SCIENCE AND ENGINEERING STUDY ABROAD: AN ASSESSMENT OF OUTCOMES FOR UNDERREPRESENTED GRADUATE STUDENTS AND RECOMMENDATIONS FOR PROGRAM DESIGN AND IMPLEMENTATION

By

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To my husband Brian for always believing we would reach the end of this long road together

To my Mum for being my best friend

To my family and friends for all your support

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While there is widespread recognition of the need for students to gain global experience, research indicates that the majority of study abroad programs at U.S. colleges and universities focus on the liberal arts and foreign languages and few study abroad opportunities exist in the science and engineering disciplines. In the 2009-2010 academic year, college students from the life and physical science and engineering disciplines comprised just 11.4 % of study abroad participants, compared to 22.3% in the social sciences and 20.8% in business and management. In addition, numerous obstacles exist for science and engineering graduate students wanting to pursue an international experience and currently only 0.6% of study abroad participants are doctoral students.

The purposes of this study were to develop and validate an assessment instrument for measuring students' academic STEM learning and personal growth outcomes and to use this tool and the Intercultural Development Inventory to investigate the self-reported academic STEM learning, personal growth and intercultural development outcomes of graduate students who participated in short-term science and

engineering-related study abroad programs at a large research university. In addition, this study investigated which components of the implemented science and engineering-related study abroad programs enhanced and/or limited the impact of these programs on participant outcomes.

This study used a mixed-methods approach and quantitative results indicate that graduate students who participated in science and engineering-related study abroad programs experienced significant changes in their academic STEM learning and personal growth outcomes. Specifically, significant differences were found in students' perceptions of the socio-cultural role of science and engineering, career perceptions, personal confidence and general global awareness. However, these students did not experience any significant changes in their intercultural development as a result of participation in a study abroad program. Detailed recommendations and best practices for program development, implementation and evaluation for graduate study abroad in the science and engineering disciplines include the incorporation of extensive networking opportunities and collaborative research or service-learning projects with host country counterparts. The results of this study indicate that appropriately designed graduate student study abroad experiences can provide unique opportunities to develop globally-minded scientists and engineers.

CHAPTER 1
INTRODUCTION

In our increasingly globalized society, a college education should prepare students to live and work effectively with people from different backgrounds. Indeed, a collective concern for institutions of higher education is the creation of globally and culturally competent graduates (Smith & Schonfeld, 2000). This emphasis was recently reinforced by the International Education Summit on the Occasion of the G8, a gathering of 16 nations, which issued a statement that education must provide opportunities for students to study across international borders and should produce graduates who are globally competent and culturally fluent (Fischer, 2012). In response, more than one-third of higher education institutions in the United States (U.S.) have now incorporated internationalization priorities into their mission statements, though there is wide variation in degrees of commitment (Siaya & Hayward, 2003; Stearns, 2009).

In general, two basic purposes for internationalization of higher education are espoused:

1. To improve the knowledge and skills of American students, thus enabling them to function in an increasingly global society, and
2. To improve the nation's status internationally (Stearns, 2009).

Colleges and universities have therefore adopted numerous initiatives to internationalize the higher education experience of students primarily as a result of the demand for an educated workforce that can remain competitive in an increasingly global economy (Lyman, 1995; Johnston & Edelstein, 1993).

Over the past 30 years, a variety of definitions of internationalization of higher education have emerged, describing it as (a) the process of integrating an international perspective into a college or university system, (b) making campuses more internationally-oriented, (c) infusing international material into the curriculum, and (d) adapting to an ever-changing, diverse external environment that is becoming more globally-focused (Bartell, 2003; De Wit, 2002; Hanson & Meyerson, 1995; Lambert, 1993; Tonkin & Edwards, 1981). More recently, internationalization of higher education has been defined as “the process of integrating an international, intercultural or global dimension into the purpose, functions or delivery of post-secondary education” (Knight, 2004, p.11). The most frequently cited objective of efforts to internationalize higher education is the graduation of culturally competent, internationally knowledgeable, and/or globally minded students (Dolby, 2004; Knight, 1997).

Internationalization programs at institutions of higher education are typically multi-faceted and involve (a) the flow of international students and scholars, (b) faculty research and exchange, (c) internationalized curriculum, (d) internationalized co-curricular units and activities, and (e) global institutional linkages. However, one of the most established and visible of these approaches is the effort to encourage U.S. college students to participate in study abroad or international study opportunities as a component of their education.

The potential benefits for college students who participate in study abroad programs are well documented (Dolby, 2004; Dwyer & Peters, 2004; Lewis & Niesenbaum, 2005). For example, a large-scale study conducted by the Institute for the International Education of Students (IES) reported long-term, positive impacts of study abroad experiences on students’ personal, professional, and academic development, influencing issues such as career path, world-view, and self-confidence of alumni (Dwyer & Peters, 2004). Meanwhile, others have documented gains in foreign language learning and cultural knowledge and an increased interest in interdisciplinary studies (Lewis & Niesenbaum, 2005). Further, according to Dolby (2004), study abroad experiences provide students with the opportunity to critically examine their own national identity and associated traits and their role in the global context.

A record number of U.S. college students are studying abroad today. According to the most recent *Open Doors 2011* report published by the Institute of International Education with the support of the U. S. Department of State’s Bureau of Educational and Cultural affairs, over 270,604 U.S. students received academic credit for courses and research abroad in the 2009 – 2010 academic year (IIE, 2011). These figures represent a 100% increase in U.S student participation in study abroad over the past decade. And yet, the growing numbers of students who do study abroad represent a small percentage of the overall number of college students and are concentrated in disciplines such as foreign languages, liberal arts and business. Meanwhile, ongoing efforts amongst both educators and policy makers are attempting to increase not only the number of students who study abroad, but also their diversity, particularly in terms of ethnicity and discipline. It is clear that a great deal of work remains to be done if study abroad is to be integrated into higher education for students of all backgrounds and from all disciplines.

