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# **AC 2012-3145: IMPACTING ENGINEERING STUDENTS' GLOBAL PERSPECTIVES: THE RESEARCH ABROAD EXPERIENCES OF HBCU UNDERGRADUATES**

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## **Impacting Engineering Students' Global Perspectives: The Research Abroad Experiences of African American Undergraduates**

### Abstract

This year, the Howard University College of Engineering, Architecture and Computer Sciences implemented an ambitious program entitled GEAR-UP (Global Education, Awareness and Research Undergraduate Program), which immersed minority, engineering undergraduates in an international context to conduct applied research in engineering. Selected engineering undergraduates participated in one of five new research collaborations formed in developing countries located in Southeast Asia, Africa or South America. This study sought to address a range of questions about minority students' experiences navigating international cultural settings. In this paper, we discuss participants' travel abroad experiences, their perspectives on conducting research in an international setting, as well as their subsequent personal and intellectual development. Specific issues discussed include students' unexpected cultural experiences, the challenges and rewards of international research, and improving preparation of future participants.

### Introduction

As a global leader, the issue of globalization in engineering cannot be adequately addressed by the United States without acknowledging national population shifts. Considering the growing minority population in the United States, it is critical that engineering students are well prepared to navigate the new challenges that arise as a result of the changing dynamics in the growingly interconnected global community. In the book, *Educating Engineers: Designing for the future of the field*, Sheri D. Sheppard et al. (2008)<sup>20</sup> highlight that engineers cannot continue to function as a "neutral problem-solver" because the work of engineers has a global impact. In a similar vein, Miller (2007)<sup>14</sup> makes an argument for engineers to be prepared beyond technology and technical skills. Twenty-first century prepared engineers will need competencies "in teamwork, communication, entrepreneurial thinking, creativity and design, and cross-disciplinary thinking in a global context" (Miller, 2007, p. 1).

A range of contemporary research describes the influential role that international learning environments have played in producing positive developmental outcomes for students. For instance, Penn and Tanner (2009)<sup>18</sup> suggest that participation in learning in foreign countries makes students more aware of their own nationality, traditions, and culture as well as develops a sense of understanding of others that are different. Penn and Tanner (2009)<sup>18</sup> explain that learning abroad "allows students to learn beyond the confines of traditional classroom instruction; instead, it transforms education in an active exercise in which students apply theory and research to real situations [...]" (p. 279). They use the acronym EAR, which stands for education, action, and reflection, to describe the benefits of learning while abroad. Education is the first step. Accordingly, students must become *educated* about what is relevant in the country of the research site. Next, through *action*, they must apply this knowledge to their experiences

abroad. Lastly, *reflection* occurs as students write about and discuss the information they learned and action they engaged in during the abroad experience. Braskamp, Braskamp, and Merrill (2009)<sup>5</sup> found that after participation in one education abroad program, students had significant gains in their relationships with other people who were different and acquired a sense of commitment to helping others in a global world. Additionally, Paige, Fry, Stallman, Josic, and Jon (2009)<sup>17</sup> found that studying abroad positively impacted students global engagement (i.e., civic engagement, knowledge production, philanthropy, social entrepreneurship, and voluntary simplicity).

In terms of future engineers specifically, study or research abroad programs have the capacity to broaden students' perspectives on the demand for and production of engineers abroad, innovative approaches to solving engineering issues, and collaboration with a global engineering workforce. In order for the United States to remain competitive, American engineers must develop these competencies (Miller, 2007)<sup>14</sup>. The work of Hembroff and Rusz (1993)<sup>8</sup> highlights the common belief that engineering was a major that did not encourage students to study abroad. As indicated by the Institute of International Education (IIE, 2009)<sup>10</sup>, students interested in studying abroad must face the possibility that they "will lose the opportunity to enroll in sequential course work on campus, lose opportunities to work closely with faculty members, not have their study abroad course work valued or accepted for credit, and thereby lengthen time to degree and increase financial costs" (p. 34). This is particularly concerning for engineering majors, many of whom have specific degree requirements that studying abroad does not fit into (see Hamir, 2011)<sup>7</sup>. In fact, one participant in a mixed method study conducted by Hamir (2011)<sup>7</sup> shared,

