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Implementing and Integrating International Research into the Engineering Curriculum at Lincoln University, Pennsylvania and the University of the West Indies, Trinidad

Dr. Monica Gray P.E., Lincoln University

Dr. Monica Gray is an Assistant Professor of Civil and Environmental Engineering at The Lincoln University. She simultaneously received her PhD in Civil and Environmental Engineering (Water Resources concentration) and Masters of Public Health (Environmental & Occupational Health concentration) from the University of South Florida, Tampa. She also received a Masters in Biological Engineering from the University of Georgia, Athens and B.S. in Agricultural Engineering from the University of the West Indies, Trinidad. Dr. Gray is a seasoned engineer and educator who has lived, studied and worked in various countries around the world.

Prior to arriving at The Lincoln University, she managed the global curriculum portfolio for over a hundred and twenty programs in sixteen countries at Arcadia University and was instrumental in successfully developing and implementing study abroad opportunities and exchanges for undergraduate engineers from institutions across the country, while internationalizing the engineering curriculum through cooperation, consortia and curriculum integration.

Ms. Constance Loretta Lundy

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Introduction

Educating engineers to meet the needs of today's global economy and diverse workforce involves preparing culturally competent individuals as well as providing increased access to members of under-represented, under-prepared and minority groups (UUMs). Minorities and Females constitute about 4% and 15% of the engineering workforce while accounting for over 13% and 50% of the general U.S. population respectively.[1] This status quo is maintained by disproportionately high attrition rates from engineering programs among UUMs, ranging from 49% for Females to 62% among African Americans.[2-4]

Many strategies are currently being employed to reduce this disparity. These efforts include first-year seminars, internships, learning communities, and capstone projects.[2, 5] Study abroad, however, has not been seriously considered as a high impact retention activity. The research shows that UUMs struggle in mathematics and science intensive programs such as engineering, not simply because of academic under-preparation per se, but more importantly, due to feelings of not belonging and lack of confidence in their ability to learn coupled with low self-efficacy and self-direction.[6-8] In fact, the common theme among successful high impact retention strategies is that they provide access to structured opportunities for all students, including UUMs, to develop self-directing competencies in both the cognitive and affective learning domains.[9, 10] Therefore, facilitating skill sets that are *sine qua non* both to successfully learn and complete engineering degree programs.

Studying abroad inherently impact students' personal and academic development.[11] Study abroad exercises students' cognitive analysis ability (*students are able to deal with ambiguity in new, ill-defined situations by formulating models and seeing relationships*), affective organizational skills (*students are able to balance their responsibilities and formulate a cohesive and systematic approach to learning*) as well as self-efficacy, which is a proximal predictor of proficiency in both these domains.[12] Self-efficacy is "*an individual's judgment of his or her capabilities to perform given actions*".[13] Indeed, study abroad can be very challenging, as culture shock requires adjustment to the host culture, and may also elicit "*feelings of not belonging*".[11] However culture shock provides students with sustained opportunities to "*deal with ambiguity in new, ill-defined situations"*. Felder[8] describes the cognitive development trajectory of college students as a continuum of knowing everything, "*ignorant certainty*", recognition that context determines answer, "*intelligent confusion*" to a point where students begin to trust their own process of organizing their learning and judgment. A similar process occurs during the study abroad experience. According to self-efficacy framework and intercultural transformation theory, study abroad participants' equilibriums are disturbed when seemingly familiar interactions occur without familiar signs or social cues. This cognitive dissonance leads to "*identity confusion*", an analogue to "*intelligent confusion*".[14] Each such interaction, however, leaves the student better equipped to handle similar encounters because of "*greater cognitive and affective capacity*". [12]

