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THE SUSTAINABILITY OF COLLABORATIVE COMMUNITY-BASED RESEARCH

Mary Ann Studer, McMaster Fellow, 2014 – 2016

During the last eleven years my work in Belize has evidenced that sustainable development is possible when academic research incorporates community direction, and recognizes local expertise as a component in the formation of new knowledge. Indeed, we are able to manage problems, and in many cases improve lives by community driven and academically supported initiatives. Academics often neglect to recognize the validity of community- based research (CBR) because CBR accepts the creation of new knowledge through multiple sources; valuing local tacit expertise and cultural context along with academic skills and knowledge (Strand, Marullo, Cutforth, Stoecker, & Donohue, 2003). Collaborative solutions to issues and challenges that work within the parameters of local resources are paramount to sustainability. Moreover, sustainability is critical in effecting a lasting improvement in the human condition. The projects that I implemented in December of 2014 and December of 2015—particularly those directed at soil quality—are indicators of the effectiveness and sustainability of these collaborative efforts.

Although these projects may seem diverse, in the context of addressing the challenges of food insecurity, poverty, lack of access to clean water, and environmental degradation; interdisciplinary solutions in the framework of the integrated natural resource management model could be employed to resolve these issues (Sanchez, Palm, & Buol, 2003, p. 159). Agricultural communities—especially with limited infrastructure, limited landholdings, and limited resources—can develop to improve community livelihoods, health, resource utilization without environmental degradation. These projects evidence the collaborative pathway toward improved human well-being, enhanced ecosystem functions, and enhanced productivity – solution areas demanded by Sanchez, et al (Sanchez, Palm, & Buol, 2003), and that have emerged through the partnering of efforts between the McMaster School and the communities in this region in Northern Belize.

Soil Macro and Micro Nutrient Analysis Conducted in Agricultural Fields on the Periphery of the Rio Bravo Conservation and Management Area in Northern Belize

The recognition of soil as natural capital is a point this project has tried to emphasize since 2005. Unfortunately, subsistence farming drives a mentality and practice that favors immediate results over long-term sustainability. To put this in context, Belize consists of 22,806 sq.km (approximately 5.5 million acres) of land, only 6.9% of which is used for agriculture. Agricultural land use can be further categorized into 3.3% arable land, 1.4% land planted with permanent crops, and 2.2% pasture land. The land used for permanent crops contributes largely to the $580.7 million in Belizean exports; the top three of which are sugar, bananas, and citrus (Central Intelligence Agency, 2016). Even by conservative estimates based on the assumption that the 5.5% of the agricultural land is farmed for local consumption, Belizeans are living on .89 acre of land per person. While multiple sources claim different calculations determining the acreage needed to sustain a person, the consensus seems to be a minimum of 1 acre per person per year (Farmland LP, 2016). Most of the Belizean farmers that I have worked with are sustaining families of 6 or more on just 2-3 acres. Limited land holdings pose one issue; soil quality is another. Soil health is critical to sustainable optimal yields (Ayoub, 1999, pp. 120-121), especially when past studies of cleared rainforest soil evidence a rapid depletion of nutrients in this land type. These parameters make a clear case for soil to be considered as a long term resource that Belizean farmers need to utilize and protect.

While fertilization at appropriate levels is the key to supporting optimal yields in former rainforest soils, over-fertilization damages the soil. Damage caused by over-fertilization decreases profits due to increased cost of field preparation, and has the potential to cause environmental damage to adjacent land and waterways in the form of chemical runoff. Accordingly, throughout the course of this project we—subsistence un-mechanized farmers on the periphery of the Rio Bravo Conservation and Management Area ("RBCMA"), and myself—are walking the fine line of optimal production with minimal inputs and striving to reduce the potential of negative environmental impact. As this project has evolved community's interests in maximizing the productivity of its land use and environmental conservation—that were formerly considered to be in tension—have merged. From December of 2014 to December of 2015, data shows that farmers who continue to have their fields tested each year maintain conditions for optimal yield (weather of course an uncontrollable factor), while keeping fertilizer inputs at minimal levels. This data now shows a ten-year trend of an overall decrease in macro nutrient (nitrogen, phosphorus, and potassium) by an average of 48% first documented at the five-year point in 2010 (Studer M. , Developing Sustainable Communities in Belize, 2010).

The protocols for testing in both 2014 and 2015 maintain methods utilized since 2005, so as to insure continuity. Analysis of soil color was completed using the Munsell scale. Texture, pH, and a physical assessment of soil quality was conducted while on-site using a modified version of the schema Observational Approach to Soil Health (Romig, Garlynd, Harris, & McSweeney, 1995). Criteria for the modification have been supported by information provided by the Assessment of Soil Quality by Maurice J. Mausbach and Cathy A. Seybold (1998). All macro and micro soil nutrient analyses were completed using LaMotte Smart2 Electronic Soil analysis apparatus. The following chemical reactions were completed to allow for digital analysis of the soil extract to quantify nutrient levels to hundredths of parts per million or pounds per acre.

Macro-Nutrients (LaMotte, 2004)

Nutrient	Protocol
Nitrate-Nitrogen	Cadmium Reduction Method
Nitrite-Nitrogen	Diazotization Method
Phosphorus	Ascorbic Acid Reduction Method
Potassium	Tetraphenylboron Method
Calcium Schwarzenbach	EDTA Method
Magnesium	Schwarzenbach EDTA Method

Micro-Nutrients (LaMotte, 2004)

Nutrient	Protocol
Manganese	Periodate Method
Iron	Bipyridyl Method
Chloride	Direct Reading Titrator Method
Copper	Diethyzdithiocarbamate Method
Ammonia-N	Nesslerization Method

December, 2014

The soil nutrient analysis for the fields tested in December 2014, showed that the fields of farmers who previously partnered with this project had low to optimal levels of macronutrients. Fertilizer had not been applied or only partially applied in many of the fields tested due to continuing rainfall in the area through December. Levels of potassium, phosphorus, and nitrogen were in the low to medium range parts per million ("ppm") in all fields sampled. A table showing the ranges for each macro nutrient is as follows:

December, 2014 results for fields farmed by ongoing partners

Nutrient	**Sample range** **Ppm**	**Medium (optimal level range ppm** (LaMotte, 2004)
Ammonia Nitrogen	19.5 – 22.0	25.0 – 68.0
Nitrate Nitrogen	8.0 – 15.0	11.0 – 29.0
Nitrite Nitrogen	2.3 – 3.4	2.5 – 4.0
Phosphorus	30.3 – 38.7	35.0 – 67.0
Potassium	79.8 – 82.9	82.0-143.0

December, 2015

Soil analyses on samples collected in December of 2015 evidenced that farmers are working within the parameters of optimal levels of fertilizer application. The only exception to this was the field owned by Bergen—a mechanized farmer with fields adjacent to the Rio Bravo Conservation and Management Area (RBCMA). In each of the nutrient ranges listed below, the highest recording was from Bergen's field. I regularly monitor Bergen's field as a control to understand the potential impact it could have on the adjacent carbon sequestration plot managed by Programme for Belize.

December, 2015 results for fields farmed by ongoing partners

Nutrient	**Sample range** **Ppm**	**Medium (optimal level range ppm** (LaMotte, 2004)
Ammonia Nitrogen	25.0 – 68.0	25.0 – 68.0
Nitrate Nitrogen	11.0 – 31.0	11.0 – 29.0
Nitrite Nitrogen	2.4 – 3.9	2.5 – 4.0
Phosphorus	36.0 – 67.0	35.0 – 67.0
Potassium	80.0 – 120.0	82.0-143.0

Nitrate Assay of Sub-Surface Water in the New River Lagoon

Testing the surface water, ground water, and conducting assays of chemical and biological contaminants in the New River Lagoon by McMaster fellows and scholars since 2005 was routine until nitrate levels soared in 2009 - 2012 (Hegemier, 2010) (Studer T. , 2012). While biological contaminates can be remediated through various methods, including: chlorination, UV sterilization, and boiling the water; chemical contaminants such as nitrates are difficult to remove, and have the potential to significantly affect an individual's health if consumed in large quantities. Even though the nitrate levels returned to normal in 2013 and continue to test normal (Golnick, 2014) (Alexander, 2014) (Homan, 2015), the source of the nitrates is—at this point—undetermined. In 2009, alternate water sources were immediately accessed by the village of San Carlos to prevent or minimize consumption (including the water chlorine generation system installed through the efforts of McMaster School). Without having identified the source of the contamination, we can only speculate about when and if high nitrate levels will reoccur. Therefore, continued testing—specifically for nitrates—in all water sources is critical to gaining a better understanding of the water dynamics in the area, and to be able to preempt human consumption of such harmful contaminants. Although McMaster scholars test surface water for chemical and biological contaminants, in this project I particularly observe assays of nitrate levels in subsurface water in the New River Lagoon. Since the New River Lagoon is Belize's largest body of fresh water, it is of critical importance for marine and human life.

