Ghana because it did not represent the community we were working with. As we listened and understood more about GES, the primary school, and our partners, we were able to form a holistic approach to co-design. We incorporated methods from both sides of the conversation. Ultimately, our presence in the community is what allowed us to form a meaningful co-design experience.

Understanding 'It is okay'

"Hello." "How are you?" "What is your name?" – The children of Dwenase, Ghana

These quotes are the three most common phrases heard in the streets of Dwenase. English is recognized as one of the official languages of Ghana, but the way that the community uses the English language is vastly different from how Americans speak it. This difference played an integral role in how we engaged and learned from the community because communication dictates how ideas are expressed.

When observing the primary school classrooms, we learned how the students interacted with each other, the teachers, and the lessons. When you walk into a classroom, the first thing you are greeted with is a chorus of 'Hello, how are you? I am fine, thank you?". Group and hands-on activities piqued the students' interest more than individual assignments. In fact, they felt most comfortable when they were participating in a group. Overall, the culture in Dwenase is focused on community. Students and teachers alike tend to play off each other's actions and opinions. The community placed a lot of value on unity. Thus, we had to gain the respect of the entire community in order to make our partners comfortable with sharing their individual ideas. We began doing this by participating in various activities with

students, informal conversations will all community members, and being formally welcomed by the chief.

One of the most prominent ways we immersed ourselves in the community was playing with the students at recess. Through this interaction, we met many students who would later become comfortable talking with us. We also learned more about how the students speak and react to different scenarios. They use phrases such as "You are a good girl" or "I love you". From these observations, we gathered that the language is very direct, but does not carry the same connotations as it does in the US. This was again reinforced at design meetings with the primary school teachers. We would present our current ideas to the teachers based on previous conversations. We showed them sketches and prototypes of potential TLMs, as well as actual TLMs in the later weeks of our time in Ghana. A common phrase that teachers would say when we asked for their opinion was: "It is okay". "It is okay" can mean many different things. It can mean that they enjoy one of our ideas. However, it could also mean that they do not particularly like the idea. Rather, they say "It is okay" because they want to be polite since we are guests in their community. The key to understanding the meaning behind their words was through their body language and enunciation. It was important to always allow the teachers to continue their thoughts after they said "It is okay" by encouraging them with additional questions or waiting for more information. This is when they would give more direct critique beyond "It is okay".

After these interactions, our co-design process changed to reflect the culture in Dwenase so that everyone understood the information they were learning. We made sure to visit the primary school often. This let the teachers and students know that we were invested in the project and they slowly become more comfortable with us. The culture in Dwenase is not one of individualism. Children are constantly together after school and the adults in Dwenase held communal service days every Thursday which encourages group activity that benefits the entire village. A Ghanaian proverb says, one tree cannot be a forest. This means it is important to be part of a community to create a relationship and foster growth. By continuing our visits to the school, participating in recesses, and teaching simple lessons, we showed our dedication to the school in the same way that community shows

dedication to each other. Ghanaian's are also very thoughtful during their interactions. We adopted this way of communication by being very attentive when having conversations, slowing our speech, and leaving lots of pauses. This ensured that our main collaborators, the teachers, always had room to voice their opinions without the need to please us. We kept our conversations very calm, allowing for an equal exchange of ideas without any extra stress. We held meetings at least twice a week with the teachers. Our meetings would often end in discussions about our personal lives and exchanging pictures from our smartphones. By sharing our own impressions of Ghana, the teachers were able to connect with our interests.

Listening and observing became our two most prominent tools for co-design. Through observation, we were able to gain the skills necessary for clear communication with the Ghanaian community. It is still important to explain and express our own opinions for co-design to occur, but it is more important to take a step back and listen to what others have to say. This is paramount because the designs should be based off a mixture of the teacher's knowledge of their own classrooms and a collaboration of all of our design opinions.