Purpose

Research indicates that the majority of study abroad programs at U.S. colleges and universities focus on the liberal arts and foreign languages and very few study abroad opportunities exist in the science, technology, engineering and mathematics (STEM) disciplines. In fact, according to the Commission on the Abraham Lincoln Study Abroad Fellowship Program report (2005), students majoring in the sciences and engineering are among the most underrepresented groups on study abroad programs. National statistics from the most recent Institute of International Education Open Doors 2011 Report on International Educational Exchange (IIE, 2011) support these findings. This report is based on a survey of approximately 3,000 accredited U.S. institutions and has complied data from over 900 colleges and universities whose students participate in study abroad programs. IIE has determined that, of all college students who studied abroad in the 2009-2010 academic year, only 20,253 (7.5%) were life or physical science majors and only 10,554 (3.9%) were engineering majors. In total, students from the life and physical science and engineering disciplines comprised just 11.4% of study abroad participants, compared to 22.3% in the social sciences and 20.8% in business and management. Furthermore, although this report does not specify the academic level of these students, the overall totals indicate that over 86% of students who studied abroad during that year were undergraduates and only 13.6% were graduate students.

The low national-level study abroad participation percentage for students majoring in science and engineering disciplines parallels study-abroad participation rates for students at the University of Florida (UF). In the 2007-2008 academic year at UF, 4.5% of study abroad students were physical or life science majors and 4.5% were engineering students. Further investigation has revealed that the majority of UF science and engineering majors participating in study abroad experiences (99% from physical and life science and 92% from engineering) were pursuing undergraduate degrees.

Currently, there is little published research examining reasons for the lack of participation in study abroad by undergraduate or graduate students in the life and physical sciences and engineering, nor have many studies documented how study abroad experiences benefit students from these disciplines who do participate. According to the Council on International Educational Exchange (CIEE, 2003), a lack of appropriate programs is not the only barrier to study abroad for college-level science and engineering students. Another major obstacle is the lack of recognition of the value of study abroad experiences in the science and engineering disciplines by students, their families, and science and engineering faculty. The CIEE report argues that study abroad professionals and faculty advocates must demonstrate the intrinsic value of study abroad in the education of tomorrow's scientists and engineers(CIEE, 2003). Similarly, the Institute on International Education (IIE) report entitled *Promoting Study Abroad in Science and Technology Fields* has called on researchers to identify the impacts of international collaborations on science and engineering students (IIE, 2009).

This dissertation study was designed to address some of these gaps in our understanding of the potential benefits of, and challenges associated with, study abroad experiences in the science and engineering disciplines, with a particular focus on graduate students. In addition, this study focused on study abroad programs that specifically target ethnically underrepresented students. The rationale for choosing this particular study sample is explained below. In 2009-2010, only 7.9% of college level study abroad students were Asian, Native Hawaiian or other Pacific Islander, 6.4% were Hispanic or Latino/a, 4.7% were Black or African-American, and 0.5% were American Indian or Alaska Native (IIE, 2011). The Commission on the Abraham Lincoln Study Abroad Fellowship Program report (2005) also declared that "minority students, including African-American and Hispanic-American students, are significantly underrepresented" and that "American colleges and universities must make new efforts not only to raise the number of students studying abroad but also to increase the diversity of these students" (p. 17).

Perhaps because of the low levels of participation in study abroad by students from underrepresented groups, few studies have investigated the impacts of these experiences on minority students. However, several reports have suggested potential benefits, including positive impacts on employment readiness, the expansion of job opportunities, increases in income potential and development of new career-relevant skills (Ikeda, 2006; Picard, Bernardino & Ehigiator, 2009). Advocates of increasing minority participation in study abroad also claim that returned study abroad students get better grades and improve their chances of acceptance to graduate, medical and law school (Martinez, 2011). However, these assertions are generally unsubstantiated by empirical research and further research is needed to determine and document the amount and types of academic STEM learning, personal growth and intercultural competence resulting from the participation of minority students in study abroad experiences.

This study specifically addressed three research questions related to graduate student outcomes resulting from participation in life and physical science and engineering-related study abroad programs:

1. How can researchers and practitioners effectively assess the academic STEM learning and personal growth outcomes of life and physical science and engineering graduate students who participate in science and engineering-related study abroad programs?

2. What are the self-reported academic STEM learning, personal growth and intercultural development outcomes for graduate science and engineering students who complete science and engineering-related study abroad programs? To answer this question, the following sub-questions were posed:

a. What are the self-reported academic STEM learning, personal growth and intercultural development outcomes for underrepresented graduate students in life and physical science and engineering who participate in science and engineering-related study abroad experiences?

b. Do the perceived academic STEM learning, personal growth and intercultural development outcomes differ for underrepresented life and physical science and engineering graduate students who participate in study abroad experiences compared to those who do not?

3. Which specific components of science and engineering-related study abroad programs enhance and/or limit the impact of these programs on the academic STEM learning, personal growth and intercultural development of participants?

The data generated in response to the research questions informed the identification of best practices for college/university study abroad experiences in life and physical science and engineering disciplines. Products include recommendations for program design and implementation and suggestions regarding appropriate techniques and instruments for assessment of academic STEM learning, personal growth and intercultural development outcomes for life and physical science and engineering students participating in study abroad experiences. These recommendations can provide guidance to both college/university science and engineering faculty and study abroad program administrators as they attempt to increase levels of study abroad participation by students, especially graduate students, in the science and engineering disciplines.

