

A Collaborative Project In West Africa: Student Research Experience In Development

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Abstract - Undergraduate and graduate students from the University of Notre Dame and the Université d'Abomey-Calavi, Bénin, West Africa, have been involved in an international research experience. Established in 1998, this project includes regional sampling of groundwater quality, water-quality monitoring / education in a village in south-central Bénin, a well drilling program, and a geostatistics course taught in Bénin. In addition to student experience, these efforts have led to significant collaboration and time commitment among the faculty involved. In reviewing these efforts, two significant differences are noted between this research experience and other service experiences in developing countries. First, collaborative research requires long-term commitment between colleagues in the U.S. and in the partner country. Hence, it is concluded, short-term trips without long-term follow-up are unlikely to provide an optimal environment for international research collaboration. Second, research experiences are optimized when they include collaboration not only among faculty and students, but also among professionals, NGOs, and local populations in the partner country.

Index Terms – Research Experience, International Collaboration, Undergraduates and Graduate Students.

INTRODUCTION

A number of new educational, research, and service opportunities have been established and designed to provide undergraduate and graduate students with experiences of science/engineering in developing countries. Examples include Engineers Without Borders (www.ewb-international.org), Engineers For A Sustainable World (www.esustainableworld.org), the SAIWI graduate student organization at the University of Nevada, Reno (www.unr.nevada.edu/~saiwi), Engineering World Health (www.ewh.org), IAESTE (www.iaeste.org), and the recent REU program on Water Resources in Developing Countries centered at the University of Notre Dame (www.nd.edu/~reuwater). These efforts are related closely to the recognition that there is an increasing need to expose undergraduate and graduate engineering students to the social, political and cultural components of engineering practice. This need is reflected, for example, in NSF's recent call for

establishing international collaborations on research and education (e.g., NSF05533) and US AID's "Association Liaison Office for University Cooperation in Development" (<http://www.aascu.org/alo>). A number of papers have also discussed the need for international exposure and collaboration within engineering curricula [1] – [3].

The Department of Civil Engineering and Geological Sciences at the University of Notre Dame (UND), in collaboration with the Université d'Abomey-Calavi (UAC) in Bénin, has relatively extensive experience with various forms of student participation in education and research experiences in developing countries. These range from classroom instruction, to a service program in Haiti, to research and education programs in Bénin, West Africa (e.g., Silliman, 2003). As noted in Silliman (2003), the format of the international program can have dramatic impact on the resulting experience of the student. The present paper discusses our experiences with research programs (versus service programs) in Bénin with emphasis on the impact on the U.S. and Bénin student, as well as impact on the faculty members directing the project. It is noted that much of this discussion is based on the observations of the faculty (Drs. Silliman and Boukari) and students (including Ms. Crane) involved in these projects. Although formal assessment is being conducted on these projects and initial results are presented, the number of students involved to date is too small to provide statistically significant (formal) assessment results. Hence, the goal of this paper is to initiate discussion of the different needs and impacts of programs designed to provide a research experience in a developing country (as compared to a service or educational experience).

BACKGROUND AND FORMAT OF RESEARCH EXPERIENCES

The University of Notre Dame (UND) has been collaborating with the Université d'Abomey-Calavi (UAC) since 1998. Initial interactions involved drilling of groundwater wells and discussion of possible educational interaction and exchange. Starting in 2000, the collaboration moved to a more structured format through the establishment of a long-term project on characterization of groundwater quality and a refocus on research experiences for the students involved. Initial field results led to the development of a formal research program (through NSF INT-0138238) and the establishment of a

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Research Experience for Undergraduates (REU) site on Water Resources in Developing Countries (through NSF EEC-0139659 – see www.nd.edu/~reuwater and www.nd.edu/~silliman/Development/benin for further details). Over the past four years, 14 U.S. undergraduate / graduate students have participated in the project (with 11 traveling for field experiences in Bénin). The project has also involved approximately 16 students from UAC, five of whom were involved in the original drilling program, eleven of whom participated in a geostatistics course in Bénin, and one who is active in our field research activities (this student also completed the course in geostatistics). Drs. Boukari and Silliman are the principal faculty involved in this project and both have travelled to the partner country multiple times. The following paragraphs briefly outline the various forms of student involvement realized to date.