*It's really hard in the Engineering program, there's just so much going on, and, especially with study abroad, it's not like...liberal arts or business where you can go abroad and it's still the same basic classes. Engineering programs are so specific that it...by the time I really looked into it seriously, it was too late (p. 139).*

The national statistics on students with study/research abroad experiences reveal the dearth of engineering students who have had such experiences and, more notably, the tiny number of minorities who have. Considering the growing minority population, it is critical that minority, engineering students are prepared to navigate the new challenges that arise as a result of the changing dynamics in the growingly interconnected global community. However, it is this very minority population that is least likely to gain experiences studying abroad. In fact, the National Science Foundation (NSF) estimates that African-American students who have study abroad experience comprise less than one percent of all engineering graduates (NSF, 2011)<sup>15</sup> and the Association of International Educators (NAFSA, 2009)<sup>2</sup>, reports that African Americans are proportionally the least likely to engage in these types of activities. While African-American students of various socio-economic backgrounds desire to engage in and value education abroad programs (Penn & Tanner, 2009)<sup>18</sup>, this interest is often not actualized into an international experience because of factors like potential financial costs.

McLellan (2007)<sup>13</sup> proposes a process called the Promote, Encourage, Prepare and Provide (PEPP) Program to improve minority involvement in international education.

First, we must promote the value of international education and global knowledge to our young people and those around them, at all stages of their education. Second, we must encourage them, and those concerned with their education, to take an interest in international education. Third, we must prepare them for international travel, through activities and information about other countries/cultures, so that they will actually want to travel abroad at some point. And finally, we must provide concrete, relevant and cost-effective programs, regardless of whether they run for two weeks, a quarter, a semester or an academic year (p.1).

In light of these challenges, some Historically Black Colleges and Universities (HBCUs) (including Spelman College and North Carolina's 11 HBCUs) are responding with study abroad initiatives to serve African-American undergraduates, primarily liberal arts majors. The Global Education Awareness Research and Undergraduate Program (GEAR-UP)<sup>22</sup> is different however. This program focuses on engineering research abroad and is during the summer months thus eliminating the concern about time to degree while also addressing the financial concerns that may hinder many African-American students from pursuing international experiences by providing travel, room, board and a stipend. Our hypothesis is that participation in GEAR-UP would influence students' "global learning and development, intercultural competence, intercultural maturity, and intercultural sensitivity" (Braskamp, Braskamp, & Merrill, 2009, p. 101)<sup>5</sup>. Ultimately the program will increase the number of African-American engineering students participating in a global education experience.

This study seeks to address a range of questions about minority students' experiences navigating international cultural settings as a part of GEAR-UP. In this paper, we describe participants' research experiences abroad, discuss their perspectives on conducting research in an international setting, and report quantitative and qualitative findings related to their subsequent personal and intellectual development. Specific issues discussed include students' unexpected cultural experiences, the challenges and rewards of international research, and ways to improve the preparation of future participants. In order for the United States to remain competitive in the field of engineering, students must acquire a sense of commitment to helping others in a global world; this research can inform researchers and educators on promising strategies that foster the development of this critical competency.

#### Description of GEAR-UP

The program was designed to increase the preparedness of engineering students to be globally engaged leaders upon graduation and to provide the opportunity for Howard engineering students to participate in an international research experience. The project involved travel to an international destination where teams of American students worked on research projects with teams of students from other countries. As a result, minority students were able to take advantage of the opportunity to interact with a select group of engineering students from some of the best technical universities around the world; experience close advising and mentoring by faculty from both their home institution and an international partner; and enhance their career preparation for global engagement.

## ASEE: International Exchange Programs in Engineering

During the academic year, American faculty worked with their international collaborators to clearly define the research project, coordinate the summer research experience for the team of students, establish a “give back” to the international institution (e.g. invited lecture, short course), and develop proposal ideas that will provide continual support for the global research activity. Student organizations, like Engineers Without Borders, and the student chapters of professional organizations assisted in informing students about the program.

### Methodology

This research takes a mixed-method approach to better understand the experiences and perspectives of African-American undergraduate engineering students who participate in an international research experience.

### Design

This is five-year cross-sectional study. Both survey research methods and various qualitative research methods (e.g., semi-structured interviews, focus groups, and journaling) will be employed during the first four years of the study. The results below cover the program’s first year of implementation. A retrospective survey was administered to students after they returned from their research abroad assignment. This retrospective method is well established and an efficient substitution for pre-test (see Sandell, 2007)<sup>19</sup>.