Statement of Need

Education in science and engineering disciplines in the United States is viewed as critical in the struggle to achieve and maintain our nation’s economic, political, and military superiority. In fact, great technological and scientific advances have occurred as a result of such global competition. For example, the development of military hardware in the early twentieth century and space technology of the 1960s were both the direct result of struggles for supremacy on the international stage (DeBoer, 1991).

These calls for an increased focus on the STEM disciplines continue today as the United States strives to maintain its position as a world leader. For example, the National Science Foundation (NSF), in the document titled *America's Pressing Challenge – Building a Stronger Foundation*, argues that "it is absolutely essential for our Nation's long-term prosperity and security that we remain a world leader in science and technology" (NSF 2006, p. i). Furthermore, the Domestic Policy Council, in *American Competitiveness Initiative: Leading the World in Innovation* claims that "sustained scientific advancement and innovation are key to maintaining our competitive edge" (Domestic Policy Council 2006, p.1). Sigma Xi (2007), a scientific research society, has also stated that success in the global economy requires the U.S. to help its scientists and engineers achieve global competence.

Beyond these national politico-economic arguments, others contend that the internationalization of science and engineering education is a socio-cultural imperative. For example, Stanley and Brickhouse (2001) argued that science education should adopt a multicultural approach and Guest, Livett and Stone (2006) suggested that science is an intrinsically international activity, since it is a human activity, and is thus impacted by culturally-embedded values and attributes, such as ethics, religion, history and politics. Meanwhile, Carter (2005) argued that science education must be considered in the context of increasing globalization and the associated reconfiguration of the social and cultural landscape.

According to Parkinson (2007), the motivation for promoting international education relates to the range and scale of technological needs of mankind in the 21st century and the associated improvements in quality of life that could be achieved. Students in engineering and the technical sciences should be prepared to tackle some of the most challenging problems facing the world in the 21st century, such as providing clean water, affordable health care, and energy-efficient transportation to the majority of the world's population who live in developing countries on meager resources.

Meanwhile, others have suggested that, rather than considering socio-cultural factors, internationalization of science education **c**ould lead to positive outcomes in terms of global standardization of language and methodologies used in science disciplines (Charlton & Andras, 2006). Certainly, as researchers in STEM fields throughout the world tackle pressing global issues, and as scientists and engineers increasingly collaborate on international projects, a greater understanding of the role of the socio-cultural aspects of these disciplines will be beneficial to all concerned.

Dr. Arden L. Bement, Jr., Director of the National Science Foundation (NSF) from 2004 to 2010, declared that "U.S. scientists and engineers must be able to operate in teams comprised of partners from different nations and cultural backgrounds" if they are to confront the many challenges in this increasingly global society (Bement, 2005, p. 2). In response to this need, the NSF elevated their international division to form a new Office of International Science and Engineering (OISE) in the director's office in 2002. The OISE supports programs designed to expand and enhance leading-edge international research and education opportunities for U.S. scientists and engineers, especially at the early career stage. Their efforts include supporting planning visits and workshops that are expected to lead to international collaborative projects, providing international research opportunities for U.S. science and engineering students and early-career scientists and engineers, and funding international partnerships.

As explained previously, study abroad experiences can be a powerful tool for internationalizing higher education and the NSF indicates that international experiences are "particularly vital for U.S. students" if they are to acquire the skills needed to lead and participate in international teams and research discoveries (Bement, 2005, p. 3). Specific NSF grant programs that include opportunities for international study include the International Research Experiences for Students (IRES) program, East Asia and Pacific Summer Institutes for US Graduate Students (EAPSI), and Partnerships for International Research and Education (PIRE). OISE also co-funds international programs with other NSF directorates including the Research Experience for Undergraduates program (REU), the Graduate Research Fellowship Program (GRFP), the Integrative Graduate Education and Research Traineeship Program (IGERT), and the Graduate STEM Fellows in K-12 Education program (GK-12).

In 2011, OISE provided support for almost 400 projects, with total funding exceeding $22 million and in the previous year, funding for a similar number of projects totaled more than $29 million. This demonstrates a significant increase in commitment to international activities when compared to the 2009 funding level of approximately $4 million and the 2008 funding level of just over $10 million.

In 2010, the University of Florida received almost $7 million for two PIRE programs, both of which involve international study opportunities for graduate students in the science, social science and engineering disciplines. In addition, UF received supplemental NSF funding of $270,000 for the South East Alliance for Graduate Students and the Professoriate (SEAGEP) program to enable the development of several short-term study abroad opportunities for minority graduate students in the science and engineering disciplines. With such a clear federal commitment to funding international study abroad experiences in science and engineering, research examining the impacts of these experiences on participants could provide useful, needed, and timely information to faculty, administrators, and government agencies regarding best practices for science and engineering-related study abroad program design, implementation, and evaluation.

Furthermore, there is strong support for such efforts from professional organizations, such as the Accreditation Board for Engineering and Technology (ABET), who argue that study abroad experiences can help students develop the soft skills needed to function in multidisciplinary teams. They contend that students should be able to communicate effectively and develop an understanding of the potential impact of engineering solutions in a global and societal context (ABET, 2000). Additionally, the American Chemistry Society (ACS, n.d.), claims that study abroad offers many benefits for students, including**:**

- Making them more attractive to graduate schools, particularly if they conduct research or learn another language while overseas;
- Enhancing their laboratory skills and allowing them to learn the chemical sciences from an international perspective.

