

# International Student Collaboration Through Projects Using Common Software and Field Experiences: Foundation to Program Development

Stephen E. Silliman<sup>1</sup>, Moussa Boukari<sup>2</sup>, and Pamela Crane<sup>1</sup>

**Abstract** –The University of Notre Dame (UND, USA) and the University of Abomey-Calavi (UAC, Bénin , West Africa) initiated a program whereby undergraduates at UND work with graduate students at UAC. The program involves two years of collaborative effort, including 8 weeks of field effort in Bénin . Constraints encountered were related to different languages used by the two student groups, funding, travel to Africa, project definition, and technical training. These constraints were addressed via four points of strength: (i) common interest in the project at the two universities, (ii) the use of a common program environment (the use of publicly available software), (iii) participation by faculty from UND and UAC, and (iv) the program is built on common student interest in obtaining experience in groundwater sampling as well as in a project with socio-cultural impact. Initial assessment of the program indicates positive attributes as well as points where improvement can be realized.

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

## INTRODUCTION

In a prior paper [1], initial discussion was presented regarding international research experiences as a distinct engineering experience separate from such international educational / service experiences as international semester programs, Engineers Without Borders ([www.ewb-international.org](http://www.ewb-international.org)), or Engineers For A Sustainable World ([www.esustainableworld.org](http://www.esustainableworld.org)). The prior discussion was based on research efforts (e.g., summer REU programs) that involved only limited collaboration between students from U.S. universities and students in the second country. As such, the previous discussion did not explore the potential for long-term student-to-student collaboration within a research program.

Within the present paper, initial planning and preparation are discussed for a new form of research experience that involves multi-year collaboration among students from multiple universities in different countries. This experience involves both academic year experience (over two academic years) at the home institution of the individual student and field experience in Bénin over an 8 week summer period. As

such, this experience has potential to address the growing needs both for undergraduate research and exposure to international engineering experiences such as are reflected in recent calls from NSF and USAID for international collaboration (e.g., NSF05533 and <http://www.aascu.org/alo>) and a number of papers on the need for international exposure in undergraduate engineering programs, e.g., [2] – [4], including the summary of discussion at the Third Annual Colloquium on Engineering Education (2004) [5].

This paper represents a contribution to ongoing discussions of internationalization of education for engineering students. It is recognized that a number of innovative programs exist for increasing international exposure for U.S. undergraduates. A number of these have been recognized, for example, by the American Council on Education and AT&T through their international technologies award [6]. Among these, those that are most similar to the program discussed herein appear to be the *Alliance by Design* program hosted by Pennsylvania State University ([7,8] and <http://cede.psu.edu/alliance/>) and the *Runestone* project hosted by Uppsala University (<http://runestone.it.uu.se>). Our understanding of these two projects is that they involve innovative approaches to allowing undergraduates from universities in the U.S. to pursue design projects teaming with counterparts in universities in the partner countries. While the program discussed here is informed by these and other efforts, we believe that it differs to a degree from these prior efforts based on its focus on research between undergraduates in the U.S. and second-degree (or graduate) students in the partner university. As discussed in our previous paper [1], we believe that interaction in the realm of research is different in several ways than is interaction based on educational exchange / collaboration or service experiences. It is therefore believed that discussion of the initial observations regarding the present program is warranted.

The program discussed herein builds on extensive collaboration between the Department of Civil Engineering and Geological Sciences at the University of Notre Dame (UND) and the Département des Sciences de la Terre at the Université d'Abomey-Calavi (UAC) in Bénin, West Africa. Prior collaboration has included classroom lectures by Drs. Boukari and Silliman (in both the United States and Bénin ), field research in Bénin, joint service efforts in Bénin and Haiti, and K-12 educational programs in both countries [see,

<sup>1</sup> Stephen Silliman and Pamela Crane, Department of Civil Engineering and Geological Sciences, University of Notre Dame, Notre Dame, IN 46556, [Silliman.1@nd.edu](mailto:Silliman.1@nd.edu)

<sup>2</sup> Moussa Boukari, Département des Sciences de la Terre, Université d'Abomey-Calavi, Cotonou, Bénin , West Africa, [mboukari@bj.refer.org](mailto:mboukari@bj.refer.org)

e.g., references [1,9] for overview of some of these programs – see also [www.nd.edu/~silliman/Development/Bénin](http://www.nd.edu/~silliman/Development/Bénin)]. The program discussed herein involves long-term research collaboration between students at UND and UAC, including a joint, 8-week summer field effort in Bénin and distance collaboration (using the internet) over a minimum of two academic years. As such, it differs from our previous efforts in short-term research [1] and, based on the focus on research collaboration rather than course-work or design, from many of the other educational experiments currently being pursued (e.g., the *Alliance for Design* and *Runestone*).