A Unique Process for Every Project

"The only constant in life is change"- Heraclitus

The cross-cultural co-design process is a complex mixture of ideas, creativity, and development. Throughout the project, we have seen several graphics of different diagrams

that show how the process should work. Due to the complexity, the flow of design should differ for every project because it is unique. There is no one template that will solve every problem because every problem is caused by different factors and impacts different parts of people's lives. This led us to modify our design process which can be seen in Figure 3.
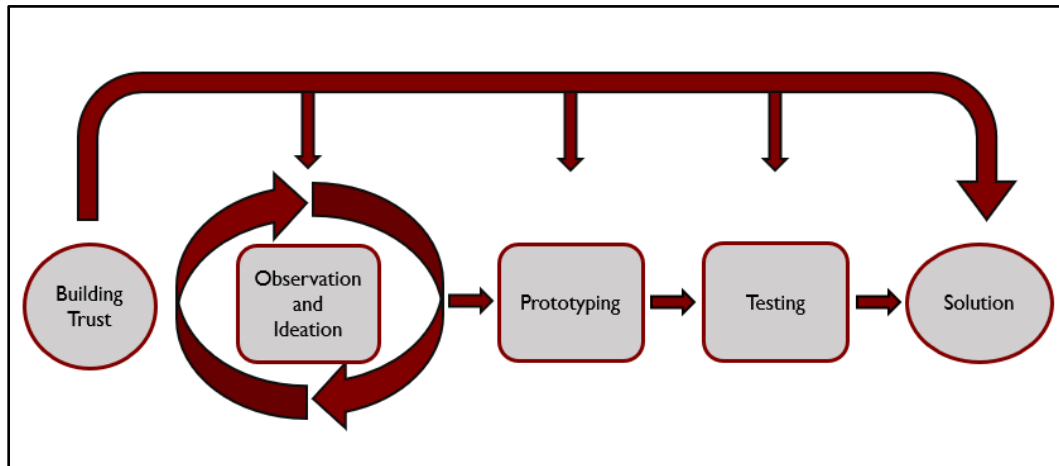

Figure 3

Our biggest change from our original design process was the added step called 'Building Trust'. This step focuses on building an authentic relationship with our partners. It ensured that we fully engaged the community during every step of the design process. No matter when or how we were interacting with the teachers, we would closely listen and consider all their feedback, which led them to share more of their opinions and ideas.

Another major change to our design process was shifting the focus from prototyping and testing to observation and ideation. During our time in Ghana, we spent a few extra weeks in the observation and ideation phase than we originally planned. This phase is what allowed us to understand and connect with the community. It created the foundation for our relationship with our partners and let us explore the content of the TLMs. Our initial plans were focused on prototyping and testing because we assumed that it would be best to design numerous different prototypes of TLMs to have teachers pick from. This is the approach that we found works best in other engineering design processes. However, once we arrived in Ghana, we discovered this is not an effective approach. The teachers focused on evolving the content of the TLMs rather than selecting from a seemingly random set of designs. Prototyping for this specific project was less about making several different versions of one

TLM, but rather, focusing on what needed to be developed in one specific subject. This led us to create one or two versions of an effective TLM. The teachers cared less about what the prototypes looked like, and more about the content that the prototype brought to life. Through our observation, we also found that it takes time to collaborate with the teachers. Therefore, if you have more prototypes, this process becomes unnecessarily tedious. In this case, the teachers would be seen less as collaborators and more of customers. By focusing more on observations and ideation, we understood what the teachers truly needed.

This approach allowed us to create TLMs that were versatile and could be used in a wide variety of classrooms contexts, lessons, and grade levels. We were able to understand the core problem before attempting to solve it with prototypes. We ended up finding various aspects that impacted the lack of TLMs in the Dwenase primary school. This included a small budget, a brand-new curriculum, and not enough personal time for the teachers to create TLMs. Addressing these issues allowed us to create low cost TLMs that fit the new curriculum. Additionally, we put various measures into place, such as an inventory, to lessen the amount of personal time teachers would need to spend fixing or creating new TLMs. At the end of the project, we observed each teacher using the materials. They each had a slightly different teaching style and were able to adapt the TLMs to every classroom. For example, one of the classes created a game to encourage participation and teamwork between the students. When observing the classrooms, we could see that the students were excited by the new tools. The teachers confirmed that they were more confident during their lessons and expressed that they are excited to make more TLMs.[9] By using co-design, we were able to create materials that suited the needs of the teachers and fit within the existing structure of the Dwenase primary school.

Cross-cultural co-design is a complex concept that changes based on a variety of factors. We found that we had to change our approach many times throughout the course of the project. However, this is okay because this summarizes exactly what the project should be about. Our ability to change our focus and approach as we learned more from the community was integral to creating a strong partnership. Through the use of co-design, our

project was able to continually evolve. The only true constant throughout our time in Ghana was change.