However, as noted previously, currently, very few study abroad opportunities exist in the science and engineering disciplines.

Significance of the Study

Given the fact that very few students in science and engineering currently participate in study abroad programs, and in the context of an increased emphasis on internationalization of higher education, it is important to conduct a comprehensive assessment of the impact of college level study abroad programs on science and engineering student participants. Based on existing literature, the three most important categories of potential student outcomes include academic learning in the science and engineering disciplines (academic STEM learning), personal growth, and intercultural development. In addition, few published studies exist to provide guidance regarding how to design, implement, and evaluate effective science and engineering-related study abroad programs.

A clear identification of student outcomes associated with participation in science and engineering-related study abroad experiences can be useful to both funding agencies and institutions of higher education as they endeavor to increase the number and effectiveness of such international experiences. This information could also be used to justify student participation in these programs to both science and engineering faculty members and academic advisors. Information regarding the academic STEM learning, personal growth and intercultural development outcomes resulting from participation in study abroad experiences can also provide guidance to faculty interested in developing and leading study abroad experiences for science and engineering graduate students. Furthermore, the identification of best practices and recommendations for the design, implementation, and evaluation of science and engineering-related study abroad programs at the university level is of national significance, enhancing efforts to engage students from these traditionally underrepresented disciplines in overseas study across numerous campuses.

Finally, in an effort to internationalize the campus, and as a component of on-going institutional accreditation, the University of Florida has established an Internationalization Task Force. This task force, under the direction of the Provost, has defined internationalization as “the conscious integration of global awareness and intercultural competence into student learning”. The three student learning outcomes identified by this task-force are that students will be able to:

- Demonstrate knowledge of global and intercultural conditions and interdependencies.
- Think critically to interpret global and intercultural issues.
- Communicate effectively with members of other cultures

Initially, these student learning outcomes will focus on the undergraduate student population. However, they are well aligned with the current study and it is anticipated that the results presented in this dissertation will provide useful information to the task force as they continue their efforts to internationalize the graduate student experience at UF.

Definitions

In this section, I first provide the definitions for terms related directly to my study sample, including science and engineering students. I then provide definitions for terms related to the treatment, including study abroad.

The definition of science and engineering students used in this study encompasses the life and physical sciences and engineering disciplines as defined by the Institute of International Education (IIE), the leading not-for-profit educational and cultural organization focused on international studies in higher education in the United States. The IIE has conducted an annual statistical survey of study abroad students since academic year 1985/86 and the most recent survey includes data from approximately 3,000 institutions of higher education in the U.S. To assign “Field of Study,” the IIE has established general categories derived from the U.S. Department of Education’s National Center for Education Statistics (NCES) Classification of Instruction Programs (CIP codes). This study, which focused on life and physical science and engineering students, follows the NCES classification, with one notable exception. Life and physical science disciplines (also referred to more generally as science disciplines) include those categorized in the biological and biomedical sciences (CIP code 26), physical sciences (CIP code 40), and science technologies/technicians (CIP code 41). However, the IIE definition of life and physical sciences does not currently include natural resources and conservation (CIP code 03). At the University of Florida, interdisciplinary ecology is housed in the College of Agriculture and Life Sciences and students studying in this field are eligible to participate in science and engineering-related study abroad programs. Thus, in addition to the disciplines described above, the definition of life and physical sciences in this study also includes natural resources and conservation. The engineering field of study includes general engineering (CIP code 14), engineering technologies/technicians (CIP code 15), construction trades (CIP code 46), mechanic and repair technologies/technicians (CIP code 47), precision production (CIP code 48), and transportation and materials (CIP code 49) (IIE, 2011).

As mentioned previously, the Commission on the Abraham Lincoln Study Abroad Fellowship Program (2005) reported significant underrepresentation on study abroad programs by both students majoring in the sciences and engineering and by students from minority groups. For the purposes of this study, I use the term “underrepresented” to refer to students from the science and engineering disciplines, which is the focus of this research. However, the students participating in this research study came from a program specifically targeting African-American, Hispanic, Native American and Pacific Islander minority groups. I will use the term “minority” to refer to these groups.

According to Peterson, Engle, Kenney, Kreutzer, Noiting and Ogden (2007), student learning outcomes are defined in terms of the “knowledge, skills and abilities an individual student possesses and can demonstrate upon completion of a learning experience or series of learning experiences” (p. 173). In this study, the specific learning experience was participation in a study abroad program and student learning focused on the areas of academic STEM learning, personal growth and intercultural development outcomes.

The Forum on Education Abroad (Bolen, 2007) defines study abroad as “education abroad that results in progress towards an academic degree at a student’s home institution” (Bolen, 2007; p. 176). These programs can be as short as a few weeks and as long as a year in duration (Bolen, 2007). For the purposes of this study, I used the definition above to focus on for-credit study abroad courses in the science and engineering disciplines offered by the University of Florida for graduate students.

Also, in the context of this research, it is important to define the type of study abroad program under consideration. Engle and Engle (2003) have identified seven defining components of overseas programs, and using a combination of these variables, they have created a classification of different types of study abroad experiences. In addition, Vande Berg, speaking on behalf of the Forum on Education Abroad' s Goals Committee on Outcomes Assessment, proposed "a more rational and useful approach to classifying education abroad programs" (Vande Berg, 2010, p. 1). He proposed a preliminary classification based on three program characteristics that are hypothesized to have the greatest impact on student learning: the nature of the classroom experience, the duration of study, and the language of instruction.