Using a Van Dorn tube, testing was conducted at various sites in the New River Lagoon in December of 2014 and 2015. All sites were marked using a Global Positioning System ("GPS"). Nitrate levels are assessed using a *Hach* Pocket Colorimeter II device and nitrate testing protocol (*cadmium reduction method)* to digitally determine nitrate levels. In December of 2014 and 2015, sites were identified as possible springs due to their greater-than-average depths. Depth was determined using a Hummingbird® Piranha Max™ 175 PT depth finder. The sites suspected to be direct sources of ground water were tested at depths up to 20m. Acidity, temperature, and dissolved oxygen levels were assessed at depth using a *Hach* HQd Digital Meter, pHC101 gel-filled pH probe, and a LDO101 dissolved oxygen probe. We acquired this equipment in November of 2015 in order to expedite the process of assessing dissolved oxygen in the New River Lagoon. In December of 2015 we began using the equipment to lay the foundation for baseline studies of the water at depth.

December, 2014

Due to continued rainfall in December of 2014, the water level in the New River Lagoon was higher than normal. Higher water levels allowed us to conduct more extensive testing deeper into the tributaries that feed Belize's largest body of freshwater. Over time, this testing will provide a clearer picture of the movement of the water that passes from runoff and ground water into the tributaries and into the New River Lagoon. The New River Lagoon then flows north to the New River and empties into the Bay of Corozal.

The nitrate levels for water sampled at a minimum of 1.0 meters below the surface showed lower nitrate levels as compared to surface levels, and the U.S. Environmental Protection Agency standard of safe levels of nitrate below 10mg/L (US Environmental Protection Agency, 2016). A total of 31 samples were taken from depths ranging from 1.0m to 20m. Samples were taken from sites upstream, downstream, and directly offshore relative to the village of San Carlos. The results for those sites that bracketed the village of San Carlos ranged from 0.0mg/L – 3.96mg/L. The primary source of nitrate contamination is usually linked to agricultural or human/animal waste runoff. San Carlos is an agricultural village, albeit one whose fields are a significant distance from the New River Lagoon. The nitrate levels found in December of 2014 were similar to nitrate levels found in water drawn from sites both upstream and downstream from the village in past years (Studer M. , Community Based Research in Northern Belize, 2012) (Studer M. A., 2014). So at this point there is not an indication that nitrates are sourced from those agricultural fields. Similarly these consistently low levels of nitrates in samples that bracketed the village fail to indicate a source within the village that could be attributable to human waste. It should be noted however that the possibility of such sources are good because within the village pit toilets are common and septic tanks rare. Samples were taken at various depths at the mouth of the New River Lagoon and further downstream directly on the New River. The level of nitrates at those sites ranged from 1.76 mg/L to 2.20 mg/L. Samples were also taken from the tributaries that feed the New River Lagoon, namely, Lemonal Creek, Ram Goat Creek, Irish Creek, Harry Jones Creek, and Lamanai Creek. All of these tributaries, with the exception of Irish Creek, lie on the east side of the Lagoon and either drain the savanna areas or small—predominately non-agricultural—villages. The results of nitrate testing for tributaries overall ranged from 0.0mg/L- 5.72mg/L.

December, 2015

In December of 2015, we received, through an equipment grant from the Hach Company, probes that allowed us to test temperature, pH, and dissolved oxygen within seconds. Since the levels of nitrates in groundwater are typically higher than in water that contains levels of dissolved oxygen greater than 0.5mg/L (Dubrovsky, et al., 2010), pairing nitrate levels with dissolved oxygen readings at coincident depths provides a better understanding of the data. Although lower water levels inhibited us from testing as far into the tributaries as we had in 2014, we were still able to obtain 20 samples at various depths throughout the New River Lagoon. Data confirmed that subsurface water in the New River Lagoon and its tributaries contained low to moderate levels of nitrates; from

0mg/L – 7.04 mg/L. Deep areas of the Lagoon thought to be associated with natural springs were also sampled at a maximum depth of 16m. Data confirmed that water at these deep sites within the Lagoon contained low to moderate levels of nitrates; ranging from 1.76 mg/L – 7.04 mg/L. These results may indicate that there is some (albeit low to moderate) transfer of nitrates into the New River Lagoon via ground water. It should be noted that the highest level of nitrates in subsurface water 7.04 mg/L—though still below the EPA standards— were at two sites. One site with 7.04 mg/L nitrate level was aligned with the village of San Carlos; the other site with elevated nitrates was in front of the Hill Bank research station. Both sites were at significant depths 9 meters and 16 meters respectively Data collected in past years had not indicated higher nitrate levels relative to the village of San Carlos (Studer M. , Community Based Research in Northern Belize, 2012) (Studer M. A., 2014), including the data collected in 2014. Higher nitrate levels aligned with or downstream from the village in 2015 could be an indicator that human activity may be at least partially contributing to the nitrate levels, so these sites will be tested repeatedly in future years. Natural springs may also be a source of nitrate leaching since higher levels of nitrates were also found at a significant depth in front of Hill Bank at a known natural spring water source. I think that this year's data may at least allude to the fact that there may be multiple sources of nitrate contamination, something that only more testing and time will confirm or refute.

Testing for dissolved oxygen at various depths was completed in December of 2015 at the same 20 sites that were sampled in the nitrate assay. The data from this assay showed no apparent correlation between depth and dissolved oxygen levels (see figure A).

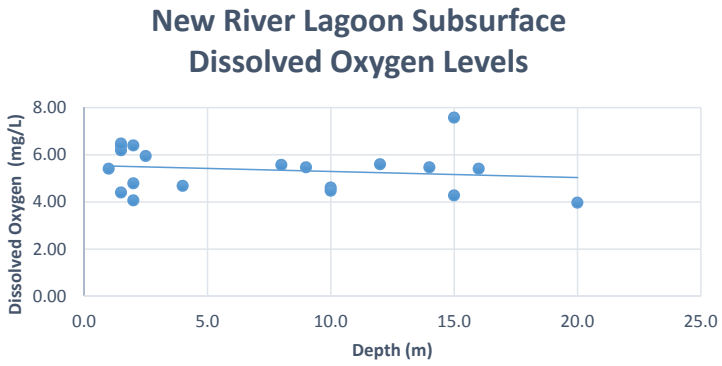
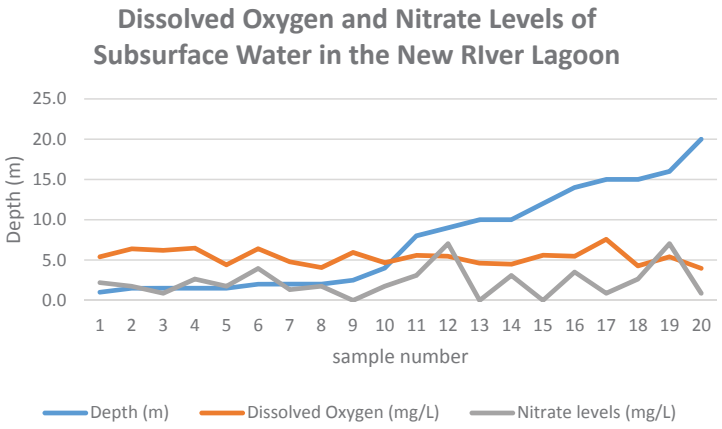


Figure A. New River Lagoon Subsurface Dissolved Oxygen Levels – sampling conducted in December, 2015.

The following chart (see figure B) shows that for all subsurface water sampled, the nitrate levels and dissolved oxygen levels did not fluctuate significantly. It should be noted that the temperature of the subsurface water did not fluctuate significantly with depth and ranged between 25.2 – 27.7 degrees Celsius.

Figure B. Dissolved Oxygen and Nitrate Levels of Subsurface Water in the New River Lagoon – sampling conducted in December, 2015.



The nitrate data from 2014 and 2015 only gives us minimal information in our goal to find the source(s) of high nitrate levels observed in the surface and ground water during the period between 2009 and 2012 (Hegemier, 2010) (Studer T. , 2012) (Golnick, 2013). Since the dry season in both 2014 and 2015 was relatively mild in terms of marsh fires we are unable to test our hypothesis that there is a correlation between nitrate levels and biomass fires. Indeed, the literature by Carmargo and Alonso (2006, p. 833), and the correlational or coincidental occurrence of significant marsh fires in the dry seasons preceding our testing in 2009 through 2012 that indicated high nitrate levels (Hegemier, 2010) (Studer T., 2012) (Golnick, 2013) would lend support to this hypothesis. Figure C demonstrates a comparison between subsurface nitrate levels at various locations that indicates minimal fluctuation in levels during years 2014 and 2015. When considering the chart below note that the U.S. Environmental Protection Agency indicates that nitrate levels for safe drinking water need to be below 10 mg/L (US Environmental Protection Agency, 2016).