Therefore study, research, internship, and/or service learning abroad experiential opportunities must be added to the hosts of high impact experiential educational strategies currently being employed to increase UUMs' participation in engineering academic programs and subsequently

the profession. In addition, spatial mobilization of the engineering sector predicated by a global economy, as well as engineering program accreditation with a student learning outcome requirement to have "*the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context*", have led to the market demand for more culturally savvy engineers. It follows therefore that an engineering educational experience abroad not only provides a structured opportunity for UUM students to increase their self-efficacy and self-direction skill sets which will help them persist and do well in their current engineering programs but also prepares them to meet the demands of the global market place. Study abroad has not been previously considered as a high impact activity, there is, however, a movement afoot to change that paradigm. The National Science Foundation in the latest Louis Stokes Alliance for Minority Participation (LSAMP) program solicitation cited researchers Bowman and Sage as follows, "*Preparing a diverse, globally-engaged scientific and technological workforce necessitates strengthening international research opportunities for students under-represented in STEM fields". [15]*

Studying abroad: benefits, challenges and opportunities

According to the Institute of International Education's (IIE) Open Doors 2015 report, over the last two decades, the number of U.S. students studying abroad has tripled to a about 300,000. This indicates that students, faculty and administrators are recognizing the benefits of the study abroad experience and are availing themselves of the opportunities. For example, research shows that students who study abroad have higher GPAs, are more likely to graduate on time, and are more attractive to employers that seek to hire candidates with intercultural competencies.[16]

African American students account for 15% of the overall U.S. undergraduate population but only represent 5.6% of the over 300,000 U.S. students studying abroad. There are several reasons for this disparity: finances, faculty leadership, attrition rates, choice of major, family support, anxiety resulting from travel inexperience, and lack of insight of the correlations between global cultural competence and career goals.[17, 18] It is interesting to note that high attrition from degree programs has been listed here also as a contributing factor for under-participation. Traditionally, study abroad has been marketed as an opportunity to experience other cultures. For minority students, this angle has not been effective as they interact across culture on a daily basis.[19] However, based on the research into the causative factors for under-representation, an opportunity to increase skill sets that can assist in persisting and doing well in their current engineering programs as well as prepare them for continual lifelong professional success might be a better approach to encourage underserved minorities to study abroad.

While STEM is now the top sending group accounting for about 23% of the study abroad cohort, engineering represents only 5% of that total. By and large, STEM fields, have very restrictive, highly sequenced and vertical curriculums, creating an additional barrier that prevents their majors from partaking of the transformative experiences gained from studying abroad. This still continues today especially in engineering. Students are fearful of not being able to find equivalent courses which may result in study abroad credits not transferring back to home institution, falling out of sequence, getting behind, and subsequent delayed graduation and increased educational cost. Faculty are equally concerned with the quality of the academic experience overseas, their lack of control over the curriculum, and possible accreditation

implications. Faculty leadership in encouraging study abroad participation under these conditions is, as would be expectedly, low.

As noted above, there are several factors that are driving demand for more engineers to study abroad: ABET accreditation, global economy, and federal funding agencies. In addition, as the number of STEM majors studying abroad increases, this may assuage concerns of both students and faculty about the ability of engineers to study abroad and still graduate on time. Further, an opportunity may exist in the fact that females constitute about 65% of the study abroad participants. This is an inherent strength that must be capitalized upon, given the high female attrition rates from engineering programs.

Strategies for broadening UUM engineering majors' participation in study abroad

The preceding discussion advances study abroad not only as a high impact strategic retention tool to ensure that more UUMs complete engineering programs but also a way to position this cohort of students for successful careers. This paper postulates, however, that to successfully engage African American engineering students to participate in study abroad, the experience must be adopted as part of an institution's overall culture, is not simply an additional item to an already packed curriculum. Internationalizing the curriculum requires strategic direction and system-wide buy-in. Successful strategies include cooperative agreements among U.S.-based and global institutions, development of U.S.-based consortia, curriculum integration, course matching, and scholarship funding, as well as a robust faculty-led program.

Cooperative agreements

Cooperative agreements or memoranda of understanding (MOU) are an effective way for U.S.-based and international institutions with mutual internationalization missions and goals to broker relationships that advance the individual and collective vision of all signatories. MOUs that tend to work and are productive in the long run are characterized by up front, explicitly negotiated needs and strong bilateral support from individual parties. Some items that are typically included in internationalization agreements are scholarly exchanges, of both faculty and students, curriculum and course integration, formal agreements with individual departments, and English as the language of instruction.