The present paper presents the foundation developed for this program, including the importance of the prior collaboration between UAC and UND. It also presents initial activities in the program, including student preparation, choice of project scope, and selection of appropriate computer models for use at both universities. Finally, it summarizes initial metrics regarding the strengths / weaknesses of this model of international experience by engineering students.

### **HISTORICAL CONTEXT OF PROGRAM**

Research collaboration between UND and UAC was initiated during the summer of 2000 (overall collaboration between UND and partners in Bénin was initiated in 1998, [1,9]). Specifically, field sampling trips occurred in the summers of 2000 and 2002-2005. This research was initially focused on characterization of groundwater quality in central and northern Bénin and was dependent primarily on Research Experience for Undergraduate (REU) students and engineering undergraduates from UND working under the joint direction of faculty from UND and UAC. There was no interaction with students from UAC. Interaction with students from Bénin began in 2003 when a faculty member from UND presented a short course on geostatistics at UAC. While this experience was judged to be beneficial to the students in Bénin, the course did not include students from UND. This initiative has continued through contributions of a faculty member from UAC to a groundwater course at UND during the 2004 academic year (only UND students involved) and another course in geostatistics taught by a UND faculty member in Bénin during the summer of 2005 (again, only UAC students involved). Assessment of these prior efforts has been provided in a previous publications [1,9].

Two new efforts have occurred over the past two years to motivate interaction between students from UND and UAC. Following on field sampling of nitrate contamination in the summer of 2003, a research project was initiated in 2004 in a village in central Bénin. This continuing project involves empowerment of the local population in monitoring groundwater quality. The project is based on one graduate student from UND and one graduate student from UAC living in the village for a period of approximately 8 weeks (each summer) in order to develop this monitoring program in collaboration with the local population.

During the summer of 2005, as a follow-on to the second geostatistics course, three UND students accompanied the

UAC students on a brief field sampling campaign. This effort allowed faculty from both UAC and UND to observe the potential for interaction among students during a field campaign. As discussed below, these observations led to identification of a number of potential positives and challenges within this type of interaction.

### **IDENTIFICATION OF CRITICAL CONSTRAINTS**

Based on observations from these prior efforts at research and collaboration, discussion was entertained regarding the potential for creating one or more projects which involved true collaboration among students from UAC and UND. The following constraints were considered to be important in initiating such collaboration (these are discussed below):

- The project(s) must be of interest to students at both UAC and UND.
- The requirements of the project(s) must take advantage of expertise of the students from both UAC and UND.
- The requirements of the project(s) must be within the technical limitations of the combined strengths of UAC and UND.
- The project(s) must cover a time frame consistent with a reasonable expectation of academic time of the students at UAC and UND: specifically, approximately one academic year of preparation, one summer of field research, and one academic year for analysis and preparation of papers.
- The potential result of the project must be both of a significance that can lead to publication and that can lead to development of future collaborative projects.
- The projects must be of sufficient significance that funding can be identified for support of the students at both UAC and UND.
- The projects must be consistent with international collaboration in two languages (French and English) using the internet as a critical form of communication.
- The projects should contribute to the ongoing collaboration between UAC and UND.

Several of these criteria are based on our prior experience. For example, we observed during the summer field work of 2005 (involving students from both UAC and UND) that lack of common knowledge of the motivation for the research and skill sets in the research were detrimental to overall progress of the collaboration. Specifically, we noted distinct separation between the UAC and UND students. For example, two of the UND students were less-well prepared than the UAC students in terms of application of geostatistics and the motivation of the field campaign. As a result, these two students became ‘extras’ in the field campaign, contributing primarily intercultural exchange. They were not prepared to contribute intellectually to the project and therefore did not help to contribute to a collaborative research environment.

It was also noted that the other UND student was more advanced in terms of both understanding of the geostatistics and understanding the purpose of the field campaign. Further,

## IDENTIFICATION OF INITIAL PROJECTS

this student was not involved in the geostatistics course which occurred immediately prior to the field campaign. Little collaborative spirit was developed between the UAC students and this student.