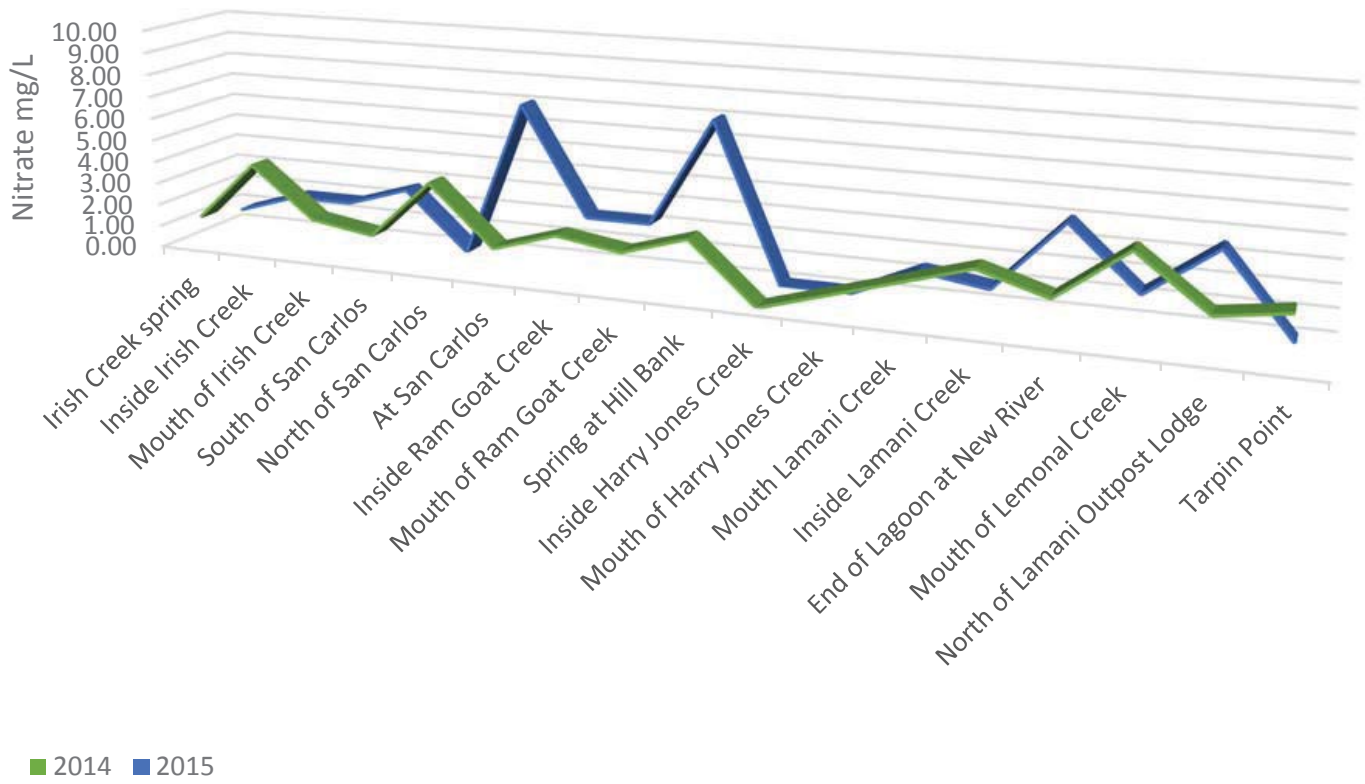


Figure C. Comparative Nitrate Levels – sampling conducted in December 2014 and December 2015.

We hope that continued data collection on this parameter will not only add to a better understanding of the source of nitrates in the subsurface water, but that it will allow the development of an overall subsurface profile of the New River Lagoon.

Conclusion

The collaborative community-based research described in the above-mentioned projects have had a significant influence in moving the communities toward improved conditions and sustainable livelihoods over the course of the last decade. Farmers are now better positioned to preserve their natural capital and manage the limited land resources they possess. Additionally, communication among farmers within communities seem to be driving more sustainable agricultural practices.

These communities are increasingly aware of the soil management components necessary for preservation of the potential productivity of fields in the tropics. Research on fragile soils in the tropics (Kang, 1997) identifies effective management protocols that over time we have discussed and encouraged Belizean farmers to implement. One of these components is appropriate and strategic fertilizer use, which the data from our testing in 2014 and 2015 indicates is happening. Another component is employing effective fallow periods and crop rotation; we can verify this is being practiced through our monitoring of fields and crops and our discussions with our partner farmers. Moreover, we have observed fields wherein intercropping (also identified by Kang as strategic to developing sustainable fields) is being utilized to facilitate diversity on a small plot, but it is not a widespread practice at this time. The final component to sustaining rainforest soil is minimizing soil disturbance (Kang, 1997), but currently no-till is only practiced by large scale mechanized farmers in the area.

The collective work of my subsurface water testing in the New River Lagoon and the work of McMaster scholars who engage in surface water and potable water testing has resulted in better access to clean water for the village of San Carlos. After multiple years of supplying data to the Belizean Ministries through our partners at Programme for Belize, the village has now been plumbed to receive water from a well and an above ground reservoir in Indian Church (a neighboring village). While the piping infrastructure was completed in December of 2015, the water was not yet flowing. The village residents, however, said that they expected running water any day. So perhaps we will be able to see a village that in 2005 had no running water and only very limited access to clean potable water, finally have access to indoor running water that is safe to drink. Through the efforts of McMaster fellows and scholars to Belize, and our partner Programme for Belize, we have observe the same village develop from having no access to electricity—again, in 2005—to being the first fully solar village in Belize. We have seen subsistence level farmers develop into entrepreneurial farmers, with much healthier fields feeding their families and making a small profit through sales to local markets. Indeed, these small individual steps, in the aggregate, have manifested themselves to bring about large-scale changes in this community. Critically, those small steps were achieved through collaborative community-based research and sustainable solutions that were only attainable through the marriage of academic knowledge and local expertise.

REFERENCES

Alexander, M. (2014). Potable Water Quality Analysis in Rural Belize. (B. Green, & M. Studer, Eds.) *The McMaster School for Advancing Humanity Journal, 8*, 18.

Ayoub, A. T. (1999). Fertilizers and the environment. *Nutrient Cycling in Agroecosystems, 55*, 117-121.

Camargo, J. A., & Alonso, A. (2006). Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment. *Environment International, 32*, 831-849.

Central Intelligence Agency. (2016, August 3). *Central America and the Caribbean: Belize*. Retrieved August 14, 2016, from The WORLD Factbook: https://www.cia.gov/library/publications/the-world-factbook/geos/bh.html

Dubrovsky, N. M., Burow, K. R., Clark, G. M., Gronberg, J. M., Hamilton, P. A., Hitt, K. J., . . . Wilber, W. G. (2010). *The Quality of Our Nation's Water - Nutrients in the Nation's Streams and Groundwater, 1992-2004.* U.S. Department of the Interior, U.S. Geological Survey. Reston, Virginia: U.S. Geological Survey. Retrieved from http://groundwaternitrate.ucdavis.edu/files/138963.pdf

Farmland LP. (2016, August 3). *One Acre Feeds a Person*. Retrieved August 14, 2016, from Health: http://www.farmlandlp.com/2012/01/one-acre-feeds-a-person/

Golnick, P. (2014). Environmental Water Quality Analysis and Ecosystem Health Indicators in Belize. (B. Green, & M. Studer, Eds.) *The McMaster School for Advancing Humanity Journal, 8*, 21.

Hegemier, J. (2010). Water Quality Analysis of the New River Lagoon. (M. Studer, D. Comer, & K. Punches, Eds.) *McMaster School for Advancing Humanity Journal, 6*, 31-37.

Homan, M. (2015). *Water Quality Analysis in Belize 2015.* McMaster School for Advancing Humanity.

Kang, B. T. (1997, March). Alley cropping-soil productivity and nutrient recycling. *Forest Ecology and Management, 91*(1), 75-82.

LaMotte. (2004). Smart 2 Electronic Soil Manual and Test Instructions.

Mausbach, M. J., & Seybold, C. A. (1998). Assessment of Soil Quality. In R. Lal (Ed.), *Soil Quality and Agricultural Sustainability.* Chelsea, Michigan: Ann Arbor Press.