Give Yourself to the People

"It's all about subject. You learn something from Africa and take it to America. Then you learn something from America and bring it to Africa" Community Member and Diamond Miner in Apinamang, Ghana

There are many ways to build on the success of the initial Teaching and Learning Materials Development Project. The most important way to continue collaborating with the Ghanaian community is to continue the equal exchange of knowledge. For the TLM project, this can include staying in contact with the teachers, finding a source of funding for any additional TLMs, and fixing or adapting TLMs as the teachers see fit. Future projects could focus on creating a systematic approach to making materials. Additional research on other existing TLMs will also form a better understanding of what is currently taught across Ghana. Overall, the TLM project can be improved and expanded upon using local knowledge from teachers.

There have also been many proposed projects to help further the education of students from various community members in Dwenase. Our partners at the primary school have expressed that audio-visual materials are an important learning tool for students. This has led to a preliminary collection of simple science and history videos for educational distribution. However, many of these videos are geared towards Western culture. Creating educational videos to match the Ghanaian curriculum would provide appropriate audio-visual tools. These videos can be made to focus on local knowledge and teaching methods. Another education-based learning tool would be to build a science lab and wood shop at the junior high school. This would help teach vocational skills to students who could use this knowledge to help their communities or to build their own business. Creating more exchanges of education has the potential to support continued collaboration between WPI and Dwenase.

Credits and Acknowledgements

Appendix

The goal of the Teaching and Learning Materials Project was to partner with teachers in Dwenase, Ghana to create practical learning tools for their classrooms. In total, there were thirteen TLMs created. It was determined that the initial set of TLMs needed to cover the three core subjects of Mathematics, English, and Science. Each TLM is versatile and able to span across multiple grade levels and lessons. In order to ensure that the TLMs can be replicated and expanded upon after the project's completion, we left detailed instructions on how build TLMs and created an inventory. The thirteen TLMs created can be seen below:

1: Human Body Model

Subject: Science

Required Materials:

- Cardboard
- Packaging Tape
- Permanent Marker

Image:

Description: An interactive pin-the-tail-on-the-donkey game were students match body parts to their respective locations. The sets created included: The Nervous System, Respiratory System, Digestive System, Outer Body Parts, and Skeletal System.

2: Ecosystem Model

Subject: Science

Required Materials:

- Cardboard
- Packaging Tape
- Twigs
- Permanent Marker
- Poster Board

Image:

Description: A trifold display showing three different habitats (aquatic, arboreal, and land) with removable animals and plants familiar to Ghanaian students.
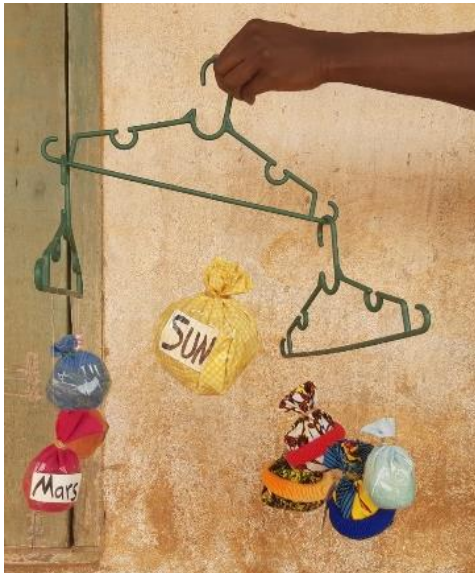
3: Solar System Model

Subject: Science

Required Materials:

- Packaging Tape
- Plastic Bags
- Permanent Marker
- Socks
- Rubber Bands
- String
- Hangers
- Hair Bands

Image:

Description: Mobile that has the sun as the center and the outer and inner planets on either side. Planets and sun are sized relative to each other.

4: Pocket Poster

Subject: English

Required Materials:

- Packaging Tape
- Poster Board
- Permanent Marker

Image:

Description: Poster with interchangeable letters and words to help teach spelling and sentence formation. Blank card can be written on with dry erase markers.
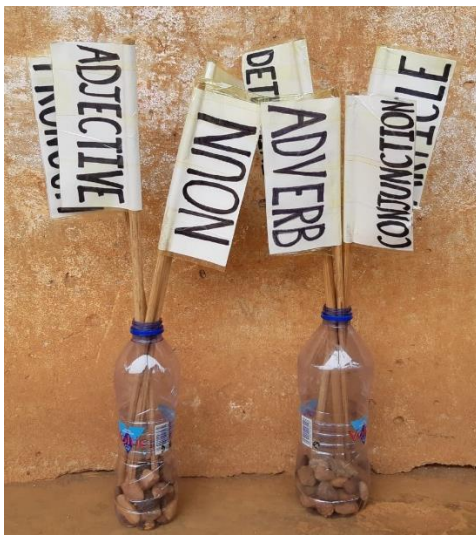
5: Parts of Speech Pointers

Subject: English

Required Materials:

- Sticks
- Poster Board
- Packaging Tape
- Permanent Marker

Image:

Description: Teachers write sentences on the board and students identify the parts of speech using the pointers.