Based on these observations, it was determined that among the most critical constraints on future efforts at creating collaborative projects were common (among the UAC and UND students) interest in the project, common or complementary preparation for the research, and potential of all students to contribute intellectually to the project. It is suggested that these constraints are at least of equal importance as the technical and publication constraints outlined below.

We also observed in our previous short-course efforts that the students from UAC expressed strong desire to understand, and become involved in, the field applications of the course materials (in this case, geostatistics). This led to constraining this effort to projects within the technical capabilities and combined strengths of the two student groups (UND and UAC). Further, we felt it important that the projects had the potential to lead to publication in a technical journal in order to fully motivate the students.

Finally, a number of practical constraints were considered important for this program. First, achieving a publishable result requires sufficient time to allow both groups of students to become familiar with the critical concepts, sufficient field work to be completed to provide appropriate data for analysis, and sufficient time for analysis and completion of an appropriate research paper. After consideration, it was determined that an appropriate time period would involve up to one academic year of preparation, one summer of field efforts, and an additional academic year for analysis of data and preparation of appropriate research papers.

Second, such collaboration between the United States and Bénin is relatively expensive. Hence, the research projects identified must be of sufficient technical interest that funding agencies will express interest. In our case, projects were identified with sufficient interest to attract funding from the National Science Foundation, a private foundation and a private funding source.

Finally, as was noted in our prior efforts at running an REU site on international water resources [1,9], pursuing projects that are independent from ongoing research efforts of the key faculty creates a difficult conflict-of-interest in terms of time commitment of those faculty. We extend this earlier comment to include research interests not only of key faculty, but also of key graduate students. Specifically, graduate students with detailed knowledge of the partner country can become deeply involved in project details unrelated to their research program, and can thus be placed in a conflicting position of choosing between supporting the collaborative effort or pursuing required research objectives. Hence, it was decided that the projects to be identified must be consistent with ongoing interests of the key players. In our case, these included continuing studies of nitrate contamination in a village setting in south-central Bénin and salt-water intrusion in coastal (southern) Bénin.

Based on these various constraints, two projects were identified for this educational prototype. The first is a continuation of a groundwater monitoring program. Within this project, students from UND and UAC are working collaboratively with the population of a village in south-central Bénin to develop a long-term, high-frequency monitoring program for groundwater quality. The project includes collaboration not only between UND and UAC, but also among a number of disciplines including geology, environmental engineering, and anthropology.

This project is subject to a number of complications (including a concurrent education program) that lead to unique constraints, and opportunities, that are beyond the scope of this paper. Hence, this project is not discussed further in this paper.

The second is a project whereby students from UND and UAC are working on the development of a predictive model of salt-water intrusion in coastal Bénin. The project addresses the constraints outlined above through use of a common summer field experience (all students performing work in Bénin) as well as open-source, public domain software. As such, we believe this project to be a relatively unique effort at international research collaboration involving both U.S. undergraduate engineering students and graduate students (second-degree students – typically 2-4 years older than the UND students) from a developing country. Hence, the initial conception and planning of this project is the focus of the remainder of this paper.

The original concept of this project, which builds on ongoing collaborative research between UAC and UND, was based on three phases (as noted in the next section of this paper, modifications to this original concept were necessary for a variety of reasons). In the first phase, students at UND and UAC were to work independently to prepare for their contribution to the research. At UND, the students would prepare for two semesters (with more active preparation in the second semester) prior to the field effort. The goal of this preparation was familiarization of these students with the groundwater modeling software to be utilized in all aspects of the program (the MODFLOW family of computer programs [10] and SEAWAT [11] are being used). At UAC, the students were to complete a course in groundwater hydrogeology with emphasis on the hydrogeology of southern Bénin.

In the second phase, the UND students were to travel to Bénin where they were to collaborate with the UAC students in three efforts. The combined research team was to complete a short course (one week) on numerical modeling and the hydrogeology of southern Bénin. The research team then would pursue a five- to six-week modeling study of the southern aquifer system in an effort to understand historical variation in water levels and chemical composition in the aquifer. Finally, the research team would perform field sampling and testing so as to develop data (water quality and

groundwater response) necessary to pursue prediction of future behavior in the aquifer.

Following the summer interaction, the students would enter the third phase of the program at their home universities. Specifically, the two student groups would attempt to jointly complete the predictive portion of the modeling (including identification and analysis of future management strategies) using the internet for communication. The goal would be preparation of one or more papers related to this modeling study for publication in professional journals.