Using this classification, I designated the study abroad programs in this research study as "faculty-led, short-term" programs as they all lasted between one and two weeks with students traveling as a cohort, primarily taught by U.S. faculty, and with the inclusion of guest speakers from the host country. I further contend that such "faculty-led, short-term" programs are the most appropriate venues for the investigation of student academic STEM learning, personal growth and intercultural development outcomes resulting from participation in study abroad experiences since most existing science and engineering-related study abroad programs are of relatively limited duration (generally three weeks or less). Also, the Forum on Education Abroad *State of the Field 2009* document (Forum, 2010) reported that U.S. and overseas higher education institutions expect their primary participation growth for study abroad to be in short-term programs. Thus, an assessment of the impacts of this type of program, especially for science and engineering students, is of particular relevance.

In summary, the definition of study abroad used in this study specifically refers to University of Florida faculty-led, short-term programs. The range of durations for these programs was 10 to 14 days and the format included site visits and field trips in the host country, as defined by Bolen (2007) and Engle and Engle (2003). This research study did not involve other study-abroad program types or programs offered by independent providers or U.S. colleges and universities other than the University of Florida.

Summary

Study abroad experiences for undergraduate and graduate students in the science and engineering disciplines are potentially an important tool in support of efforts to internationalize these fields of study and could contribute to the development of scientists and engineers with globally-relevant knowledge and skills. However, as is evident from numerous published reports and studies, students majoring in these disciplines are among the most underrepresented groups on study abroad programs. Furthermore, the body of existing research literature includes few studies documenting the impact of study abroad experiences on students (especially graduate students) in the life and physical sciences or engineering. For this reason, I chose to investigate the impact of study abroad experiences on science and engineering graduate student participants.

The results of this research can be used to provide funding agencies and faculty at other higher education institutions with a clearer understanding of the impacts of study abroad experiences on the academic STEM learning, personal growth and intercultural development of student participants. In addition, the development of a best practices model for the design, implementation, and evaluation of science and engineering-focused study abroad programs could help study abroad professionals and faculty develop more effective programs.

Dissertation Overview

This dissertation is presented in a hybrid format with the first three chapters following the traditional outline. This first chapter includes a statement of the problem this dissertation addresses and its significance to the field of science education. Chapter 2 presents the theoretical framework for this research study and provides a review of several categories of relevant literature, including the history and current state of the field in study abroad. It also includes a review of the role of study abroad in the science and engineering disciplines and the assessment of outcomes associated with these programs. The third chapter details the dissertation study's design, including the methodological framework, research questions, study setting and information about the study participants. This chapter also outlines the data collection and data analysis procedures for the three research questions.

The next three chapters are written as separate articles. Chapter 4 addresses the first research question and presents details regarding the development and evaluation of an instrument for assessing academic STEM learning and personal growth outcomes for science and engineering graduate students who participate in study abroad programs. Chapter 5 then presents quantitative results of an assessment of academic STEM learning, personal growth and intercultural development outcomes of science and engineering graduate students who participated in a short-term study abroad program. Chapter 6 presents the findings of qualitative analyses of students' study abroad program experiences and identifies best practices for the design and implementation of graduate level study abroad in the science and engineering disciplines. Finally, Chapter 7 presents an overview of the dissertation study's findings and provides further discussion and conclusions for the study as a whole.

CHAPTER 2
REVIEW OF LITERATURE

To examine the background of college study abroad in the United States, this literature review provides a discussion of the research that is relevant to the current study. First, it presents an overview of the theoretical frameworks that have been applied in study abroad research and outlines the specific framework that I used for this dissertation project. Second, it provides an overview of the definitions and history of study abroad at the college-level. Next is an examination of the rationale and benefits of study abroad participation in general and specifically for students from the science and engineering disciplines and from minority groups. Finally, it presents a review the literature related to outcomes assessment for study abroad programs, with particular emphasis on science and engineering programs. This chapter also discusses how the current research contributes to the bodies of literature on the assessment of outcomes for science and engineering study abroad programs.

Theoretical Framework

The development of a theoretical framework for research in the area of study abroad experiences has been quite limited and most work in the area has been practitioner-based (Hoffa, 1993; King & Baxter Magolda, 2005). As with other study abroad research studies, I obtained direction for this study by examining related theories and concepts in other areas of educational research, developmental learning, cognitive and educational psychology, experiential learning and intercultural development.

Currently, study abroad researchers and practitioners conceptualize the field using three prominent theoretical frameworks; positivism, relativism and experiential-constructivism (Vande Berg, Paige & Hemming Lou, 2012). Positivism, which initially served as the foundational theoretical framework for study abroad, is now waning in popularity as research has demonstrated that mere exposure to different places, peoples and cultures does not necessarily lead to learning for all students. Relativism, based on the early work of educational psychologists such as Dewey and Piaget, is still popular as a theoretical framework for study abroad. In the relativism framework, educators structure learning experiences, support the student learning process, and operate on the premise that immersion and social and physical interaction are the factors that facilitate learning. Most recently, and of greatest relevance to the current study, the experiential-constructivism theoretical framework has been applied to study abroad contexts. This framework emerged from the work of Kolb and Fry (1979) on experiential learning theory. They developed a cycle of learning that flows from concrete experience to reflective observation to abstract conceptualization to active experimentation and back to concrete experience. During study abroad experiences, educators work directly with students to facilitate their learning, provide frequent feedback, and actively involve students in the learning process.

In the context of this study, I contend that academic STEM learning resulting from participation in these particular study abroad experiences is both experiential and transformative in nature. During the study abroad programs, students encountered real-world examples/applications of the same concepts and skills they were first exposed to in classroom and/or laboratory experiences on their home campuses. At the same time, students completing these study abroad programs often faced situations that were much more complex, challenging, and at times, even contradictory, when compared to the initial conceptions and beliefs generated as a result of their prior traditional coursework.