### Instrument

#### *Impact of Research Abroad Experience Survey*

The Impact of Research Abroad Experience Survey (see Appendix A; Sandell, 2007)<sup>19</sup> asks questions about the four critical areas in student development that study abroad programs can address: *International Perspective*, *Personal Development*, *Intellectual Development*, and *Student Roles*. The survey consists of retrospective questions further described below. Each item for each section below was rated on a 4-point Likert-type scale ranging from “to a great extent” to “not at all”.

*International Perspective* questions inquired about the influence the experience had on the way student’s viewed world issues, U.S. culture, and professions in other countries. Additionally, questions assessed students’ interactions with individuals from other cultures. An example item asks students to “indicate the extent to which you believe your research abroad experience influenced your discussion with other people about international and transcultural issues.”

*Personal Development* questions assessed the extent to which the research abroad experience influenced students’ educational decisions, volunteer activities, self-confidence and outlook on life in the United States. An example item asks students to “indicate the extent to which you believe your research abroad experience makes you reassess your outlook on life in the US”.

*Intellectual Development* questions assessed the extent to which the research abroad experience directly influenced their intellectual development as well as on how much the experience has

motivated them to learn about other countries and cultures. An example item asks students to “*indicate the extent to which you believe your research abroad experience affects your selection of reading materials*”.

*Student Role* questions assessed the extent to which the travel abroad experience was relevant to being and enhanced their effectiveness as students. An example item asks students to “*indicate the extent to which you believe your research abroad experience improved your confidence in your abilities as a student*”.

## Participants

Participants were selected by a team of faculty in addition to the principal contacts at each participating international institution. There were several criteria for participation, including successful completion of the *Introduction to Engineering* course, a declared engineering major, a grade point average (GPA) greater than 2.5, thorough verbal and written command of the English language, exceptional interpersonal skills, and willingness to serve as ambassadors for the program and as mentors for future students. Participants were US citizens or permanent residents and were scheduled to graduate after May 2011.

Participating students were grouped in teams of four to conduct research on a project(s) of local importance to the host institution with an equal number of international students. During the summer of 2011 students were hosted at one of the following four international research sites: Universidad Santo Tomas (Chile); Bahir Dar University (Ethiopia); University of Nairobi (Kenya) and Ateneo de Manila University (Philippines).

## International Research Sites

### *Universidad Santo Tomas (Chile)*

The Universidad Santo Tomás is one of the largest private universities in Chile, with a national presence at 23 campuses throughout Chile, currently enrolling over 22,000 students. It is also part of a global network of St. Thomas universities, including a campus in the United States. Three Howard students (see Figure 1) conducted their research at the Centro de Formación Técnica campus in downtown Santiago, but also had the opportunity to visit UST campuses and interact with students in Viña del Mar and Concepción. Their cyber security research project focused on distributed denial of service attacks (DDoS) and other anomalous web traffic behavior in selected countries including Egypt, Indonesia, Italy, and Colombia. In a paper produced from this research project, Banks et al. (2011)<sup>4</sup> indicate that the purpose of the research is to “develop a database of the anomalies and [...] distinguish between the non-DDoS anomalous behavior and those that represent actual attacks (p. 2). Their findings demonstrate that the number of computer viruses was not significantly related to the prevalence of DDoS attacks in any country included in the analysis.