This concept fulfills, to a greater or lesser degree, each of the constraints outlined above. First, this project carries significant interest to both UAC and UND. For UAC, this project has been identified by scientists in Bénin as critical to the future management of a critical water resource in Bénin. As a result, it provides an opportunity for the UAC students to apply practical geologic analysis tools to a real problem and therefore represents practical training for these students who will likely pursue careers in government or industry in Bénin. It also opens the possibility of graduate studies outside of Bénin. For UND, this project represents an opportunity for the students to apply engineering analysis tools to a critical socio-economic question, while pursuing field work in the partner country.

The skill sets required for this project include a combination of the mathematics for the predictive model (a strength of the students from UND) and knowledge of the local geology / production from the Cotonou well field (a strength of the students from UAC when combined with local records available for water production supporting Cotonou, the largest city in Bénin). Hence, both student groups have significant, complementary strengths to bring to the project.

In selecting the models to be used in this project, the third constraint led us to identify open-source, public-domain programs for all aspects of the modeling. As such, the faculty and students in Bénin have free access to the software, thus removing economic pressure on UAC (although it is noted that the software is more easily utilized using commercial and/or public domain GUIs – the commercial versions have cost ranging from \$200 - \$1300 – available to the students at UND, these GUIs are being provided for the Bénin program). The final programs selected include the MODFLOW family of programs [10] for analysis of flow and SEAWAT [11] for prediction of density-dependent transport. Both packages are available from a U.S. Geological Survey URL ([http://water.usgs.gov/software/ground\\_water.html](http://water.usgs.gov/software/ground_water.html)) and have been widely applied to similar research efforts.

Similarly, in delineating the field portion of the research effort, the techniques to be utilized will include field-portable specific-ion electrodes, field colorimeters, and similar portable devices. Limitation to field portable devices is related to the lack of advanced analytical equipment in Bénin and the desire to allow the UAC and UND students to fully engage in the field measurements. As such, the field research is within the capabilities of both research programs and the anticipated skill sets of the students. A concession to the research that violates the spirit of this constraint is the planned collection of select

water samples for isotopic analysis (to be run at a private laboratory in Canada) and the planned analysis of major and trace elements in select samples using ICP-OES and ICP-MS capabilities at UND. This use of more sophisticated laboratories will both be beyond the capabilities of the students involved and will lead to a significant delay (beyond the 8 week summer period) in receipt of the final analyses. Hence, this aspect of the project will be beyond the direct control of the students. It is believed, however, that use of these measurements is critical to establishing the quality of the final research results and therefore represents a reasonable use of advanced technologies despite these technologies being beyond the regular capabilities of the students.

With respect to the constraints involving outside interest in the project (potential to develop publications, continuing projects, and funding), review of the literature and recent international conferences indicates active interest in studies of salt-water intrusion. Further, many of the larger cities in Africa (and other regions of the world) are located in coastal environments in which salt-water intrusion may play a crucial role in long-term management of water resources. Finally, development of a calibrated / validated model of salt-water intrusion in coastal Bénin provides the opportunity both to pursue publication in technical journals and identify future research hypotheses (e.g., studies of alternative management strategies and verification of model predictions through continuing monitoring). Hence, this project was considered viable from the vantage point of these constraints.

The constraint that is perhaps most difficult to address is the language barrier. The UAC students are most comfortable using French (although they commonly speak multiple local languages as well as limited English) whereas the UND students are most comfortable in English. As a result, projects that require rapid, verbal communication under critical field conditions are considered problematic. In contrast, computer modeling combined with simple field techniques reduces the need for communication under critical time-constraints and therefore reduces opportunity for long-term, negative consequences of miscommunication. Hence, by placing the project within a mathematical context, the students will have the luxury of learning key technical terms in the partner language in a relatively relaxed atmosphere. The key point of continuing concern in this regard will be the ability of these students to engage in discussion of complex boundary conditions and/or interpretation of modeling results. The availability of faculty at UAC who are fluent in English will help to overcome such difficulties should they occur.