6: Bottle Top Letters

Subject: English

Required Materials:

- Bottle Caps
- Large Water Bottle
- Rubber Band
- Cloth

Image:

Description: Bottle Caps with letters written on them for more interaction when spelling.

7: Place Value Poster

Subject: Mathematics

Required Materials:

- Packaging Tape
- Poster Board
- Permanent Marker
- Dry Erase Board Marker

Image:

Description: Poster with the ability to write in numbers at each place values with a dry erase marker.

8: Interactive Shapes

Subject: Mathematics

Required Materials:

- Cardboard
- Packaging Tape
- Poster Paper
- Permanent Marker

Image:

Description: Cardboard shapes used for tracing and identification of shapes. Posters shows a puzzles of geometric representations of object (house, cat, person).

9: Measurement Bottles

Subject: Mathematics

Required Materials:

- Bel-Aqua 1.5 L Water Bottle

- Permanent Marker

Image:

Description: Bottles to be filled with sand, rocks, or water to show different measurements.

10: Scale

Subject: Mathematics

Required Materials:

- Water Bottles
- Rubber Bands
- Glue
- Wooden Stick
- Wire
- Rocks

Image:
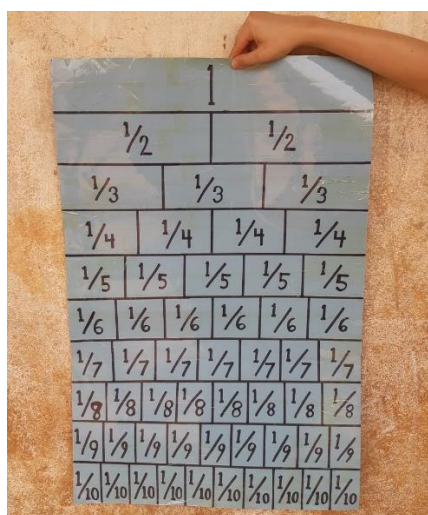

Description: Used to show relative weights of objects.

11: Fractions Poster

Subject: Mathematics

Required Materials:

- Poster Paper

- Packaging Tape

- Permanent Marker

Image:

Description: Poster for visualization of fractions.

12: Fractions Pie Chart

Subject: Mathematics

Required Materials:

- Cardboard
- Scrap Fabric
- Glue
- Packaging Tape

Image:

Description: Shows fractions as part of a circle. Pieces are removable and interchangeable.

13: Bottle Top Counters

Subject: Mathematics

Required Materials:

- Bottle Caps

Image:

Description: Used for simple math such as addition and subtraction.

End Notes

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[1] Latham, M. E. (2011). *The right kind of revolution: modernization, development, and U.S. Foreign Policy from the Cold War to the present.* Ithaca, NY: Cornell University.

[2] Stellar, D. (2010, July 1). *The PlayPump: What Went Wrong?* State of the Planet. https://blogs.ei.columbia.edu/2010/07/01/the-playpump-what-went-wrong/

[3] Cleaver, S. (n.d). *Hands-On Is Minds-On.* Scholastic. https://www.scholastic.com/browse/article.jsp?id=3751901

[4] Brown, R. L. (2018, November 26). *In Rwanda, zippy drones deliver quick fix, but gloss over deep needs.* The Cristian Science Monitor. https://www.csmonitor.com/Technology/2018/1218/In-Rwanda-zippy-drones-deliver-quick-fix-but-gloss-over-deeper-needs

[5] Brown, R. L. (2018, November 26). *In Rwanda, zippy drones deliver quick fix, but gloss over deep needs.* The Cristian Science Monitor. https://www.csmonitor.com/Technology/2018/1218/In-Rwanda-zippy-drones-deliver-quick-fix-but-gloss-over-deeper-needs

[6] UK Design council. (2005). *Double Diamond Design Process* [Infographic]. https://ioannouolga.blog/2018/03/27/double-diamond/

[7] Norman, D. A. (2013). *The Design of Everyday Things.* New York: Basic Books.

[8] E. Oteng (personal communication, January 17, 2020).

[9] M. O. Agyemang (personal communication, February 19, 2020).