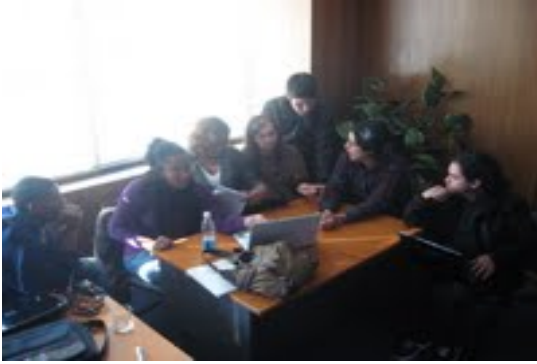


Figure 1. *Students brainstorming research problem in Chile*



Figure 2. *Students ski for the first time while in Chile*

*Bahir Dar University (Ethiopia)*

Bahir Dar University is located in East African country of Ethiopia, which is the second most populous nation in Africa. The university hosts more than 45,000 students and is located in one of the fastest growing towns in the country, Bahir Dar. In Ethiopia, a group of 4 students studied at the Bahir Dar University (see Figure 3 and Figure 4). Their research project focused on the flooding of rivers and predicting traffic patterns. Some specific topics included designing a pedestrian bridge and developing a solar panel and wind turbine hybrid power system. Kirk (2011)<sup>11</sup> sought to redesign the major route from south and north Ethiopia to include a pedestrian bridge in order to cut down on traffic congestion on the Abay Bridge. On the other hand, Awoke, Carter, Gibbs, Abatneh, and Piggott (2011)<sup>3</sup> sought design a hybrid solar photovoltaic-wind turbine system for a rural village. Through their research, it was determined that “when wind turbine and solar PV system are interfaced, the power generation from these is mutually supplemented, and the resultant hybrid system offers a reliable and cost-effective electric supply in a decentralized mode” (p. 38).



Figure 3. *Students at Bahir Dar University in Ethiopia*



Figure 4. *Students with professor at research site in Ethiopia*

*University of Nairobi (Kenya)*

University of Nairobi is located in East Africa in a developing and emerging African nation, Kenya. The university offers approximately 200 academic programs. In Kenya, a group of four

students studied at the University of Nairobi (see Figure 5 and Figure 6). Their research project focused on water treatment and recycling topics such the containment of obnoxious gases and extraction of methane from anaerobic ponds, heavy metal analysis and removal, biochemical oxygen demand (BOD) reduction. Ouma and Reed (2011)<sup>16</sup> analyzed biological, chemical and architectural biochemical oxygen demand (BOD) reduction models and results “yielded barley straw, an indirect method of BOD reduction by algae control, as the most feasible option for implementation” (p 1). Hayes and Kamau (2011)<sup>8</sup> used atomic absorption spectrophotometry “to investigate the concentration and distribution of cadmium, chromium and lead in wastewater” (p. 1). Lastly, Wallace and Mwazighe (2011)<sup>21</sup> conducted research in order to determine the most appropriate technology “for the extraction of methane from the anaerobic ponds” (p. 1).



Figure 5. *Students conducting research in Kenya*



Figure 6. *Students at university in Kenya*

#### *Ateneo de Manila University (Philippines)*

Ateneo de Manila University is located in Southeast Asia and is the world’s 12<sup>th</sup> most populous country. The university was founded in 1859 and is ranked as one of the top 250 universities in the world. In Philippines, a group of 4 students studied at the Ateneo de Manila University (see Figure 7). Their research project was focused on human computer interface and included topics like techniques for modifying the human phenotype ontology, open source bug tracking software, and evaluation to determine optima ontology extraction. Andallaza, Jimenez, and Knox (2011)<sup>1</sup> focus on developing embodied conversational agents (ECA) varying phenotypically to be used as virtual algebra tutors for ninth grade students. Davis and Coronel (2011)<sup>6</sup> suggest that there is a lack of a “gold standard” for determining a complete ontology. Their research focused on possible strategies to address this need.





Figure 7. *Students in Philippines*

## Outcomes

### *Qualitative Experiences: Journaling*

While researching abroad, students' practiced journaling, which is an effective way to capture rich qualitative data describing their experiences. The students at various research sites around the world recorded their perceptions using electronic blogs. The four major themes that emerged were *Communication Issues*, *Coordination*, *Research Engagement*, and the *Positive Impact of Experiences*. Several excerpts are provided below.

#### *Communication Issues*

Communication issues were a common theme across many of the research sites. These varied from language barriers to access to communication tools such as the Internet. Early in the research process, GEAR-UP students in Chile contributed the English section of the research problem. In attempting to identify the research problem, one student describes,

*"some things got lost in translation but eventually we were able to agree on the key points of the problem. [...] After making the statement more concise and focused in Spanish we translated it into English as well so that both parts are the research team would be fully aware of the task we are attempting to solve.*

In Kenya, one of the first and most disappointing things the students reported noticing was a lack of free Wi-Fi access. Shocked, one student states,