When considering all of these factors, it makes sense to use an integrated theoretical framework when examining science and engineering-focused study-abroad programs. To be useful, this framework needs to incorporate and blend cognitive and psychosocial development theories from both general education and discipline-specific perspectives. King and Baxter Magolda (2005) suggest that cognitive and psychosocial dimensions are, in fact, really parts of the same developmental process. In the following sections, I highlight the leading academic learning and personal growth theories that contribute to a holistic theoretical framework for study abroad.

Academic Learning Theory

At the center of the theoretical framework for intellectual development used in this study is the constructivist paradigm of learning developed by Jean Piaget, who suggested that individuals construct new knowledge from their own experiences (Piaget, 1967). Piaget's constructivist theory, which has been broadly applied in education contexts, especially in the STEM disciplines, contends that humans generate knowledge and meaning as a result of interactions between their experiences and existing ideas. According to constructivism, students use different cognitive processes to construct their own unique understandings of material to be learned. Learning is an active, meaning-making process and students continually strive to make sense of their experiences based on the influence of their own prior knowledge, experience, and attitudes.

While the literature on constructivist learning theory still tends to emphasize the notion that "knowledge" is personally constructed by each individual, in recent years, the role that shared experience plays in the construction of knowledge (i.e., social constructivism) has received greater attention (Richardson, 2003; Prawat & Floden, 1994). Lev Vygotsky's work on culturally-mediated learning provides the foundation for the theory of social constructivism and suggests cognitive development is a social process and that learning requires interaction with others in order to modify/adapt prior knowledge to new situations and environments (Salomon & Perkins, 1998). Social constructivism extends traditional constructivism with an additional focus on the potential impact interaction with other people and cultures can have on learning. Given this focus on the role of human awareness and interaction, the theory of social constructivism is an obvious fit for framing investigations of study abroad experiences.

Experiential learning

One offshoot of constructivist learning theory that is particularly applicable to study abroad research is the concept of active or experiential learning. This theoretical paradigm is based on the work of John Dewey and has been widely embraced by researchers in the areas of experiential and service learning. Dewey was a proponent of apprenticeship and the need for real-world experience in education. In his work, *School and Society*, Dewey proclaimed that "object lessons" cannot be a substitute for actually living the experience (1902, p. 11).

The essential elements of effective education practice identified by Dewey set the stage for today's modern theories regarding experiential learning, which is a key component of all study abroad programs. According to Dewey's experiential learning model, learning should be more than memorizing facts and formulas. It should enable students to develop a more complex conceptual understanding of a topic in the context of real life with real consequences. This type of active learning requires learners to be actively engaged in the process of making their own observations, gathering facts and evidence, and engaging in their own reflective analyses of new information in the context of reality. Moreover, studies by the National Training Laboratory have determined that there is a positive correlation between the degree of active engagement used by instructors and the degree of retention of subject matter by college-level learners (Permaul, 2009).

Building on the work of Dewey, David A. Kolb stated, “learning is the process whereby knowledge is created through the transformation of experience” (1984, p. 38). He developed a cyclical model of learning, arguing that experience is translated through reflection into concrete concepts, which are in turn used for active experimental and new experiences (Figure 2-1). Study abroad experiences can offer participants expanded opportunities for experiential learning in real world contexts and help them directly apply the abstract concepts and theoretical knowledge acquired in more traditional classroom settings.

Transformative learning

Transformative learning is another facet of constructivist learning theory that complements the experiential learning theory described above. Transformative learning involves a “change in the frame of reference or the structures of assumption through which students understand their experiences” (Mezirow, 1997, p.5). Transformative learning is believed to be triggered by an unsettling or disorientating experience, creating dissonance in what the students are hearing, seeing and feeling which then causes them to re-examine and question their existing knowledge and assumptions. According to Brewer and Cunningham, “study abroad has tremendous potential for transformative learning” (2009, p. 10). In this theoretical framework, the learner moves from a situation of disorientation and disequilibrium through a period of questioning assumptions, to a stage characterized by integration of new and old assumptions, and the resulting outcome is a change in frame of reference or worldview.

In the context of this study, academic STEM learning had the potential to be both experiential and transformative in nature. At the initiation of this study, all participants held their own unique conceptions regarding targeted learning outcomes in areas including scientific knowledge and skills, professional self-efficacy in science and engineering, global science communication, and the socio-cultural role of science and engineering. These initial conceptions were based on each individual's previous experience and learning. During the study abroad programs, these students were exposed to new information in new contexts which then had to be reconciled and integrated with their existing knowledge and conceptions.

Personal Development Theory

While the experiential-constructivism theoretical framework is important to consider when researching study abroad programs, learning during these experiences can only occur if students are developmentally ready to receive and process the experiences productively (Brewer & Cunningham, 2009). In addition to the targeted academic learning goals of study abroad programs, there is a widely held assumption that studying abroad also contributes to an individual's personal growth, accelerating their development along some continua of cognitive and/or affective development (Bolen, 2007).

In terms of human development theory, several approaches offer potential frameworks for studying the impact of study abroad participation on an individual's psychosocial and interpersonal development (Pascarella & Ternezini, 2005). However, of particular interest are Arthur Chickering's theory of vectors of student identity development and Milton Bennett's development model of intercultural sensitivity.