For administrators who are concerned about ABET accreditation issues, a conservative option might include finding a partner university in a country that is a signatory of the Washington Accord and ensuring that the perspective institution is accredited by that country's accreditation body. The Washington Accord, signed in 1989, is an international mobility agreement among engineering accrediting bodies in seventeen countries. Each signatory recognizes accredited engineering programs in others' jurisdiction as being substantially equivalent to its own. For example, South Africa is a signatory of the Washington Accord, and its accrediting body is the Engineering Council of South Africa.[20] If Lincoln University has an ABET accredited engineering program and wishes to sign an MOU with the University of Pretoria (UP) in South Africa, which is accredited by the Engineering Council of South Africa, then both programs are recognized as being substantially equivalent to each other. In this case, Lincoln's administrations would be even happier to realize that UP is also ABET accredited which is not a very common occurrence outside the U.S.

Local and regional consortia
Capitalizing on the idea of strength in numbers, local and regional universities sometimes come together to form a consortium. These partnerships may include stakeholders from across each member institution. It is common to include both study abroad officials and faculty. Individual schools may be relatively small and often do not have the enrollment numbers to create a cost effective study abroad contingent. By coming together, a group of schools can create agreements among themselves as well as with the global partner(s). The consortium then sends a large group of students to their partner institution(s) reducing the overall cost per student as well as ensuring the integrity of the educational experience. Member schools sometimes sign off on course credits though a process of triangulation. For example, if Lincoln and University of Delaware (UD) are part of a consortium and UD gave credit for a Statics course taken at the University of the West Indies (UWI), then Lincoln, by virtue of its consortium membership, would be more inclined to also accept those credits for its students studying at UWI.

Curriculum integration and course-to-course matching
Curriculum integration involves the time and offering synchronization of typical, fundamental engineering courses. Both the global and U.S. partner institutions evaluate their individual course sequence to determine common core offerings and work to offer those courses in tandem. Typical core courses that lend themselves to such processes include Statics, Dynamics and Fluids. Inherent in this process is the analysis to determine the equivalency of the courses as well as removal of the guess work about when is the best time for engineering students to study abroad. Courses are therefore pre-approved for engineering credit; thus, students go abroad confident that they can make adequate progression towards completing their degree on time.

Scholarship funding opportunities
Financial constraint is a major concern for all students even though it has become relatively easier to get study abroad scholarships for STEM majors compared to other majors. Many scholarships specifically target minority student populations. The following is a discussion of a few:

- Benjamin A. Gilman International Scholarship – funded by the U.S. Department of State and administered by IIE, this scholarship funds traditionally under-represented cohorts in study abroad and shows a preference for non-traditional destinations. Students can study, research or intern while they are abroad. Funding is typically up to $5000 but can be increased to $8000 if students study a critical needs language. STEM is considered a priority group.
- Vira I. Heinz Women in Global Leadership program – funded by the Vira I. Heinz Endowment and administered by University of Pittsburgh, this program awards scholarships to three women from each participating institution of at least $5000 with an additional $1000 if they study outside of Western Europe. STEM is considered a privileged group.
- Third party study abroad providers – usually offer scholarships to participating students. Universities or consortium can negotiate better rates for their students especially for large cohorts, typically at least 10 students.

Faculty-led programs
Faculty-led programming is an essential component to campus internationalization plans aimed at making study abroad part of the academic culture and not the exception. Programs may include faculty taking students abroad and delivering course(s) in the host country in which the

students are studying. The abroad experience can be a continuation of a course taught on campus and/or a team taught course where U.S.-based and the host foreign country's students are grouped to work on a project during the semester and then come together at the end. Whatever the iteration, faculty-led opportunities ease many traditional fears and significantly impact the internationalization process. First, faculty who take students abroad are more likely to send students abroad. Second, since the faculty member delivers the content, there is no question as to the quality of the experience. Finally, if the abroad experience is a continuation of an on-campus course, then the program fee can be embedded in the course cost and can thus make use of the students' financial aid packages that are already in place.