*"here, in order to get Wi-Fi you must purchase a USB stick (which is usually sold and operated by major phone companies such as Safaricom, Airtel, and Yu) which is supposed to give you Wi-Fi. Not only do these sticks work poorly (the speed of the internet is slower than that of a snail) but when you purchase airtime (minutes) for these sticks, you must pay 50 shillings a day (equivalent to \$0.50) and not only that, you must go out each and everyday to buy the airtime for the USB sticks, and the internet is only accessible between the hours of 12:00 PM and 12:00 AM the day of your airtime purchase!"*

Later, the student is made aware of an easier but more expensive alternative, which may positively impact research productivity. The student states,

*“although it cost me a pretty penny for Internet, I am quite content because now when I am alone in my room at night I can be quite productive, filling out scholarship applications, doing research for my project here, and interacting with the world outside of Kenya once again.”*

Similarly, in the Philippines, there were some limitations expressed concerning technology. For instance, one student’s project involved developing games for an Android device, and writes,

*“now, I’m currently downloading some Android developer software on my computer. [...] It’s currently on 29%. I started downloading 3 hours ago. After my downloading is completed, I will start working on some basic coding examples.”*

Additionally, near the end of the study abroad experience, one student in the Philippines describes the following complications,

*“today I had my usual meeting with my advisor and due to some major complications my research project has been changed. It kind of unfortunate because my journal was mostly complete. So today I start from scratch! I don’t mind though because this new venture seems exciting. I need the assistance of a server for part of my experiments so that part will have to wait until I return to Howard.”*

These issues are concerning because, as alluded to, they relate to student research productivity. However, the challenge of dealing with new and unexpected communication issues resulted in student resourcefulness and overall, students were able to confront the challenge.

#### *Coordination and Time Restraints*

Another concerning issue that many GEAR-UP students experienced centered on coordination and time restraints. These issues ranged from transportation limitations to complications when arranging meetings with other researchers. In Indonesia, a student who was assigned to the research project addressing the public transportation limitations in the city of Jakarta journals about his or her perspective on the issue. The student states,

*“overall there are a lot of issues that need to be addressed, but also a lot of basic principles that can be implemented to help these problems. The major roadblock is increasing and improving actual enforcement of road safety and policies. Also it’s necessary to get the people to want to use the public transportation by making it appealing. This also ties into making the services safe and maintaining them so people will want to use them. There is a lot to account for and this is only the top layer of problems we have observed.”*

Later in the research abroad program at the Indonesia site, students began to become aware of limitations, such as being able to coordinate the collaborative efforts of other researchers in order to complete the research project. The student states,

*“my topic is Rainwater management, which is an extremely huge problem here in Jakarta. The research just really started, the only problem is the students doing the research with us have internships of their own. So sometimes we are trying to work with managing schedules.”*

A student in Kenya expressed frustration with the research project process because of the limited time left in which to complete the project. The student states,

*“my partner and myself have a 2 part project... first we have to try to contain the obnoxious gases that are being emitted from the entrance of the Ruai wastewater treatment plant and second we have to figure out how to extract the methane from the anaerobic ponds on the site and use the methane as an energy source. The problem that I’m having is that we have no materials or anything of the sort besides the Internet (which is only during the university’s business hours) and [my partner] is supposed to be going to get this equipment from one of the departments on campus in order to test the amount of methane in the anaerobic ponds... and we still have no equipment! [...] I’m feeling like it’s down to the wire and I can’t do this project alone so I need someone to be as pressed about the situation like I am.”*

In the process of conducting research abroad, several students gained experiences adjusting to and working through various constraints. While these situations were difficult and challenging, they required the use of students’ critical thinking and problem solving skills helping to further develop them as future global engineers.

#### *Research Engagement*

The types of hands-on research projects available made students particularly engaged in the research process. For instance, one student at the Indonesia site describes his or her excitement during the data collection phase of the research process. The student states,

*“we discussed the weather, compared McMillian reservoir [located at home university in US] to the one we were at, and compared the universities. Once the test was complete, we gathered our materials and headed toward the car to go back to campus. The entire process was exciting for me because I had never actually seen the way reservoirs work.”*

Despite early doubts about being able to complete the research project in the given timeframe, a student at the Kenya site later describes her gratefulness that everything ended up going well. The student states,