Romig, D. E., Garlynd, M. J., Harris, R. F., & McSweeney, K. (1995). How Farmers Assess Soil Health and Quality. *Journal of Soil and Water Conservation, 50*(3), 229-236.

Sanchez, P. A., Palm, C. A., & Buol, S. W. (2003). Fertility Capability Soil Classification: a Tool to Help Assess Soil Quality in the Tropics. *Geoderma, 114*, 157-185.

Strand, K., Marullo, S., Cutforth, N., Stoecker, R., & Donohue, P. (2003). *Community-Based Research and Higher Education: Principles and Practices.* San Francisco: Jossey-Bass.

Studer, M. (2010). Developing Sustainable Communities in Belize. *The Journal of the McMaster School for Advancing Humanity*, 5-19.

Studer, M. (2012). Community Based Research in Northern Belize. *McMaster School for Advancing Humanity Journal, 7*, 16-17.

Studer, M. A. (2014). Research Coming Together to Effect Change in Northern Belize. *The Journal for the McMaster School for Advancing Humanity*, 7-13.

Studer, T. (2012). Water Quality Analysis in Belize 2010-2011. (M. Studer, & D. Comer, Eds.) *McMaster School for Advancing Humanity Journal, 7*, 14.

US Environmental Protection Agency. (2016, August 3). *Estimated Nitrate Concentrations in Ground Water Used for Drinking*. Retrieved August 14, 2016, from Nutrient Policy and Data: https://www.epa.gov/nutrient-policy-data/estimated-nitrate-concentrations-groundwater-used-drinking

WATER QUALITY TESTING IN SAN CARLOS, BELIZE

Melina Alexander, McMaster Scholar, Belize 2014 – 2015

According to the CIA World Factbook 98.9% of Belize's urban, and all of its rural population has improved access to drinking water. (Central Intelligence Agency, 2016). Improved access is defined as "piped water into dwelling, yard, or plot; public tap or standpipe; tubewell or borehole; protected dug well; protected spring; or rainwater collection" (Central Intelligence Agency, 2016). McMaster Scholars have collected data since 2004 with respect to baseline water quality in San Carlos, Belize, and the surrounding areas. According to our previously-collected data, many of the tested water sources, such as the wells and cisterns, provide water that is not safe for consumption. Further, this author has observed families consuming water from chemically and biologically contaminated potable and environmental water sources. Although, San Carlos may have access to "improved" water, access to clean water is an amenity that is not available to many residents of San Carlos.

The purpose of this author's project was to continue the ongoing water quality analysis of the New River Lagoon, its tributaries, and surrounding potable water sources. The outcome of this project is to ensure the availability of sustainable clean water for San Carlos. Methods employed included chemical and biological testing local water sources, in an effort to assess the total water quality. Specifically, I performed tests to collect data relating to nitrate nitrogen levels, orthophosphates, free chlorine, dissolved oxygen, pH levels, ammonia levels, and bacteria harmful to the human body. Similar to the methods employed by my predecessors, I used *Hach* Water Testing Kits at all the sites tested during the 2012 - 13 and 2013 - 14 trips, as well as any newly requested sites. I then collected and compiled the data.

After completing the water sampling and testing, I recorded and conveyed the data to the community partners in San Carlos as well as Programme for Belize. The new data supplements the prior years' results and was distributed to the community partners in an effort to inform policy decisions regarding how best to make clean water available to the residents of San Carlos. Testing this year indicates that the values of phosphates, ammonia, free chlorine, and pH have remained at safe levels for consumption below 0.1 mg/L, 0 mg/L, below 4 ppm, and between 6.5 and 8.5, respectively. Biological contaminates, however, continue to be a major concern. Biological contaminates were found in 11 of 26 potable water sources tested. Further, consistent with tests performed last year, every well in San Carlos tested positive for biological contaminates. The environmental water tested did not appear to contain values sufficient to render the sources unsafe, as they showed that pH values were within safe limits of 6.5 and 8.5. Additionally, Nitrate levels--which have tested abnormally high in the past--have returned to safe levels of below 10 ppm. Moreover, dissolved oxygen-which had also been problematic in previous testing--returned of safe levels for aquatic life of above 5.0 mg/L. Dissolved oxygen testing, however, will require continual monitoring because some of the values nearly reached unsafe levels. Phosphate and Chlorine levels were all found to be 0 mg/L. Ammonia levels were all found to be below .5 mg/L.

It is imperative for the village of San Carlos, as well as other surrounding villages, to have easy access to sources of clean water. The solar powered water chlorination system installed by previous McMaster Fellows and Scholars, as well as friends of the McMaster school, is one such source. This system is capable of providing 30,000 gallons of water per day. This system only requires one cup of salt to operate, and the byproduct of the purification process is bleach and hydrogen peroxide, which can be used to clean the system. The water chlorination system is a sustainable means sufficient to fulfill the clean water demands of San Carlos. Moreover, between this system and another system being installed in a nearby village, there will hopefully be enough clean water in the village to use for all aspects of daily life.

Although San Carlos has increased access to clean water, it is still imperative to engage in a dialogue so as to stress the importance of utilizing safe water sources over contaminated wells. Indeed, the next step in the clean water process for San Carlos will be to undertake clean water education initiatives. Over the coming years future McMaster scholars will need to engage the community in a bi-lateral dialogue to encourage a preference for admittedly more onerous clean water sources over the convenient yet contaminated

wells and lagoon. Further, should individuals opt to consume water from unsafe sources, boiling should be encouraged to reduce biological contaminates. With the goal to have access to clean improved water, and the distribution of information encouraging a preference toward the clean improved water sources, I am confident that we can reach our shared goal to increase access to and consumption of clean water.

REFERENCE

Central Intelligence Agency. (2016, July 11). *Central America and Caribbean: Belize*. Retrieved July 20, 2016, from The World Factbook: https://www.cia.gov/library/publications/the-world-factbook/geos/bh.html

WORKING TO IMPROVE EDUCATION IN RURAL BELIZE

Megan Davis, McMaster Scholar, Belize 2014 – 2015

The purpose of this project was to provide teachers in Belize with examples of active learning strategies while helping students make the connection between their education and the agricultural context in which they live. In addition, McMaster scholars have observed only marginal parental support and involvement in the San Carlos School. After an informal discussion with the teachers, I found that parental involvement in their children's formal education is limited to conferences that are held twice a semester. Parental involvement is important for the academic and emotional functioning of students and it has the potential to increase children's self-esteem and self-worth (Wang & Sheikh-Khalil, 2014, pp. 619-620). Accordingly, increased parental involvement in the school in San Carlos Belize could also strengthen as parents see a direct connection through their children's work between classroom learning and their livelihoods.

Before traveling to Belize, I researched the Belizean National Curriculum for all educational standards. By conducting this research, I was able to become familiar with the content children are expected to learn. The lessons I designed aligned with the Belizean National Curriculum for each grade level from Infant I to Standard VI (ages five-to-twelve years). In addition, I created a resource binder for the teachers that contained complete information about the lessons I would be teaching.

In Belize, and prior to teaching, I talked with each teacher about his or her goals for the students and the overall classroom. The teachers expressed that their main goal for the students was to provide them with the knowledge necessary to pass nationally mandated tests. We also discussed students' prior knowledge, abilities, and the extent of family involvement in the classrooms.

After talking with the teachers, I conducted soil science lessons over two days. These lessons incorporated active learning strategies and delivered content to the students that aligned with the Belizean National Curriculum. Each lesson was designed to be implemented with only available resources, so that the lesson would be sustainable in an educational resource poor environment. The teachers observed the lessons and then we discussed the features of active learning that were utilized. The teachers noticed an increase in some students' willingness to participate vocally in the lesson. The teachers were interested in making other connections between the content—as determined by the Belizean National Curriculum—and the lives of the students and their parents. The principal, Mr. Carillo, noted that if other lessons could be taught that relate content to their community, perhaps parents would develop an interest in their children's education and this would improve the child's overall educational success. Currently, teachers aim to prepare students to perform well on government mandated tests. Learning and academic achievement, however, can occur though myriad means. Indeed, the teachers recognized that active learning strategies were able to engage at least some students more effectively. The implications of this project, while specific to San Carlos, Belize may prove to be beneficial to the overall success of school-age children in other rural communities.

REFERENCE

Wang, M.-T., & Sheikh-Khalil, S. (2014). Does Parental Involvement Matter for Student Achievement and Mental Health in High School. *Child Development, 85*(2), 610-625.

TEACHING SELF-ESTEEM AND IMPROVING HEALTH IN RURAL BELIZE

Caroline Hesterman, McMaster Scholar, Belize 2014 – 2015

Increased information on health, and building self-esteem are important components in enhancing the well-being of those living in Belize. In December of 2014, I traveled to Belize and implemented self-esteem building activities in the village of San Carlos. I also led a breast cancer education session with the women of San Carlos, where I emphasized the importance of early detection through self-breast examinations. Working on these two distinct projects with two sub-populations in the village of San Carlos, I hope to contribute to improving their knowledge about personal health.