Case study: partnership between Lincoln University and the University of the West Indies

Lincoln University of Pennsylvania, in collaboration with the University of the West Indies, St. Augustine, Trinidad & Tobago and the Greater Philadelphia Region Louis Stokes Alliance for Minority Participation (Philadelphia AMP), has entered into a series of progressive partnerships in support of its Faculty-led STEM Research Internship Program to the Caribbean. The following details that progression and provides a case study for implementation of the internationalization strategies discussed above.

Lincoln University

Lincoln University, the nation's oldest degree granting Historically Black College and University (HBCU), has an outstanding track record for preparing UMM STEM majors for possible careers and graduate studies in STEM-related fields. Since its inception, Lincoln University has attracted a diverse student population and faculty from the surrounding community, region, and the world. The mission of the university has always been to prepare its students to be leaders of the highest caliber, both at home and abroad. Our alumni include African leaders such as Nnami Azikiwe, first president of the Federal Republic of Nigeria; Kwame Nkrumah, first president of Ghana; and most recently, 1994 graduate Saara Kuugongelwa-Amadhila, Namibia's first female Prime Minister. In the pre and post- apartheid years, Lincoln University served as the orientation center of over a thousand South African students who came to study in U.S. universities. Our strong ties with the African continent continues today such that in the last five years, almost half of our international student population was from African countries. Here in the U.S. our most notable alumni include Thurgood Marshall, the first African American U.S. Supreme Court Justice; Langston Hughes, world-acclaimed poet; Lillian Fishburne, the first African American female U.S. Navy Rear Admiral; and Hildrus A. Poindexter, the first African American to earn both an M.D. *(1929, Harvard University)* and a Ph.D. *(1932, Columbia University)* as well as the first African American internationally-recognized authority on tropical diseases.

Our students study abroad during the traditional semesters with no attendance during the shorter terms such as winter or spring break. Students study in a large contingent of countries with spotty participation in the Caribbean and almost exclusively using third party study abroad program providers. Our study abroad portfolio comprises about 50 graduate and undergraduate students per year, the majority of whom are Business and Language majors, from a total population pool ranging from 1,500 to 1,900. Thus, STEM majors are in the minority of study abroad participants accounting for about 18% of the 240 students who studied abroad in the last 5 years. STEM participants have been self-selecting as our programs have not been intentionally

integrated within their curriculum. One of the key barriers for all our students is lack of financial resources. About 96% of our students receive financial aid and are thus economically challenged.

The University of the West Indies – St. Augustine, Trinidad & Tobago

UWI – St. Augustine is one of the four campuses of the premier regional university system serving seventeen countries of the Commonwealth Caribbean and home to the flagship Faculty (College) of Engineering. Its mission is to enhance Caribbean development by collaborating with regional and international partner institutions to establish networks for the next generation of leaders. The university is therefore very well connected throughout the Caribbean and is at the forefront of scientific research, resource management and policy development. As a regional university, U.S. students studying there have the opportunity to interact with students from multiple Caribbean islands simultaneously.

Greater Philadelphia Region Louis Stokes Alliance for Minority Participation (Philadelphia AMP)

Philadelphia AMP is sponsored by the National Science Foundation (NSF) and consists of nine tertiary institutions, including Lincoln University. The mission of the Alliance is to substantially increase the numbers of under-represented minorities earning baccalaureate and advanced degrees by employing recruitment and retention strategies at the college level to promote minority talent in STEM disciplines. NSF has recognized international STEM research as a high impact, successful recruitment and retention strategy. The Philadelphia AMP is now in its 20th year and is therefore classified as a senior level Alliance. With this status comes the additional responsibility of focusing on international STEM research. Therefore the Alliance funds and supports international research opportunities for students under-represented in STEM fields.