Identity development

Chickering's theory, which was first published in *Education and Identity* (1969) and subsequently revised in collaboration with Linda Reisser, offers a foundational framework for the personal growth perspective examined in this research study (Chickering, 1969; Chickering & Reisser, 1993). Chickering and Reisser contended that there are seven vectors that provide an applicable framework for examining the personal development of college students of all genders, ages, ethnicities, and backgrounds (Reisser, 1995). Specifically, the vectors are (a) developing competence, (b) managing emotions, (c) moving through autonomy toward interdependence, (d) developing mature interpersonal relationships, (e) establishing identity, (f) developing purpose, and (g) developing integrity.

In a more recent publication, Chickering worked with Larry Braskamp to adapt these vectors of identity development to the adoption of a global perspective for personal and social responsibility (Chickering & Braskamp, 2009). They contend that the "college-aged student needs to develop and internalize a global perspective into her thinking, sense of identity, and relationships with others" and have proposed the enhancement of four of the original vectors (2009, p. 27). These include: moving through autonomy toward interdependence, establishing identity, developing purpose, and managing emotions.

The ability of students to *move through autonomy toward interdependence* relates to the intercultural competence goal of study abroad when a student is expected to understand and communicate with people from different national, ethnic and cultural groups. In doing so, students learn the importance of compromise, reciprocity and community commitment, all of which Chickering and Braskamp (2009) argue can help move an individual toward a greater understanding and acceptance of interdependence. Study abroad may also play an important role in *establishing identity* as students' identity formation is "enriched by more wide-ranging experiences, knowledge and insights" (Chickering & Braskamp, 2009, p. 27). Similarly, *developing purpose* refers to the students' sense of being engaged in the world around them and having the ability to make a difference. This is also a goal of many study abroad programs and specifically relates to this study's personal growth sub-constructs of global awareness and career perceptions. Finally, in terms of managing emotions, study abroad frequently creates opportunities for students to become more aware of their own emotions and develop the flexibility needed as they encounter real-world issues. In this study, I examined students' emotional development with the personal growth sub-construct, personal confidence.

In addition to the four vectors selected by Chickering and Braskamp, I argue that the development of interpersonal competence, which signifies a student's ability to work and communicate effectively with others, is also of relevance in study abroad experiences, especially those focusing on science and engineering disciplines. In fact, much of the research on personal growth in study abroad has largely focused on the development of intercultural skills and competencies.

Intercultural development

The theory of intercultural development is perhaps the best-known and most widely applied theoretical framework of personal growth used in study abroad research. This model is based on the premise that improving students' understanding of cultural differences is vital to their general education (Mahoney & Schamber, 2004).

Furthermore, the ability to communicate and negotiate among diverse cultures has been shown to correlate with success both in college and beyond (Banks, 2001).

The well-known Developmental Model of Intercultural Sensitivity (DMIS), developed by Milton Bennett, acknowledges the variety of ways that individuals respond to cultural differences. This model (Figure 2-2) defines intercultural sensitivity from the perspective of personal development and the capacity of the individual to adapt to cultural differences (Bennett, 1998). Bennett contends that individuals experience cultural differences in a series of predictable stages (Bennett, Bennett & Allen, 1999). In this model, the first three stages, *denial of difference*, *defense of difference* and *minimization of difference* are identified as ethnocentric stages. In these stages, the individual values his/her own culture more highly than other cultures.

The latter three stages, *acceptance of difference*, *adaptation to difference*, and *integration of difference* are defined as ethnorelative, whereby other cultures are viewed in an increasingly positive and non-threatening light. The DMIS model charts an individual's journey from denial and defense, through minimization, adaptation, and integration with another culture. However, progression through these stages is not fixed, but rather functions as a continuum of increasing ability to deal with cultural differences, the end goal being "greater recognition and acceptance of difference" (Bennett, 1993, p. 22). This theory of intercultural sensitivity forms the basis for the Intercultural Development Inventory, which I used as an assessment instrument in the current study. Details of the IDI are provided in a later section of this literature review.

Holistic Theoretical Framework

Engle and Engle (2003) suggest that two broad types of study abroad programs are essentially distinct from each other: culture-based programs and knowledge-transfer programs. The latter programs, they claim, take form primarily in areas such as biological field study and scientific exchange and the study of technological applications, during which individuals may remain distinct or remote from their host culture. However, it has been determined that, for individuals who become successful in a diverse world, a large part of that success is due to their ability to communicate and negotiate among diverse cultures (Banks, 2001). It is my contention that science and engineering students are no different from any other type of student and that a successful study aboard program includes the development of new academic knowledge and skills and the exchange of information and ideas.

The following section provides background information on study abroad as practiced in the U.S. and provides a context for the current study with an examination of the history and characteristics of study abroad programs in the United States.

College-Level Study Abroad in the United States

History of Study Abroad in the United States

Historically, study abroad finds its roots in the pursuit of high culture and the Grand Tour, which originated in 17th century England as a component of a classical education. Expansion of this concept to the United States in the 19th century resulted in wealthy families sending their young people to Europe to absorb and assimilate the culture.

The beginnings of modern study abroad in the United States are traced to a University of Delaware program that sent a group of eight students to France during their junior year in 1923. The earliest official college-level study abroad program in the U.S. quickly followed, beginning in 1926 when 504 American students boarded a steamship that served as a floating university for the study of Japanese culture. Land-based study abroad first appeared in the 1950s, when a handful of American college students participated in overseas programs (Baskin, 1965). The number of college and university study abroad programs and students steadily increased throughout the next few decades, though the focus was primarily on language learning.