In rural Belize, the majority of females do not continue their education past the age of thirteen (Central Intelligence Agency, 2016). In 2013 I traveled to Belize to build self-esteem and confidence in the young women within the village of San Carlos, Belize. That project was well received, and our community partners and I resolved to implement the project on a larger scale for all the children in the school. Instilling confidence in young people can lead to increased motivation to higher achievement in education. Indeed, self-efficacy has a large connection with educational performances (Lent, Brown, & Larkin, 1986, p. 268). In 2014, I continued the self-esteem building activities with the women of San Carlos from the previous year. We discussed the content of the women's journals—that we started in 2013— and how this activity was helping them develop themselves in positive ways. Then I worked with children in the school. I worked with the students to build self-esteem by teaching leadership skills through sport. Most of the students seem to love soccer, so I chose soccer as the context in which we explored and practiced leadership skills. Sports play a very important role in building self-confidence (Bowker, 2006, p. 227). Through these leadership activities it is hoped that children are at least beginning to gain that confidence.

The second part of my project was intended to address the lack of routine medical care available and accessible by those in the San Carlos community. My observations in 2013, as well as data obtained from previous McMaster scholars, indicates that within a sample of the twenty-five households in San Carlos, the majority of families reported having never seen a doctor. This may be attributable to a number of factors, including: cost/affordability, lack of transportation, fear, or cultural beliefs. Through conversations between past McMaster teams and local residents, it has become apparent that there is a negative attitude associated with visiting a doctor that may be attributable to misinformation. For example, an elderly man in the village reported to McMaster Fellow Mary Ann Studer that one does not have cancer until you go to the doctor. Associating the diagnosis with the onset of disease stands in the way of any early treatment options. To begin to address this issue I specifically focused on providing information on the early detection of breast cancer. Breast cancer mortality rates among Latin American women are rapidly increasing (Banegas, et al., 2012, p. 101). This may be due to the attitudes described above and it may be due to the fact that many women are unaware about methods of early detection.

While in Belize I worked to distribute information about breast cancer and the importance of self-breast exams as a form of early detection. Associate Fellow Rena Rager and I held a meeting with the women of San Carlos and taught them how to perform self-breast examinations. In addition to providing instruction about the early detection of breast cancer, we provided a resource sheet containing contact information for treatment and support centers in Belize and Guatemala that would be both accessible and affordable for most. The breast cancer information session was well attended and the women felt comfortable enough to ask questions. Hopefully, for some, this will be the first step in undoing the notion that cancer is a "death sentence."

REFERENCES

Banegas, M. P., Bird, Y., Moraros, J., King, S., Prapsiri, S., & Thompson, B. (2012). Breast Cancer Knowledge, Attitudes, and Early Detection Practices in United States-Mexico Border Latinas. *Journal of Women's Health, 21*(1), 101-107.

Bowker, A. (2006). The Relationship Between Sports Participation and Self-Esteem During Early Adolescence. *Canadian Journal of Behavioural Science, 38*(3), pp. 214-229.

Central Intelligence Agency. (2016, August 11). *Central America and Caribbean: Belize*. Retrieved August 14, 2016, from The World Factbook: https://www.cia.gov/library/publications/the-world-factbook/geos/bh.html

Lent, R. W., Brown, S. D., & Larkin, K. C. (1986). Self-Efficacy in the Prediction of Academic Performance and Perceived Career Options. *Journal of Counseling Psychology, 33*(3), 265-269.

PRESCHOOL EDUCATION IN SAN CARLOS, BELIZE

Joseph Perry, McMaster Scholar, Belize 2014 – 2015

"[P]reschool programs may have slightly larger benefits for children whose parents speak a language other than English at home" (Magnuson, Lahaie, & Waldfogel, 2006, p. 1244). This is most likely true for many families in San Carlos, Belize, where English is a secondary language not often spoken at home. In San Carlos, English is not taught to children until they enter Infant I, the first level of education. Preschools are also beneficial to children who are economically disadvantaged, and larger gains are typically found in communities with a high percentage of economically disadvantaged students (Magnuson, Lahaie, & Waldfogel, Preschool and School Readineses of Chilren with Immigrants, 2006). With nearly 41% of the country below the poverty line in Belize, much of the country is considered to be economically disadvantaged (Central Intelligence Agency, 2013). It is important to set children on the path to success early in their lives. Indeed, "the earliest years of life are a particularly promising time to intervene in the lives of low income children" (Ludwig & Phillips, 2008). The village of San Carlos is a subsistence level agricultural village with many in the village farming small plots of land, and 15% of the village of San Carlos unemployed (Lopez, 2014). Indeed, subsistence level communities are most concerned with ensuring that their basic needs are met.

This project focused on working with mothers, teachers, and the librarian of San Carlos, Belize to effectively plan and carry out preschool lessons. Working with community partners to develop preschool lessons will better prepare children in San Carlos to enter Infant I—the equivalent of kindergarten in the United States—with knowledge that will help them be more successful in their educational endeavors. Parents play an important role in preparing their children for education, but it is important that they are properly trained to do so effectively (Restrepo & Towle-Harmon, 2008). This project was imperative because it helped train community partners how to create lessons and activities that will prepare their child to be more successful in school and throughout life more generally. Preschool programs are crucial in preparing children for schooling, and currently San Carlos lacks an organized preschool curriculum. Although, the Minister of Education in Belize recognizes the importance of preschool programs, currently the want of educational resources makes the establishment of a formal preschool program infeasible in San Carlos. In December of 2013 former McMaster Scholar Hallie Sullivan began a preschool center in the library that could be used by the librarian to teach preschool lessons. This project provided the next step and helped to provide training so that in addition to the librarian, community members in the village can effectively alternate teaching in the preschool.

In Belize I began my project talking with the mothers, teachers, and the librarian to help form connections. I spoke with the Infant I teacher to better understand how prepared the students are when they enter Infant I. I also spoke to the librarian to see what efforts she was undertaking the preschool area of the library. Additionally, I also discussed the mother's interests, such as cooking, dancing, and singing. Together, we collaborated about how these ideas could be used in the preschool to help benefit the children in preschool.

Further, I prepared a resource binder containing 15-20 general lessons and delivered it to the community. I reviewed these lessons with the Infant I teacher and librarian to determine how we could make them more effective. We modified the lessons as needed. Research shows that "exposing children to print at an early age is helpful in many aspects of learning to read" (Wasik & Hindman, 2011). It is also important that the activities are engaging and interactive for the children. For example, games and storybooks are

more developmentally appropriate for young students rather than things like worksheets (Wasik & Hindman, 2011). These activities helped provide mothers ideas that align with the standards of Infant I in order to best prepare children for their primary education.

There was a significant interest from the women about ways that they can get involved in the preschool. The collaborative process employed by this project incorporated best practices supported by research as well as the practical ideas possessed by the librarian, teachers, and other community members. By merging research-based practices and the interests of our community partners it is likely that they will develop the confidence and ability to become effective educators and active stakeholders in the process thus encouraging continued participation. Indeed, I intended the sample lessons to serve as examples and guides to help our community partners create lessons. As such, it is intended that this project will stimulate a commitment to providing children with adequate preschool educational opportunities so that the students will be more prepared when they enter Infant I and beyond.

REFERENCES

Central Intelligence Agency. (2013). *The World Factbook*. Retrieved from Cenral Intelligence Agency: https://www.cia.gov/library/publications/the-world-factbook/geos/bh.html

Lopez, Z. (2014, March 6). (J. Perry, Interviewer)

Ludwig, J., & Phillips, D. A. (2008). Long-Term Effects of Head Start on Low-Income Children. *Annals of the New York Academy of Sciences, 1136*, pp. 257-268.

Magnuson, K., Lahaie, C., & Waldfogel, J. (2006, December). Preschool and School Readiness of Children of Immigrants. *Social Science Quarterly, 87*(5), pp. 1241-1262.

Restrepo, M. A., & Towle-Harmon, M. (2008, September). Addressing Emergent Literacy Skills in Engligh-Language Learners. *The ASHA Leader, 13*, pp. 10-13.

Studer, M. A. (2014, February 20). (J. Perry, Interviewer)

Wasik, B., & Hindman, A. (2011). The morning message in early childhood classrooms: Guidelines for best practice. *Early Childhood Education Journal, 39*, pp. 183-183.