The U.S. students who have travelled to Bénin have been involved in two types of research projects. The first involves 2-3 week field sampling campaigns in which the student travels with Drs. Silliman and Boukari to various locations in Bénin collecting groundwater samples from hand-pump wells. This project involves extensive interaction with Dr. Boukari, representatives from a governmental organization responsible for water supply development (Direction de l'Hydraulique, or DH), and an NGO responsible for logistics (Centre Afrika Obota, or CAO). However, it involves only minimal interaction with Bénin students or the populations in the local villages. For example, time spent at each sampling location is limited to the time required to pump the wells sufficiently to ensure representative samples, collect the sample, and perform standard field characterizations (pH, temperature, conductivity, etc.). This time is typically less than 30 minutes, severely limiting the amount of interaction possible with the local population. Bénin students have not, to date, been involved in the sampling effort. Technical skills developed in this project include chemical sampling strategies, design of spatial sampling networks, development of research hypotheses with international collaborators, exposure to resource limitations in developing countries, and substantial experience in the challenges of field sampling in remote locations. Non-technical skill development includes being exposed to a substantially different culture, visiting a wide variety of locations within the partner country, working closely with peers in a challenging environment, and recognizing similarities / differences in the motivation (and work habits) of different cultures with respect to research on groundwater quality.

The second type of project on which a U.S. student (as well as a Bénin student) has participated involves working directly with a local population in research directed towards both understanding anthropogenic sources of groundwater contamination and strategies for empowering the local population to characterize and manage a village water supply. In contrast to the first project, this project involves focused efforts in one village without substantial travel throughout the remainder of the country. Further, it involves developing a level of mutual respect and a close working relationship both

among the students from the two countries and with the local population. Technical skills developed include significant expertise in a number of field and analytical test procedures, basic anthropological techniques, and the study of geostatistical analysis as applied to data sets with multiple levels of uncertainty. Non-technical skill development is wide ranging including living in a small Bénin village, developing a working relationship with the local population based on mutual trust / respect, and working with a peer student from the partner country on a project of common interest.

The Bénin students have been exposed to three types of interactions. First, students were involved primarily as observers / field-hands in a drilling project. They were provided with opportunities to contribute to the mechanical process of drilling, casing and developing a well while having substantial opportunity to interact with a professor from the U.S. No U.S. students were present during this portion of the program and the program was not research oriented. Technical skills developed include site assessment for installation of a groundwater well, and drilling / development of a groundwater well. Non-technical skills included working with groundwater professionals from both within and outside of Bénin as well as working with a local population in identifying water needs and water priorities.

Second, Bénin students were involved in a geostatistics course taught by Dr. Silliman at UAC. This three-week summer course provided substantial opportunity to develop technical skills in the use of computers (not a common skill within this program at UAC) and the fundamentals of data analysis and interpretation. Non-technical skills included interaction with a professional from outside of Bénin and exposure to the research philosophy of this professional. This initial effort involved only Bénin students (as noted below, efforts are underway to secure funding to allow a joint U.S. / Bénin course to be taught in Bénin during the summer of 2006).

Finally, as noted above, one student has been involved directly in village-level research in Bénin. This student was also one of the students involved in the geostatistics course. This research opportunity represents a unique opportunity for this student that would not have been possible without the presence of the ongoing collaboration, and includes development of technical and non-technical skills as outlined above for the U.S. student.

DISCUSSION OF THE RESEARCH EXPERIENCES

Each of the projects provided a substantially different experience for the student. We have most experience (and observe the greatest dissimilarities) with three of these projects and will therefore focus on the impact of these three: (i) Bénin students completing the geostatistics course, (ii) groups of U.S. students pursuing a field sampling campaign in Bénin, and (iii) the collaboration between the U.S. student and Bénin student working within an individual village in Bénin.

Geostatistics Course

The geostatistics course was taught in May of 2003 at UAC. The students involved were pursuing a “2nd stage” degree, loosely equivalent to a U.S. Masters degree, in earth sciences. Due to limited resources, these students had not previously had an opportunity to apply computer methods to their scientific studies. As would be expected, therefore, a significant component of the learning experience for these students was the introduction to the use of computers for scientific research. By the end of the course, the students were capable of writing basic statistical programs in MATLAB[®] and completing presentations using PowerPoint[®]. Beyond this introduction to computers, the students were exposed to the theory and practice of spatial data analysis for large data sets (using, for example, graphical methods, principal component analysis, indicator variables, and cluster analysis).