STEM faculty-led programing

The Faculty-led STEM Research Internship Program to the Caribbean is currently Lincoln University's only faculty-led STEM opportunity. It first ran in summer 2015 with five STEM students, sponsored by Philadelphia AMP and Lincoln University, and was hosted by UWI-St. Augustine. The general research agenda was natural resource management with a focus on the interrelationship among conservation strategies in individual sectors (e.g., water resource issues in solid waste management) as well as sustainability versus entrepreneurship (i.e., the balance between preserving for future generations versus and the need to make a living now). The program's pedagogy featured a "double-exposure" approach where students learn locally and apply globally. Program objectives included exploration of the unique environmental resources available in the both countries; analysis of how resources are harnessed to foster sustainable development, employment and cultural enrichment; and contextualization of the contradictory balancing of environmental realities, conservation strategies and the need for sustainable livelihood. Upon completion of the program, students were expected to be able to discuss and describe how the unique resources of an environment/county facilitate the emergence of conservation strategies, and cultural and economic activities; evaluate and articulate the challenges of preserving natural resources, cultural traditions as well as ensuring sustainable livelihoods; and perform basic research both in the lab and in the field.

Students were introduced to resource and environmental management concepts in the classroom and through a virtual-hybrid platform with attendant U.S.-based field trips to the communities adjacent to Lincoln University. While all students were expected to become articulate in all

presented topics, each student was assigned an area of focus on which to conduct comparative research. The five comparative research projects were water treatment, wastewater treatment, solid waste management, food production and soil management. The international portion of the program was a mirror image of the U.S.-based field studies culminating in PowerPoint presentations in Trinidad. Students continued their research upon return to the U.S., resulting in poster presentations at Lincoln University's fall Annual Science Fair. Notably, three of the five participants placed in the top three of their categories. Participants were also required to attend a series of professional development activities with the Office of Career Services with the aim of helping them update their resumes and articulate the research abroad experience to future employers and graduate schools. All students completed all requirements of the program. Primary feedback were requests for extending the Trinidad leg of the program by about a week and more interactions with Caribbean students. The most challenging aspects to the program revolved around coordinating field trips in both countries.

The summer 2016 instalment will again be hosted by UWI-St. Augustine and funded in part by Philadelphia AMP. Engineering students were the primary target of the STEM majors. The focus this year is energy, featuring peer-pairing of U.S. and Caribbean students on projects to model international, multidisciplinary teams. The summer 2015 program ran in late June when most students at UWI-St. Augustine had already left for the summer. The U.S. contingent will arrive in Trinidad during the first week of May before the end of the spring semester, to facilitate more integration and multinational team work with Caribbean students before their summer break.

Campus internationalization

While Lincoln University has always had a global vision, STEM students have not been directly targeted towards fulfilling the global competency mission. In light of Lincoln's long history serving UUM STEM majors, the imperative to prepare students for the global marketplace, the mandate arising out of membership in the Philadelphia AMP to provide *"international research opportunities for students under-represented in STEM fields"* and the desire to offer this life changing experience to more students, it has been concluded that the STEM fields are areas of synergistic and strategic growth. Consequently, an expert on STEM-related campus internationalization was invited to campus to speak to relevant cohorts across all departments. As an outcome to those meetings, Lincoln's president has formed the Committee on International-Global Initiatives (CIGI) to address the issues of increasing the availability of study abroad opportunities, increasing international student enrollment, creating opportunities for international faculty development and expanding of an internationalized curriculum.

The Faculty-led STEM Research Internship Program to the Caribbean aligns with this strategic direction and is therefore fully supported by the administration. Lincoln University now firmly re-commits its faculty and administrators to the task of exploring and implementing new policies and procedures that will expand the numbers and enhance the education of students, especially STEM majors, who wish to fully embrace research and practical experiences globally. This re-commitment is especially important for the Engineering Science Program (ESP), which has seen tremendous growth in the last year. During the development of the ESP curriculum, spring semester of the sophomore year, was made to mirror spring semester of the first year at UWI-St. Augustine to facilitate future semester-length student exchanges. An aspirational goal of this program is that each engineering student will have at least one study abroad experience before graduation.

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