EMERGENCY RESPONSE TRAINING IN BELIZE

Zachary Roush, McMaster Scholar, Belize 2014 – 2015

The issue of safety in remote areas of Belize, such as San Carlos is imperative. The closest hospital to the village is roughly three hours away, and if a person were to be seriously injured individuals in San Carlos would be exposed to significant risks while traveling to seek medical attention. In this project, I worked in conjunction with Programme for Belize to teach emergency response training; which consists of CPR, first aid, snake bite management, and water safety training for our community partners in San Carlos. In addition to the village of San Carlos, I also provided snake bite management training to the rangers and foresters that work out of the Hill Bank Research Station. In Belize, snake bite management is of particular importance because Belize is home to many types of venomous snakes. Proper snake bite management techniques gives a person more time to travel to the hospital and obtain anti-venom treatment. By teaching emergency response and water safety, I hope to provide the people of San Carlos and the research station with knowledge to help their fellow Belizeans properly respond in the event of a critical injury.

According to the World Health Organization ("WHO"), the third leading cause of unintentional injury/death worldwide is drowning, and accounts for about seven percent of deaths due to injury (World Health Organization, 2014). In previous years, McMaster scholars have provided emergency response and water safety training. Community partners, however, have particularly requested training on the subject of head injuries, specifically concussions.

While in Belize I provided information about head injuries to the villagers and trained the residents on how to deal with these types of injuries. Additionally, I reviewed snake bites and how to apply the PIM bandage with a Peace Corps worker that was stationed in the village. Thereafter, I reviewed CPR and the Heimlich maneuver. I replenished the first aid and snake bite kits that previous scholars have made. I demonstrated head stabilization techniques in the water for head injuries sustained in the water, and explained that if someone experienced a head injury that it is imperative that they stabilize the head so that no more damage is sustained to the head or spinal column. I also emphasized that the children should not play along the lagoon unsupervised and that they should always tell someone that they are going to be near the lagoon. I also reviewed that if they are going to swim in the lagoon that they should never swim alone.

I further covered CPR with the children of the village and even had all the older kids perform CPR on mannequins, so that they would be prepared in the event they needed to perform CPR. I taught some basic first aid to the women's group of the village. I advised them to make sure that the wound was washed out with clean water and soap, and that there was first aid supplies available in their clinic. I also provided the Peace Corps volunteer with snake bite response kits. The snake bite kits contain cards that have pictures of the venomous snakes in Belize for identification purposes, elastic bandages, and an immobilization splint. It is important to identify a snake after suffering a bite so the right anti-venom can be administered. Along with San Carlos, I provided snake bite kits to our other community partners in Belize.

REFERENCES

World Health Organization. (2014, November). *Media centre: Drowning*. Retrieved August 14, 2016, from http://www.who.int/mediacentre/factsheets/fs347/en/

TROUBLESHOOTING TECHNOLOGY IN BELIZE

Zachary Roush, McMaster Scholar, Belize 2014 – 2015

The use of technology in the village of San Carlos has increased due to the work of previous McMaster Scholars. With the introduction of technology such as laptops, however, problems can arise. One of the issues with the laptops is that without training, this technology infusion cannot be sustained. In my project, I worked to provide basic troubleshooting education to the librarian who manages the laptop computers and their use in San Carlos.

With former McMaster Scholar Chelsea Bell's introduction of laptops to the school in San Carlos in 2012, the students have overwhelmingly embraced the new technology. There are, however, always going to be problems with the computers, and the people of San Carlos are neither trained in computer repair nor do they have the enough experience with the technology to attempt basic troubleshooting measures. The first thing that someone should do when confronted with a computer problem is to simply start over and restart the computer (Goldsborough, 2013, p. 64). Indeed, one should turn off the computer and wait for around 30 seconds and then turn it back on (Goldsborough, 2013, p. 64). Moreover, one must ensure that all the cords are connected securely, this would mainly apply to desktops—because laptops do not necessarily have cables other than the power adapter (Goldsborough, 2013, p. 64).

By helping the students, teachers, and the librarian learn about common problems that may arise with the laptops, and potential solutions, perhaps the majority of the laptops can continue to function effectively for the village. Indeed, I identified six common laptop problems. Such problems include: frayed power cords, cracked cases, bad fans, stuck keys, scratched screens, and waterlogged laptops (Nadel, 2009). Further, if the computer is running slow, it may be that it does not have enough space on the drive to create files, which hinders the speed of the computer (Kim, 2013). These sources were the foundation for a computer troubleshooting guide that I compiled prior to traveling to Belize

While in Belize I assessed each of the laptops, and provided the copies of the troubleshooting manual to the librarian. I then discussed the manual with the librarian and teachers in the school and answered any questions that they had. I also went over the importance of documentation, which is keeping a record of the problems that the computers have. This will allow future McMaster scholars while in Belize to have complete background information available in the event that basic troubleshooting does not restore functionality. As the residents of the village become accustomed to the technology, and more students have access to better technology, their experience and ability to maintain these laptops will increase.

REFERENCES

Goldsborough, R. (2013). Dealing with PC Problems. Teacher Librarian, 41(2), 64-64.

Kim, B. (2013, September 4). How to solve the 10 most common tech support problems yourself. Retrieved August 25, 2016, from PC World: http://www.pcworld.com/article/2047667/how-to-solve-the-10-most-common-tech-support-problems-yourself.html

Nadel, B. (2009, September 10). Easy Fixes for Six Common Laptop Problems. Retrieved August 25, 2016, from PC World: http://www.pcworld.com/article/171753/laptop_repairs.html?page=4

MERGING EDUCATION WITH TECHNOLOGY

Tory Savage, McMaster Scholar, Belize 2014 – 2015

Technology has become a major part of the education system. Adequate access to technology is imperative if students in remote villages—such as San Carlos, Belize—are to be competitive with their peers from areas of Belize with more available access to technological resources. The focus of this project was to evaluate how computers supplied to San Carlos by former McMaster initiatives are being utilized in schools by students and teachers. Additionally, through this project I aimed to work with the community in an effort to maximize the efficiency of the community's technological resources. This project served as a catalyst for aiding the community in developing a stronger working understanding of how technology can be used to aid the school's educational pursuits.

In San Carlos, I began by taking inventory of the computers in the library, and documented any necessary repairs or maintenance. Following interviews with the Orange Walk District Education Officer Miss Alvarez and the teachers in San Carlos, community partners and I sought to determine how best to assist students to prepare for the technology courses they would likely encounter in high school. Currently, there are no standard preparation criteria in either the primary or secondary education levels designed to educate students as to the use of technology. Accordingly, it would be prudent to establish a partnership with local high schools that San Carlos students are likely to attend so as to articulate technological learning standards.

A secondary objective of this project was to establish a means to improve communication between school officials and rural teachers by utilizing web-based services such as Gmail and Google Drive. Currently due to the lack of adequate communication, McMaster scholars have observed school closures resulting from the logistical difficulties associated with delivering necessary documents to the school's district office. The number of days of class missed due to logistics could be significantly reduced by utilizing a web-based service such as a shared Google Drive. Although web-based services may aid local school officials in communicating with the district office, San Carlos is still without adequate access to the internet.

Although the district office has previously expressed an intent to improve internet connectivity in San Carlos, our community partners indicate that the infrastructure in San Carlos is currently incapable of providing access to this remote village. Accordingly, a further project might involve searching for alternative means for the residents of San Carlos to have internet access or determining how best to connect ourselves to the political process to encourage the government-owned Belize Telemedia Limited to improve its infrastructure in San Carlos.

The Belize McMaster initiatives have been engaging with the community of San Carlos for the past ten years. McMaster's collaborative process has yielded significant progress in San Carlos in a number of different fields. Indeed, the number of students from San Carlos attending high school has increased from zero in 2005 to seven in 2013. Only recently, however, have McMaster initiatives focused on improving access technology in education. Previously, limitations on the availability of electricity impeded the community's ability to utilize technology. Parts of San Carlos and the school now use solar energy systems, which has allowed increased access to technology to become more feasible. Now that access to technology has become more feasible, in order for the students from San Carlos to remain competitive with high school students from all parts of Belize, they will need increased exposure to computers and other technologies throughout their primary education. Future McMaster scholars and community partners should accordingly focus their attention on educational initiatives so that San Carlos students may use the increased access to technological resources to become more competitive with students from villages that have had full access to such resources.

IMPROVING FUNCTIONAL LITERACY IN BELIZE

Ashlyn Deming, McMaster Scholar, Belize 2015 – 2016

This project focused on the improvement of functional literacy in San Carlos and Rancho Dolores, Belize, through the implementation of a pen pal project between these schools and the Defiance elementary after-school program. This project also focused on improving pedagogical training for Belizean teachers. The purpose of this project was to inspire students to pursue a greater understanding of English, which for most, is their second language, and to provide teachers—who have little pedagogical training—with access to material to improve their teaching strategies. I created resource binders containing innovative teaching pedagogies to enhance student learning. I modeled these effective strategies when teaching the lessons I designed to improve functional literacy.