#### **FROM CONCEPTION TO REALITY – INITIAL ASSESSMENT**

Funding for pursuit of this program was received from NSF (OISE-0526128) in the fall of 2005. The timing of this funding led to an immediate impact on the original program design. Specifically, receiving the funding in the fall, after students had registered for their fall classes at UND, led to a

situation in which the students to be selected for the program could not be expected to dedicate substantial academic time to this program in the fall semester (due to existing full course loads). Hence, a selection process was designed and implemented, with final selection of participants occurring late in the first semester. The students were encouraged to pursue readings (provided by the program coordinator) over the Christmas holidays, but were not held accountable for academic credit in the fall semester. This loss of the fall semester is, we believe, instrumental in difficulties we faced during the spring semester whereby the UND students associated with the salt-water intrusion project found it difficult to dedicate the time necessary to become proficient at the models and to complete initial modeling. Hence, these students were not fully prepared at the beginning of their travel to Bénin. In terms of assessing the program at this stage (initial arrival in Bénin), therefore, it is apparent that a single-semester of preparation with time commitment equivalent to a single course was inadequate for preparing students for this type of research effort.

Initial experience with the start-up of this program also led to assessment of student enthusiasm for this offering (as compared to prior service or short-term research offerings). In collecting applications and completing the interview process for this program, three observations were made. First, the application pool was once again over-represented with women as compared to the population in our undergraduate engineering programs. This observation is consistent with the application pools in our prior efforts [1, 9] and with the literature on the types of experiential programs likely to preferentially attract women.

Second, the long term commitment (the equivalent of 3 courses over 3 semesters) appeared to discourage student enthusiasm for this program. For example, while the application packet for this program clearly indicated the commitment required in terms of credit hours of research over two academic years, we had a number of applicants reach the interview stage only to withdraw during (or after) the interview based on the perception that the program was overly restrictive relative to their undergraduate engineering degree program.

This observation must be considered within the context of the typical undergraduate engineering curriculum at Notre Dame. The civil engineering curriculum, for example, allows the students a total of 2 civil engineering electives, 1 technical elective and 1 free elective. Hence, those students opting to participate in this program without exceeding the minimum credit requirement will dedicate 3 of 4 of these electives to this program.

Third, we believe that this longer term commitment also had a negative impact on the number of students who applied to the program. Specifically, while opportunities to work and study in a developing country have, in our previous efforts, resulted in a large number of applications from the UND undergraduate population, this was not the case in the present program. Specifically, despite several announcements of the availability of the application packet, the number of

applications was quite small. Hence, we anticipate that lower numbers of applications will continue to be a problem in future offerings of this program.

Experience and practicalities up to this point in the program has also led to somewhat revised expectations for the summer research period. In the original concept, the UND and UAC students were scheduled to complete a 2-3 week course in modeling and salt-water intrusion, followed by 5-6 weeks of work in modeling and field characterization along coastal Bénin. As plans for the summer have expanded, however, the integration of this effort with other field efforts required of the authors of this paper (including the water-quality project, the education project, and interest in revisiting previous research on regional groundwater quality) have led to compromises among the various field efforts. With respect to the student activities for the salt-water intrusion project, this has resulted in reducing the planned time for the short course to approximately 8 days of classroom activity (approximately 6 hours per day). This change was necessitated by three competing interests: -1- the lead faculty member from UND is limited to a total of 3 weeks in Bénin for this summer, -2- there is a need for both lead faculty to visit, with the graduate student, the village hosting the water-quality and education projects (requiring ~2-3 day commitment for travel and meetings), and -3- the lead faculty and graduate student wish to expand the experience of the UAC and UND students through pursuing a short, secondary field sampling campaign which will expose these students to additional field strategies with respect to characterization of regional groundwater. While it is not anticipated that this modification of plans will adversely impact the salt-water intrusion project (and will contribute to the overall educational experience for the students), it is recognized that the need for flexibility in the field makes setting formal schedules for the summer interaction problematic.

### **CONCLUSIONS AT THIS STAGE AND FUTURE PLANS**

Based on our previous efforts and review of programs available at other universities, we note that a number of formats have previously been tested for developing international experience for U.S. undergraduates. Further, it was observed [1,9] that the benefit to the student is strongly dependent on the expectations of the program (e.g., service versus educational versus research). The program described herein presents a new format to encourage active collaboration among students, albeit a format that requires substantially greater commitment from the faculty and graduate students overseeing the program, as well as from the students involved in the program.

The new format addresses several of the short-comings and requirements of international research experiences as addressed in our previous work [1,9]. Specifically, it builds long-term research collaboration around research activities which: (i) are built upon active collaboration among faculty and graduate students, (ii) are based on long-term commitment

to the program by faculty from both countries, and (iii) involve substantial face-to-face time commitment of the U.S. students and faculty in the partner country.