*“finally, on Friday, we were all able to get together to head back out to the Ruai Waste Water Treatment Plant. There each of our four groups were able to collect samples from different sections of the plant that we needed in order to carry out our studies in a lab, starting tomorrow.”*

Another student at the Kenya site says,

*“research is going pretty well. We had our first presentations yesterday to the professors and they gave a lot of good feedback. We have about 2 1/2 weeks left and a lot of work left to get done so it’s pretty much crunch time. I love the students from the University of Nairobi. They are fun but they also help to keep us focused which is good.”*

A student in the Philippines described the positive impact the research abroad program had relatively early on. The student says,

*“so this research is really making an impression on me, I am now eager for classes to resume in the fall and have a clear view of the technical electives I need to take to pursue my career goals. I am flooded with ideas for the direction of my project and am excited to confirm that this will be my senior project! I am currently in the process of outlining my paper and creating a benchmark for the tests I will run to complete my short-term project.”*

Being engaged in research served as a motivator for some students. Another student at the Philippines research site describes,

*“the goal is to acquire/develop an ontology on breast cancer for a patient information retrieval system containing records of breast cancer patients. Interesting right? So I am going to start my own project, hopefully I will be able to utilize it for my senior project this fall and build on it! My focus will be on editing genetic sequence ontology. My adviser and I are collaborating to find a specific use of my edited ontology.”*

Another student expressed enthusiasm about the research project, stating,

*“I will work on the design of an agent Aplusix. The goal of this project is to create a fully functional agent that determines problems when students are learning algebra using a pretested ideal as a benchmark. In this process, I will not only design the agent but I will also have a chance to work directly with the students who will benefit from it. I am looking forward to this opportunity because they get to critic my work and provide insight on improvements.”*

The participants make it clear that they are interested in these research topics and find the hands-on experience engaging. They are eager to make a contribution to solving real-world problems through their research.

#### *Positive Impact of Experiences*

Despite the limitations referenced by the GEAR-UP students, they expressed gratitude for the experience and revealed that the opportunity helped with their personal growth. One student in Chile expressed gratefulness for the opportunity to network while abroad and writes,

*“Today, we also had the pleasure of having lunch with a few representatives from the school. It was good to be able to sit down with them and have conversation about many topics. We also were able to share reciprocal appreciation for us being here and being able to work with select students from the university.”*

Near the end of the experience, one student realized how large of an impact the program made by immersing students in a new and very different cultural setting at the Indonesia site. The student states, *“we find happiness in the simplest of things now and that is a true sign that we are becoming more humble than we have ever been.”*

A telling observation made by a student in the Philippines dealt with a recent awareness of the conditions some people must live in. The student states,

*“knowing we only have only 6 days left is quite bittersweet; This has been a very humbling experience. This trip has made me think of the things that I have that I take for granted. In some parts of the island children are so poverty-stricken past the point of having shoes or underwear, it’s very eye opening and unfortunate.”*

Overall, students were grateful for the opportunity to research abroad. Getting closer to heading back to the states, one student at the Philippines site reflects on the overall experiences. The student states,

*“the most important thing that I can say I have taken from this trip is that we are all given a series of amazing opportunities that somehow can first appear as impossible solutions but it is our choice to embrace the journey and move towards it. [...]I have worked with software I never knew of prior and now have an understanding of them and more. [...]I am so grateful because when I return to the United States I will now have a renewed mindset and a better appreciation of the many blessings I have.”*

Through journaling, participants were able to share how their cross-disciplinary and cross-national thinking increased while researching abroad. The experience made students more aware of their nationality and unique opportunities they have as American students. They also have a better understanding of international context and communities and exposure to global engineering issues.

## Survey Results

### *Relationships Among Sub-scales*

Participants were administered a survey as complementary evidence of the impact the travel abroad experience had on students. Overall, there were several relationships found among the five scales (see Table 1). Results demonstrate that *International Perspectives* was positively and significantly correlated with *Personal Development*, *Intellectual Development*, and *Student Roles*. Additionally, *Personal Development* is positively and significantly correlated with *International Perspective* and *Student Roles*. Lastly, *Intellectual Development* was positively and significantly correlated with *Student Roles*. This suggests that as one of the four critical areas of development for students studying abroad was positively impacted, the other areas were consistently positively impacted as well. Further, descriptive analysis reveals that, taken together, the research abroad experience had a positive impact on students in terms of their international perspectives, personal development, intellectual development, and student roles (see Table 2).