An interesting aspect of this experience was the interaction between the students and Dr. Silliman. Specifically, due to cultural differences, the students in Bénin were uncomfortable critiquing the course offered by Dr. Silliman. Only with prodding were they willing to share their views. However, once they began to feel comfortable in expressing their views, the impact and limitations of the course were clearly expressed. Among these were:

- Positive Impacts as Identified by the Students:
- Ability to use computers for scientific investigation, including an introduction to MATLAB[®]
- Information content of course
- Opportunity to work with real data sets
- Opportunity to present research results using PowerPoint[®]
- Opportunity to interact with an international colleague

Limitations:

- Language skills of lecturer (Dr. Silliman)
- Limited access to computers
- Short duration of course
- Desire to pursue a field sampling campaign as part of course
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Overall evaluation of this course experience indicate that it was a positive experience for the students, providing unique exposure to the international scientific community. Of the 11 students who participated in the course, one has opted to pursue a research graduate degree in Bénin (and is active in our field research program). The remaining students completed their 2nd-stage degrees and have left the university. Hence, long-term impact of this experience will be difficult to assess.

After consideration of the strengths and weaknesses of the course, we conclude that the experience was a positive experience for the students, but not dramatically different than might be gained from a regular course offered at UAC. After assessing student response to this course, as well as our other ongoing efforts at developing research collaboration, we conclude that this experience could be improved, including: (i)

addition of field sampling, (ii) addition of permanent computers for student access, and, most significantly, (iii) addition of interaction with students from the U.S. In response to this assessment, two permanent computers have been secured for student use and efforts are underway to include field activities in the next offering of this course (May, 2005) and to secure funding for the summer of 2006 through which a group of U.S. students would travel to Bénin to complete the course with their Bénin peers.

Field Sampling

Students from the U.S. have assisted in the field sampling campaign since the summer of 2002. The students have been formally surveyed regarding their experiences both before and after the field experience. Impacts on these students have been multifaceted, ranging from significant influence on their choice of career to disappointment with the inability, in such a wide-ranging sampling campaign, to make closer connection with the local population. Comments regarding this experience, as taken from the student surveys, include:

- *I expected to join up with a heavily research-oriented program, involving field work in Bénin. From the beginning, I was introduced to very sophisticated techniques of analysis, and the program retained a very clear start-to-finish vision of how these techniques would be used with relation to our groundwater sampling in Bénin. (previously cited in Silliman, 2003)*
- *My experience with Notre Dame's REU Ground Water in Developing Countries was a defining event in my life. Academically, it confirmed my interest in working on water issues as I continue down the path of an environmental engineer.*
- *Personally, it was my first introduction to developing countries, and the program allowed me the opportunity to see Béninois (sp) life in many different environments and from a number of different perspectives, including that of a local university professor and the governmental water agency. Notre Dame's program instilled in me a desire to maintain a lifelong involvement with the developing countries of the world.*
- *The slight 'no' (disappointment) will be my initial expectation to work on the village local level. We ended up working much more with the local government agency, and not the villagers.*

It was interesting to note, with respect to the last comment, that at least one student differentiated between working with the local population and working with local government agencies concerned with water issues. This student interpreted working closely with a local, in-country government agency as not fulfilling the desire to work with the people of Bénin, despite the observation that the employees of that agency were all Béninoise.

As previously noted in Silliman (2003), this format represents a significant research experience for the student. This is indicated (Silliman, 2003) through student evaluation of the experience, as well as changes in student evaluation of

their undergraduate curricula in a before / after set of surveys. The students were asked, for example, to evaluate their undergraduate curriculum for various components ranging from basic courses in the math and sciences, to opportunities to consider projects based in the international (and developing country) environments. Specifically, the students were asked both “how important should each component be in an undergraduate curriculum?” and “how important has each component been in the curriculum you are completing?” The difference between responses (“should” versus “has been”) was viewed both before and after the field experience. On average, the students did not show significantly higher discrepancies between “should” and “has been” for the majority of the components. However, when results were compared for the components “opportunities to pursue classes / projects outside of the United States” and “opportunities to pursue projects in developing countries”, the students were much more critical of their undergraduate curricula at the end of this research experience than they were prior to the experience, a strong indication that the experience changed their view of certain aspects of the engineering profession.

In terms of overall impact of the experience, Silliman (2003) noted that the research experience was clearly positive for the students. However, this research experience was accompanied by significantly higher costs (in terms of financing for travel, insurance, etc., as well as faculty time-commitment) and risk (due to the need for international travel and living conditions in the developing country). It remained unclear whether the increased impact of the international experience as compared to a classic (U.S. based) REU experience justified the additional cost and risk associated with this experience. We remain neutral with respect to this particular question and note that the failure of the sampling program to make close connections with either the local population or students in the partner country represents a limitation on this experience.