Initial assessment of this new program leads to several initial conclusions:

First, this type of collaborative, long-term program appears feasible. In this case, feasibility appears to be derived both from the long-term collaboration of the primary faculty and graduate students and, in part, from the joint interest (among the faculty and students from UAC and UND) on the specific research project selected. Hence, it is concluded the continuing to pursue this type of formal, long-term program is worthwhile.

Second, despite the positive momentum gained in the program, initial struggles with the program lend support to the observation that [9] “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, our initial efforts at assessment of the student experience demonstrate that an extended period of preparation prior to travel to the partner country is essential to preparing the U.S. students for their international experience. However, this extended time commitment (in terms of course credits) appears to discourage applications and enrollment in this program.

These initial observations suggest a number of questions for continuing assessment during the remainder of this first offering of the program:

First, in terms of the final product derived from the collaboration, the program will be assessed in terms of the students’ ability to produce one or more publications jointly authored by students (and faculty) from UAC and UND.

Second, the impact of participation on the future plans of students both from UND and UAC will be monitored and assessed. We have extensive assessment of students from UND to serve as baseline for the UND students. Unfortunately, we do not have an equivalent baseline for students from UAC and will be limited to applying pre- and post-program comparison tools for these students.

Third, the time commitment and satisfaction of the lead faculty and lead graduate student will be assessed at several points during this two-year program to determine satisfaction relative to the value returned to their research based on that time commitment.

Fourth, the time commitment and satisfaction of the UND and UAC students involved in the program will be assessed at multiple times during the summer and coming academic year to determine continuing dedication to the program and

satisfaction with the program. These data will also illustrate any differences in commitment / satisfaction between the UND and UAC students.

Finally, the degree to which the students from UAC and UND form international teams (as evidenced by their joint activities during the common time in Bénin and the level of interaction via the internet during the coming academic year) will be assessed through performing team assessment at the beginning of the summer period, at the end of the summer period, and at the middle of the coming academic year.

**ACKNOWLEDGEMENT**

Support for this work was received from the National Science Foundation (OISE-0526128) as well as funds from the West Foundation (Indianapolis, Indiana) and the Veldman family.

**REFERENCES**

[1] Silliman, S., M. Boukari, and P. Crane, *A Collaborative Project In West Africa: Student Research Experience In Development*, proceedings FIE annual conference, 2005, Indianapolis, Indiana.

[2] Qamhiyah A.Z., *Internationalization of the undergraduate engineering program, part 1: The need*, International Journal of Engineering Education, 21 (1), 2005, 158-165.

[3] Teichler, U., *The changing debate on internationalisation of higher education*, Higher Education, 48(1), 2004, 5-26.

[4] Kulacki, F.A., *The education of mechanical engineers for the 21st century*, JSME International Journal Series A – Mechanics and Material Engineering, 39 (4), 1996, 467-478.

[5] Jones, R.C., W.S. Butcher, and J.C. Prey, *The Globalization of Engineering*, ASEE Prism, 14(9), 2005, 54-55.

[6] ACE/AT&T Award: Technology as a Tool for Internationalization., 2005, <http://www.acenet.edu/AM/Template.cfm?Section=Home&Template=/CM/ContentDisplay.cfm&ContentID=1041>

[7] Hager, W., R. Devon, J. Lesenne, and D. Saintive, *A French – American collaboration in engineering and technology education*, ASEE annual conference proceedings, session 3148, 1998.

[8] Devon, R., W. Hager, D. Sathianathan, D. Seaintive, M. Nowe, and J. Lesenne, *Alliance by Design: International Student Design Teams*, ASEE annual conference proceedings, session 2544, 1998.

[9] Silliman, S.E., *Comparison of Education Models for Increasing Student Exposure to Engineering in Developing Countries*, ASEE annual conference proceedings, session 1660, 2003.

[10] Harbaugh, A.W., MODFLOW-2005, the U.S. Geological Survey modular ground-water model -- the Ground-Water Flow Process: U.S. Geological Survey Techniques and Methods 6-A16., 2005.

[11] Guo, W., and Langevin, C.D., *User's guide to SEAWAT: A computer program for simulation of three-dimensional variable-density ground-water flow: Techniques of Water-Resources Investigations of the U.S. Geological Survey*, Book 6, Chapter A7, 77 p.