These quantitative findings support the sentiments expressed by student participants in their journals, as evidenced in the excerpts discussed previously.

Table 1. *Impact of Research Abroad Experience Survey Sub-scale Correlations*

	International Perspectives	Personal Development	Intellectual Development	Student Roles
International Perspectives	-	-	-	-
Personal Development	.822*	-	-	-
Intellectual Development	.869*	.648*	-	-
Student Roles	.745*	.696*	.657*	-

Note. \* =  $p < .01$

Table 2. *Mean Values from the Impact of Research Abroad Experience Survey*

	Mean	Standard Deviation
International Perspectives	3.55	.42
Personal Development	3.49	.58
Intellectual Development	3.64	.61
Student Roles	3.57	.50

## Summary and Conclusions

### *Challenges and rewards of international research*

Research abroad programs encourage students to think globally while also preparing future engineers in these competencies (Miller, 2007) <sup>14</sup>. The one major challenge of research and study abroad programs, though, is the task of efficiently preparing students to go abroad (Markowski & Mainwaring, 1995) <sup>12</sup>. Along these lines, the GEAR-UP experiences from the first year of implementation revealed the three primary areas of concern for future program implementation: (1) begin pre-departure process early, (2) require a in-depth travel abroad course pre-departure, and (3) build in process of gathering background materials for the assigned research projects prior to departure. Markowski and Mainwaring (1995) suggest that another major task is to adequately research the quality of the exchange sites and potential inequity in experiences of abroad students assigned to different sites. Other factors for consideration include participants' language acquisition and cultural values awareness. Questions to be considered in future research on GEAR-UP and similar research abroad programs are: How do research site differences impact student participants differently? Will students at some sites experience more stress related to managing a new language environment than those at other sites? Is engineering taught differently? What are the different levels of interpersonal contact encouraged at various research sites? Despite the challenges, the benefits gained for minority engineering students and future global engineers include unique opportunities to build personal connections abroad, to experience personal growth, and to develop an increased global perspective.

References

1. Andallaza, T. C. S., Jimenez, J. M., & Knox, Q. L. (2011). *The design and analysis of an affective agent for Aplusix*. Unpublished manuscript.
2. Association for International Educators (NAFSA, 2011). *Research on Underrepresentation*. Retrieved from: <http://www.nafsa.org/resource/library/default.aspx?id=18255>
3. Awoke, M. Carter, C. D., Gibbs, B. A., Abatneh, Y., & Piggott, P. I. (2011). *Off-Grid 10kW Solar panel and 1kW Wind Turbine Hybrid Power System for a Small Rural Ethiopian Village*. Unpublished manuscript.
4. Banks, K. B., Blackstone, J. M., Gonzalez del Valle, P., Mujica, S., Aedo, C. M., Sanchez, A. M., ... Patterson, W. (2011). *DDoS and other anomalous web traffic behavior in selected countries*. Unpublished manuscript.
5. Braskamp, L., Braskamp, D., & Merrill, K. (2009). Assessing progress in global learning and development of students with education abroad experiences. *Frontiers: The Interdisciplinary Journal of International Education, 18*, 101-118.
6. Davis, R., & Coronel, A. (2011). *Determining criteria for ontology extraction techniques for the evaluation of a sub-ontology extraction from the human phenotype ontology*. Unpublished manuscript.
7. Hamir, H. B. (2011). *Go Abroad and Graduate On –Time: Study abroad participation, degree completion, and time-to-degree*. (Unpublished doctoral dissertation). The University of Nebraska, Lincoln, NE.
8. Hayes, A., & Kamau, J. (2011). *Heavy metals analysis and removal: Dandora Wastewater Treatment Plant*. Unpublished Manuscript.
9. Hembroff, L. A., & Rusz, D. L. (1993). *Minorities and overseas studies programs: Correlates of differential participation*. New York: Council on International Educational Exchange.
10. Institute of International Education (IIE, 2009). *Meeting America's Global Challenge: Expanding study abroad capacity at U.S. colleges and universities*. Retrieved from <http://www.iie.org/en/Research-and-Publications/Publications-and-Reports/IIE-Bookstore/Expanding-Study-Abroad-Capacity-at-US-Colleges-and-Universities>.
11. Kirk, S. E., II. (2011). *Designing a pedestrian bridge to connect North and South Ethiopia crossing the Blue Nile River*. Unpublished manuscript.
12. Markowski, K., & Mainwaring, D. (1995). Engineering Study Abroad? - - 'It's like expecting Carl Lewis to run backwards without any training. *European Journal of Engineering Education, 20*, 1, 31-39.
13. McLellan, C. E. (2007). A lesson plan to improve minority study abroad participation. *Issues in Higher Education, 24*(19), 1.
14. Miller, R. K. (2007). *Beyond Study Abroad: Preparing Engineers for the New Global Economy*. ABET Annual Meeting, Incline Village, NV.
15. National Science Foundation (NSF; 2011). *Higher Education in Science and Engineering*. Retrieved from: <http://nsf.gov/statistics/seind10/c2/c2h.htm>.
16. Ouma, J. O., & Reed, L. N. (2011). *Comparison of chemical, biological, and architectural methods of biochemical oxygen demand (BOD) reduction in Ruai Wastewater Treatment Plant*. Unpublished Manuscript.
17. Paige, M. R., Fry, G. W., Stallman, E. M., Josic, J., & Jon, J. (2009). Study abroad for global engagement: The long-term impact of mobility experiences. *Intercultural Education, 20*, 29-44.
18. Penn, E. B., & Tanner, J. (2009). Black Students and International Education: An assessment. *Journal of Black Studies, 40*, 266-282.
19. Sandell, E. J. (2007). Impact of International Educational Experiences on Undergraduate Students. *The Delta Kappa Gamma Bulletin*.
20. Sheppard, S. D., Macatangay, K., Colby, A., Sullivan, W. M., & Shulman, L. S. (2008). *Educating Engineers: Designing for the Future of the Field*. San Francisco, CA: Jossey-Bass.
21. Wallace, A. J., & Mwazighe, F. (2011). *Containing obnoxious gases and extracting methan from anaerobic ponds*. Unpublished manuscript.
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Appendix A.