Collaborative Research

During the summer of 2004, two UND students worked in the village of Adourékoman, Bénin, in pursuit of a research and education program. The first student, an undergraduate, worked with local teachers and grade-school students in initiating an educational (video) exchange program among K-12 students. This student had minimal interaction with the faculty or with Bénin university students. The second student, a graduate student, initiated a research project on groundwater quality. This student was joined in this effort by a graduate student from UAC as well as a representative of CAO. The undergraduate remained in Adourékoman for a period of approximately one week (although he did not sleep in the village). The graduate students lived full time in the village of Adourékoman for a period of approximately 4 weeks. Both projects are being extended during the summer of 2005.

It is important to note that the collaboration between the UND and UAC graduate students, as well as collaboration with the people of Adourékoman was the result of the long-

term commitment of both UND and UAC to collaboration. In particular, development of the trust and openness required to work with the local population in their pursuit of a sustainable water supply required close collaboration among UND, UAC, DH and CAO. Only through this collaboration could an appropriate field site (Adourékoman) be identified and could the local population feel comfortable enough with the research program to allow them to be surveyed relative to their priorities in terms of water quality and water supply management.

Although this research is ongoing, such that it remains too early to determine if the result of the technical aspects of the research will be successful, a number of observations have already been acquired relative to the impact of this experience on the students involved and the potential for inclusion of additional students (undergraduate and graduate) from both UND and UAC. First, this is the first of the three project formats that has led to true collaboration between UND and UAC graduate students. In this case, both the UND and UAC graduate students intend to base their graduate research projects on this site. Second, the students in this project have personal ownership of the project. This contrasts with the geostatistics class in which students were active participants, but did not guide or control content. This also contrasts with the sampling program in which students were active participants, but only as assistants to the faculty members in charge of the project. Third, the stakeholders (the local population) are intimately involved in all aspects of this project, ranging from housing the graduate students, to leading discussion of local priorities on water use and water quality, to completing training in water quality testing such that they have the tools to monitor their own water quality. While interaction with the local stakeholders is also evident in the field sampling program (through interaction with DH), it is far more developed in the research program based in Adourékoman. This is evidenced both by the success of the ongoing research in Adourékoman and by expressed interest among all parties involved to expand this program.

Of the three formats discussed, this format clearly has the greatest time commitment by, and empowerment of, the students involved. Further, it is the only format which has taken full advantage of the international opportunity to produce true research collaboration among the students involved. Finally, this format has the potential to result in a number of collaborative extensions of this project involving multiple students from both the U.S. and Bénin. Thus, this format is considered to represent the strongest international research experience of the three formats discussed. This strength is very much a product of the time commitment that has been made to developing collaborations among project partners, including the local population.

Brief Comment on Faculty Contribution

Prior to discussing the relative merits of the various research experience formats, it is important to note that these experiences require significant faculty commitment, and that

this commitment takes a form that is somewhat different than that required for international educational (e.g. semester abroad) or service (e.g., short-term service trips) programs. Faculty commitment, in our experience, is a non-decreasing (essentially monotonically increasing) function of time and complexity of the experience. Initially pursued as a drilling project, the project in Bénin rapidly escalated to include research and educational collaboration among faculty members at both UAC and UND. Based on the interests of the UND and UAC faculty, as well as those of DH and CAO, the project now includes research on groundwater quality in Bénin, local empowerment of the Bénin population to monitor water quality, educational exchange of Drs. Silliman and Boukari, an educational initiative to develop K-12 educational exchange through digital video, and collaborative efforts between Drs. Boukari and Silliman on a water project in Haiti.

This expanding time commitment is significant to the following discussion for two reasons. First, commitment to this research / education collaboration has developed in a manner very similar to commitment to research collaboration among colleagues in the United States. Specifically, the collaboration has evolved as the contributors have found common interests in research and education. Hence, much like research collaboration in the U.S., it is difficult to conceive of committing the resources necessary to further expand projects of this type without involving greater numbers of faculty. Second, this expanding collaboration, with its associated time commitment on the faculty, is among the primary reasons that UND and UAC could develop the successful collaboration on research in Adourékoman. It is precisely the interest in continuing to expand on this collaboration (including the partner agencies) that holds promise to develop new, increasingly integrated, collaboration among students at UND and UAC. It is therefore concluded that success in developing true research collaboration among students in the U.S. and students at collaborating universities in developing countries requires significant commitment by the lead faculty to provide the necessary time and resources required to create a long-term, research collaboration among faculty at the home and foreign institution. As such, it is critical that such a research experience be based on common research interests, common research vision, and availability of long-term research support (financial and administrative) at both the U.S. and partner institutions.