Functional literacy means that one has the minimal ability to meet social and personal needs and the ability to operate within a given society (Organisation for Economic Co-operation and Development, 2001). Unfortunately, Belize struggles with a low functional literacy rate. Due to Belize's history as a British colony, its schools are required to teach English even though, for many families, English is their second language. The discrepancy between a student's native language and English, then, contributes to Belize's low functional literacy rate. Moreover, "[t]ourism is the number one foreign exchange earner in [Belize's] small economy" (Central Intelligence Agency, 2016). Because a large proportion of tourists speak English, it is important for Belizeans to be functionally literate in that language. Without functional literacy, many Belizeans will be unsuccessful as they endeavor to find employment, and may, therefore, struggle financially. The pen pal and reading comprehension activities were implemented not only to help the McMaster School understand the extent of this problem in the communities with whom we work, but they also served as an opportunity to improve our community partners' mastery of the English language and increase functional literacy.

In addition to the low functional literacy rate among the residents of Belize, many of the teachers have out-of-date texts and lack pedagogical training. Unfortunately, teachers in the schools that we partner with, almost entirely rely on lecturing and repetition (Naslund-Hadley, Haydee, & Martin, 2016, p. 24). Students are supposed to be learning critical thinking skills throughout their education, and practices such as lecturing the majority of the time may be preventing that (Naslund-Hadley, Haydee, & Martin, 2016, pp. 24-25). The resource binders were specifically designed to help the teachers implement new teaching strategies that are beneficial to the students' learning.

In Defiance, I worked closely with the Defiance Elementary after-school program, conducted lessons about Belize with the students, and prepared students to write the letters that were then taken to the students in Belize.

Once I arrived in Belize, I implemented the pen pal project with the Infant I, and II; and Standard I, II, and III classrooms in San Carlos. Additionally, I implemented this project in the Infant I and II classroom at Rancho Dolores. I also modeled active learning strategies through the lessons I taught, so the teachers could gauge the students' enthusiasm about the lesson. Once I returned, I evaluated the students' letters and the data from the reading comprehension activity and determined the readability scores and grade level through Microsoft Word.

Overall, the students did well when writing their pen pal letters and during the reading comprehension activity. The students in San Carlos had little to no difficulty executing the assigned tasks. In Rancho Dolores, however, students found the tasks to be more challenging. Since the average grade level of the letters was just under three—which is roughly equivalent to the grade that would be associated with these children—the majority of the students are writing, reading, and understanding the content at an appropriate level. Although the vagueness of both the definition of functional literacy and the measures used to asses it make it difficult to measure (Kirsch & Guthrie, 1977 - 1978, p. 504). This project demonstrates that the students in these communities have a functional literacy appropriate for their age level. Additionally, I learned that teachers are beginning to receive pedagogical training. There is a gap, however, between those who are and are not trained in teaching strategies. The resource binders prepared for the teachers should significantly contribute to closing this gap.

REFERENCES

Central Intelligence Agency. (2016, August 11). *Central America and Caribbean: Belize*. Retrieved August 14, 2016, from The WOrld Factbook: https://www.cia.gov/library/publications/the-world-factbook/geos/bh.html

Kirsch, I., & Guthrie, J. T. (1977-1978). The concept and measurement of functional literacy. *Reading Research Quarterly, 13*(4), 485-507.

Naslund-Hadley, E., Haydee, A., & Martin, D. (2016). *Challenges and Opportunities in the Belize Education Sector.* Inter-American Development Bank. Retrieved from https://publications.iadb.org/bitstream/handle/11319/5926/Challenges%20and%20Opportunities%20in%20the%20Belize%20Education%20Sector.pdf?sequence=1

Organisation for Economic Co-operation and Development. (2001, November 14). *Literate, Functionally*. Retrieved August 15, 2016, from Glossary of Statistical Terms: https://stats.oecd.org/glossary/detail.asp?ID=153

WATER QUALITY TESTING IN BELIZE

Madeline Homan, McMaster Scholar, Belize 2015 – 2016

In this research project I conducted the water quality analysis of both the potable and environmental water at various village sites, and in the New River Lagoon in Belize. The data collected in this project contributed to the data collected over the past decade by previous McMaster fellows and scholars. Moreover, we conveyed the results from this study to the community partners in the villages of San Carlos, Rancho Dolores, and with the Programme for Belize—the managing entity of Rio Bravo Conservation and Management Area ("RBCMA") which borders the New River Lagoon. In the project we tested for bacterial contaminants, nitrate nitrogen, phosphorous, dissolved oxygen, pH, free chlorine, and ammonia levels.

In this project we continue to analyze new samples and the baseline data for any trends in high or low levels of chemicals, as well as to keep the Belizean community appraised of any hazards or precautions they should be taking for their drinking water. By collaborating with our Belize community partners, we are able to discuss possible solutions as to better techniques for cleaner water or more efficient solutions to using clean safe drinking water.

Water is a necessity, but, when water becomes polluted with chemicals, both inorganic and organic, it renders the water unsafe for consumption, hygiene (teeth brushing), and cooking in some cases. The data collected by the McMaster School for Advancing Humanity is the only source of continued data monitoring the water quality of the New River Lagoon. Previous testing in the potable sites indicated biological contaminants and high nitrate levels in three of the past ten years, so it is important to continue collecting data to monitor the situation. Water use, sanitation, and hygiene education are also important aspects to this project because it informs children as well as parents about the hazards associated with using poor quality water. In addition, water hygiene education will help to change habits relative to clean water usage.

In this project we used Hach water testing kits that test for nitrate, phosphate, and ammonia. A dissolved oxygen probe and a pH probe were also donated through Hach for our work in the New River Lagoon. Past data was examined in order to get a good understanding of the data that has been recorded through previous years. In Belize, I conducted tests at the locations tested by previous McMaster scholars. Additionally, I collected samples at another village, Rancho Dolores. On site, I was able to conduct bacterial testing and was able to report the bacteria data. Once we got back to Defiance College, I compiled all the data that we collected on site and analyzed the results.

After the data was analyzed I distributed my findings to our community partners, Programme for Belize, San Carlos, and Rancho Dolores. The 2015 data that was collected shows that twenty of the twenty-four tested potable sites were contaminated and not safe

to drink. The values of pH, phosphates, free chlorine, and ammonia have remained at safe levels for ingesting with results between 6.5 and 8.5, below 0.1 mg/L, below 0.2 mg/l, and below 4 pm, respectively. Biological contaminants are yet again a major concern in the villages according to the previous and recent data. These samples came from their wells, cisterns, and other storage containers that could be the source of contamination due to lack of cleaning. Finally, the environmental water tested didn't show any values of concern.

After analyzing the results, two out of the three cased water pumps were safe to use in the village of San Carlos. There was no water being pumped to the individual houses from the reservoir in Indian Church, so the houses were using either collected rain water in cisterns, community water pumps, or wells. The people in the village were also buying bottled water instead of using well water or rain water. The water collected in the New River Lagoon appeared to be within the normal range for all chemical contaminants. Future McMaster scholars should include a water hygiene element in the schools. When looking at the surveys given in the schools, it seems as though the children understand that water should be clear, but they are still not using water safely in their homes. For future projects, this would be vital to not only teach the children in the schools that not all clear water is safe for drinking, but also the adults in the villages and teaching the importance of washing fruits and vegetables with clean water.

HEALTH EDUCATION IN BELIZE

Brittany Pease, McMaster Scholar, Belize 2015 – 2016

In Belize, I conducted two different projects; CPR, first aid, water safety, wound care training; and a senior citizen exercise class. Both projects were focused on health education. San Carlos and Rancho Dolores are located in remote areas. Indeed, the nearest hospital from these villages is approximately two-to-three hours away. The goal of the CPR, first aid, and water safety project was to provide the people with information and education to manage acute conditions until further help can be received. Additionally, the purpose of the women's senior exercise project was to teach women exercises that would help to improve cardiovascular health, strength, and balance. The CPR, first aid, and water safety project worked to combat death caused by hypoxia, accidental drowning, and accidents. Moreover, the women in Rancho Dolores specifically requested an exercise class for seniors. The exercise class concentrated to reduce risk factors for diabetes, heart disease, and hypertension. Indeed, the exercise program was designed to help the women manage and even prevent common chronic diseases such as diabetes, hypertension, and maintain an active lifestyle.