**IMPACT OF RESEARCH ABROAD EXPERIENCE**

With your current research abroad experience, this survey seeks to gain an understanding of the impact this experience has had on you. Please take time to reflect on your experience. Please answer honestly.

**A. IMPACT ON INTERNATIONAL PERSPECTIVES**

Based on your research abroad experience, please indicate below the extent to which your research abroad experience has:

	To a Great Extent	Somewhat	Very Little	Not at all
Shaped and influenced your evaluation of world issues?				
Enhanced your understanding of US culture?				
Influenced your understanding of professions in countries other than the US?				
Influenced your discussion with other people about international and transcultural issues?				
Affected your interaction with people from other cultures?				
Influenced you to encourage university students to participate in international education experiences?				

**B. IMPACT ON PERSONAL DEVELOPMENT**

Based on your research abroad experience, please indicate below the extent to which your research abroad experience has:

	To a Great Extent	Somewhat	Very Little	Not at all
Made you reassess your outlook on life in the US?				
Affected your family decisions (spouse, parenting, living arrangements and so forth)?				
Affected your interpersonal relationships (friends family and neighbors)?				
Influenced education decisions you have made since your research abroad experience?				
Helped add an intercultural dimension in your <i>volunteer</i> activities?				
Helped add an intercultural dimension in your <i>social</i> activities?				
Helped add an intercultural dimension in your <i>religious</i> activities?				
Contributed to your level of self-confidence?				



C. IMPACT ON INTELLECTUAL DEVELOPMENT

Based on your research abroad experience, please indicate below the extent to which your research abroad experience has:

	To a Great Extent	Somewhat	Very Little	Not at all
Affected your selection of reading materials?				
Affected your ability to speak/ read languages other than your first language?				
Influenced your intellectual development?				
Enhanced your motivation and/or ability to learn another language after returning to the US?				

D. IMPACT ON STUDENT ROLE

Based on your research abroad experience, please indicate below the extent to which your research abroad experience has:

	To a Great Extent	Somewhat	Very Little	Not at all
Had a long term impact on your role as a student?				
Been relevant to your being a student?				
Enhanced your effectiveness as a student?				
Improved your confidence in your abilities as a student?				