DISCUSSION

Our experience with developing collaborative research experiences in developing countries has led to a number of project formats as well as a number of observations of strengths and weaknesses of these various formats. In all cases, significant positive benefit was derived from the project formats. With the course taught to Bénin students in Bénin, the students were exposed both to the use of computers in scientific / engineering research and to basic techniques in data analysis. Through the field sampling campaign, students from the U.S. were exposed both to field sampling strategies

(and associated technologies) as well as to the opportunities and challenges faced in developing countries. The field research in Adourékoman provided the opportunity for true collaborative research between students in the U.S. and students in Bénin.

In considering the overall impact of these projects, however, a number of weaknesses were identified within the individual formats. The course, for example, included no interaction between the students in Bénin and their counterparts in the U.S. Further, at that time, the computers used for the course were solely on loan to UAC (from UND) such that the students were without computing resources following completion of the course (two desk-top computers have since been purchased for this department at UAC). Similarly, the field sampling campaign involved no interaction among U.S. and Béninoise students. Finally, the students involved had only minimal opportunity to develop individual ownership of the research (as noted in several of the student evaluations).

Identification of these weaknesses leads to an observation regarding a significant difference between international research experiences in a developing country versus international service experiences in developing countries. Service experiences, such as those hosted by the organizations Engineers for a Sustainable World, Engineering World Health, and Notre Dame's Haiti seminar (www.nd.edu/~silliman/Development/haiti), tend to focus, as primary objectives, on the student experience of a different culture and the application of engineering skills in addressing a specific engineering problem. For example, in the Haiti seminar at Notre Dame, we focus on repair of hand-pump wells for water supply. In the Engineering World Health program, the focus is on establishing and repairing medical equipment. As such, these types of projects are amenable to short-term visits with minimal development of intellectual exchange with either professionals or the local populations in the partner country. This is not to say that such exchange cannot occur in these projects: empirical evidence suggests that it often does. This is to say only that such intellectual exchange is not necessary in order to achieve the primary objectives of the project: student experience and application of engineering skills.

In contrast, development of true research collaboration necessarily involves an objective of intellectual exchange between partners in the different countries. Hence, while of value from an educational standpoint, the geostatistics course taught in Bénin must be considered a precursor to an international research experience rather than the research experience itself. The field sampling campaigns come closer to the target, but are based more on the long-term intellectual engagement of the faculty and professionals involved than on the intellectual engagement of the students who are in country for only short periods of time. Of the formats discussed, therefore, only the third format – involving collaborative research among students from the U.S. and Bénin, as well as the local population – approaches a format in which the primary objective of intellectual exchange (among the

students) can be obtained. Within this format, the students work as a team and success of one student is, in many ways, tied directly to the efforts and intellectual engagement of their peer in the partner country.

Achieving an international research experience in developing countries, therefore, appears to present far more formidable challenges than does achieving an international learning or service experience. Specifically, based on our observations over the past several years, it is argued that achieving such a research experience will require:

- Active collaboration among faculty and/or colleagues in both the home and partner countries. This collaboration is likely to become a significant component of the research efforts of the faculty involved.
- Long-term commitment to the collaboration. A collaborative research experience (for the student) is likely to approach the goal of intellectual exchange with students in the partner country only after the research collaboration between institutions is well established.
- Substantial time in the partner country. Based on our experience, it is considered unlikely that effective research collaboration can be achieved without substantial time commitment in the partner country, thus allowing identification of social, educational and research norms and priorities.
- A common language for the research effort. Continuous translation of complex ideas can become a significant impediment to research progress and, as is the case in our particular situation, may prevent students from the partner country from studying in the U.S. (or vice-versa).

It is noted that these requirements closely parallel the requirements of research collaboration among colleagues

within the U.S. or between colleagues in the U.S. with those in Europe. This result is significant, we believe, as it highlights the level of commitment necessary to move from service-oriented experiences to true research experiences with our colleagues, and their students, in developing countries. Such commitment should not be taken lightly either by the U.S. faculty or student, and is a necessary next step in developing a more complete engineering graduate both in the U.S. and in our partner countries.

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