In San Carlos and Rancho Dolores, I taught a CPR and first aid course. Approximately fifteen children attended the session in San Carlos and twenty children and adults attended in Rancho Dolores. Additionally, I taught a water safety education course in San Carlos. With regard to CPR, I taught the compression-only method because it is the most effective technique. (Nishiyama, et al., 2014). Indeed, compression-only CPR is superior to conventional CPR because those performing CPR can more accurately remember how to perform CPR and do it correctly (Nishiyama, et al., 2014). To teach CPR, I first explained under what situations it is to be used. Then, I demonstrated how to properly perform CPR. Thereafter, the audience then practiced CPR. Furthermore, I also taught our community partners how to perform the Heimlich maneuver. Lastly, I gave a tutorial on proper wound care.

In Rancho Dolores I lead a class of fourteen women on the importance of exercise, and keeping track of their vital signs. The group was taught a Tai Chi routine, stretches, and resistance band exercises. Tai Chi and resistance band training are both effective to improve strength and balance. I lead the women through the Tai Chi routine. I also made Tai Chi exercise cards for them to follow. Thereafter, I taught them various resistance band exercise, and presented them with cards that included a variety of these exercises. Finally, I checked the vitals of the participants, including; weight, blood pressure, and heart rate. These vitals were tracked, and written down in their exercise booklet. The booklet and pedometers were distributed so that the women may record their physical activity.

In San Carlos there is proof that the CPR, first aid, and water safety education and training has been effective. Since the training began seven years ago, it has been put into practice on two occasions to save infants. In Rancho Dolores this was the first year for the education. This was the first year this program was initiated. Baseline measurements for weight, blood pressure, and heart rate were given. In San Carlos there is proof that the education to manage acute conditions has been effective. In the future, it would be beneficial to assess our community partners to determine what information they have retained and what should be reviewed.

REFERENCE

Nishiyama, C., Iwami, T., Kitamura, T., Ando, M., Sakamoto, T., Marukawa, S., & Kawamura, T. (2014). Long-term Retention of Cardiopulmonary Resuscitation Skills After Shortened Chest Compression-only Training and Conventional Training: A Randomized Controlled Trial. Academic Emergency Medicine, 21(1), 47-54 8p. doi:10.1111/acem.12293

INFANT BENCHMARKS AND E-READERS

Joseph Perry, McMaster Scholar, Belize 2015 – 2016

Children develop rapidly during their first years of life, and these years are a critical part in their development as this is when the foundation for future development is laid (National Down Syndrome Society, 2012). This project provided the mothers of San Carlos, Belize with information regarding developmental benchmarks to help detect developmental delays and provide early intervention when needed. This project also provided teacher training, and student access to e-readers in the village of Rancho Dolores. By helping to provide Rancho Dolores with e-readers, we aim to improve education by providing access to educational materials that may not otherwise be available in these remote areas.

Research shows that the first years of a child's life are important, as this is when they develop many of the basic abilities and learning patterns that will influence the rest of their lives (Park, 2008). "Children reach milestones in how they play, learn, speak, act, and move" (U.S. Department of Health & Human Services, 2016). It is important that parents be aware of these milestones, because parents who have a better understanding of child development usually are more proactive in seeking support services for their child (Park, 2008). With ten new babies being born in San Carlos in the past year, it is imperative that the mothers have knowledge of developmental milestones, so that they are able to monitor their children and seek the appropriate intervention when needed. Having limited access to doctors in the village, resources about developmental benchmarks will be beneficial when the child does have the opportunity to see the doctor, so that the mothers can discuss areas of concern.

In Belize I met with the women to discuss the importance of developmental milestones and early intervention. Then, I provided them with a checklist of developmental benchmarks found on the Centers for Disease Control website. These were distributed to the women in both English and Spanish. We spent time as a group going through the checklist. We talked through different benchmarks, and how to assess if their child was successfully reaching them. They agreed that these would be beneficial to use occasionally to assess their children. We finished our conversation by talking about what to do if their child may not reach a certain benchmark. The women were instructed to take the child to a doctor if their child continually lacks in a certain area, as the earlier the intervention is implemented, the more successful it can be.

Furthermore, while visiting the village of Rancho Dolores, McMaster scholars observed that the community has a small library but does not have access to many books. The teachers of the village recognize the importance of reading, but do not have the means to supply the library or children with books. E-readers are a great resource as each electronic reader can store hundreds of books, of which many can be downloaded for free. By providing e-readers to the village we have provided them access to a large and continued supply of books in a cost effective way.

Before traveling to Belize five e-readers were purchased and set up with over forty free books. In the village I spent time speaking with the Standard I teacher, Ms. Sutherland. I shared with her the passwords to the accounts and information she would need to download additional books. I also showed her the basic functions of the e-readers. Ms. Sutherland had some experience with technology, and quickly grasped the concepts I was demonstrating to her. Ms. Sutherland and I also spent time establishing rules for the e-readers. I then introduced the e-readers to the students. I shared with them the rules and procedures that Ms. Sutherland and I discussed. I then spent time demonstrating and letting the students practice the basic functions of the e-readers. The students then partnered up to complete a scavenger hunt race with the e-readers. The students then explored the e-readers, and I offered support and answered any questions they had.

With ten new babies born in the village in the past year—some to new moms—there was a need for a developmental benchmarks workshop. There were eight women that attended the workshop, most with their babies. The women were eager to look at the checklist and understood the importance of both the checklist and early intervention. The students in Rancho Dolores responded very well to the e-readers. The e-readers were introduced to ten students in the Standard I classroom. The students quickly picked up on the functions of the e-readers; the students were excited to be able to use them and were looking up words in the dictionary from around the room when they had free time. The Standard I teacher was also excited to have them available and believed that they would be beneficial in her teaching.

REFERENCES

National Down Syndrome Society. (2012). *Early Intervention*. Retrieved August 21, 2016, from National Down Syndrome Society: http://www.ndss.org/Resources/Therapies-Development/Early-Intervention/

Park, B. (2008). The Earlier, the Better: Early Intervention Programs for Infants and Toddlers at Risk. *Dimensions of Early Childhood, 36*(1), 3-6. Retrieved August 21, 2016, from http://southernearlychildhood.org/upload/pdf/The_Earlier_the_Better_Early_Intervention_Programs_for_Infants_and_Toddlers_at_Risk_Boyoung_Park_Vol_36_No_1.pdf

U.S. Department of Health & Human Services. (2016, August 18). *Developmental MIlestones*. Retrieved August 21, 2016, from Centers for Disease Control and Prevention: http://www.cdc.gov/ncbddd/actearly/milestones/

FAMILY DOCUMENTATION AND TECHNOLOGY ASSESSMENT IN RURAL BELIZE

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This family history project was implemented in the rural village of San Carlos, Belize. The McMaster School has been traveling to Belize for eleven years, and observations by many scholars indicate that family has always been important to our community partners in the village. Moreover, we have further observed that the people of San Carlos often define family broadly to include individuals who are not biologically related. Through this project family ties were explored and children were introduced to a fun way to learn about one's family history by documenting the current members of the family. With this project, the villagers are able to have record of their family at a specific point and time, which can serve as a way to see growth and recognize the importance of the past.

The family documentation project provided a point in time representation of the families, a map of the village with the name of the families that live in the houses, and incorporated parental collaboration in children's schoolwork. This project was performed through multiple steps. The first was teaching a brief lesson on family history to the two upper level classrooms in San Carlos, and providing the students with family trees to take home and complete with their parents or guardians. The second part was providing family photographs to the villagers. Many of these photos were taken in front of their homes, which also served as a way to map out the village and document the families that live there. With the family photographs, the villagers that participated were recorded. This served as a way to learn the families in the village.

The lesson on family trees went well; the students were engaged and they asked questions about the trees that were handed out. Moreover, there were about twenty-five families that had their pictures taken, and they were all provided with printed copies of the photos that were taken after they were edited. The photographs were well received by the families.

Secondly, I undertook a technology assessment in Rancho Dolores. Through this survey, I now have a better understanding of the needs of our community partners in this village. From the assessment, I learned that of the fourteen people I interviewed eight of them had used a computer before, and that two of them owned a computer. It was also determined that in order for the village library to get internet from the government, they would need to have at least four computers. Along with this data my discussion about technology with the residents of Rancho Dolores identified future projects that the villagers had specifically asked for, many of which had been done by previous scholars in the village of San Carlos. There are eight potential projects that are related to computers, either through use or repair and education. The technology assessment will eventually work to increase technological means in the community and increase access to information.

The laptops in San Carlos that had been brought down in previous years by McMaster teams were assessed. This involved testing the battery life, the keyboards, and space on the computers' hard drives; along with checking for any additional problems that may be encountered during the startup process. Of the computers in San Carlos, two of the eight computers were found to have some sort of problem and were brought back to be repaired. One of the problems was simply that the computer's original battery had died, and needed to be replaced. The other computer had a problem with the startup process. These will be repaired and returned to the village next year.