In 1988, a report by the Advisory Council for International Educational Exchange, entitled “Educating for Global Competence” articulated the desire to increase study abroad participation rates and include students from majors beyond the languages and area studies. This report advocated increasing college study abroad participation in the U.S. to 10% by 1995, expanding study abroad to include students from underrepresented majors and minority groups, extending study abroad experiences to non-traditional destination countries outside Western Europe, and institutionalizing study abroad within the mission of internationalizing colleges and universities.

Today, such programs are an integral part of efforts to internationalize the education experience of students at many colleges and universities in the U.S. According to the 2011 Open Doors Report by the IIE, a record 270,604 American college students participated in study abroad programs during 2009-2010, representing a 3.8% increase over the previous year and over a 150% increase over the past decade (IIE, 2011).

Definitions of Study Abroad

Study abroad, education abroad, overseas study, and international education are just a few of the terms that are frequently used, often interchangeably, to describe the experience of a college student who completes a portion of his/her program of study outside the geographical boundaries of the United States. Some colleges and universities include all programs, whether for credit or not, under the umbrella of “study abroad” while others, such as the Institute for International Education, are only concerned with students who study abroad for credit (IIE, 2011; University of Wisconsin, 2010)

Whichever term is selected, and for the purposes of this study, I will use “study abroad,” there are many different types and iterations of an overseas program in which students can participate. The term “study abroad” has come to represent a wide spectrum of vastly different overseas-study options, ranging from intersession trips of a week to yearlong study at a foreign institution (Engle & Engle, 2003). A great deal of debate surrounds the strengths and weaknesses of these different program types, with short-term programs lauded for providing opportunities for greater numbers of students, while longer-term programs claim to achieve more desirable outcomes (Chieffo & Griffiths, 2004; Dwyer & Peters, 2004; Lewis & Niesenbaum, 2005). It is not the purpose of this project to address this debate, though it should be noted that it is ultimately not the length, but rather the characteristics and objectives of a study abroad program that contribute to student learning (Chieffo & Griffiths, 2004).

However, in the context of any research study, it is important to define the type of study abroad program under consideration. Engle and Engle (2003) identified seven defining components of overseas programs, including: (1) length of the program, (2) entry target-language competence, (3) language used in course work, (4) context of academic work, (5) types of student housing, (6) provisions for guided/structured cultural interaction, and (7) experiential learning and guided reflection on cultural experience. Using a combination of these variables, Engle and Engle (2003) created a classification of different types of study abroad experiences, including the study tour and short-term program types. The study tour is typically a program lasting less than two weeks, which includes academically relevant site visits and field trips, with instruction entirely in English and limited cultural interactions. The short-term program, according to Engle and Engle (2003), typically lasts 3 to 8 weeks, includes subject matter instruction in English, with some limited foreign language exposure and may include homestays or accommodation with foreign students, which facilitate more cultural interactions than in the study tour format.

More recently, however, Vande Berg, speaking on behalf of the Forum on Education Abroad' s Goals Committee on Outcomes Assessment, proposed "a more rational and useful approach to classifying education abroad programs" (Vande Berg, 2010, p. 1). He suggested that the conventional approach for classifying programs based on duration and structure is not workable for research purposes and outcomes assessment as these categories frequently overlap. Indeed, this is the case in the current study, where the programs examined could be classified as both study tour and short-term according to the Engle and Engle (2003) approach. Rather, Vande Berg proposed an approach to classification based on the level of cultural integration that focuses principally on student learning. His system grades programs on a continuum in relation to the extent to which they provide students with structure and opportunities to integrate with the host culture. He argues that this approach, which essentially de-constructs programs into several common elements, enables measurement of outcomes and comparison across programs. However, Vande Berg suggested the need for further research to determine the program characteristics that have the most impact on student learning. In the meantime, he proposed a preliminary classification based on three program characteristics that he hypothesized to have the greatest impact on student learning: the nature of the classroom experience, duration of study, and language of instruction. In this context, the programs included in the current study were classified as faculty-led short-term, during which students studied in a cohort, were taught by both American and host country faculty, and used English as the primary language of instruction.

Rationale – Why Study Abroad?

Many colleges and universities promote study abroad programs as opportunities for students to experience another country, acquire new knowledge and skills needed to become productive and successful members of the global community, broaden their worldview, and increase their intercultural awareness to promote cross-cultural understanding (Anderson et al., 2006; Black & Duhon, 2006). Underlying these claims is the need for a college education to prepare students for a future as inter-culturally competent global citizens, with the skills and knowledge required to work in an increasingly globalized world. Indeed, the phenomenon of globalization is frequently cited as being the driving force for the growing levels of interest and participation in study abroad (Lewin, 2009).

With increased global economic competition and demands for increased global cooperation, the need for students to obtain extensive exposure to the perspectives and practices of other cultures has been deemed essential for the purposes of promoting global peace and prosperity, however one defines those terms. Globalization and the geopolitical realities of the Post 9-11 world have driven home the need for U.S. college graduates to be “globally competent,” regardless of exactly how an institution chooses to define that term (Brewer & Cunningham, 2009). In terms of the pedagogy associated with education using this globalized perspective, the concepts of global citizenship and intercultural awareness have become predominant in the higher education literature.

Global Citizenship

The concept of global or world citizenship is an historic one that has its roots in Greek and Roman philosophy and political theory of the early twentieth century. Global citizenship emerged as a concept in colleges and universities in the late 1990s, when it was incorporated into numerous mission statements and institutional goals (Schattle, 2007). However, despite the widespread use of this term and the fact that it is frequently invoked as the desired outcome of an internationalized education, there appears to be little consensus about the definition of global citizenship. While the terms citizenship and citizen usually refer to a person's national identity, as it is associated with a single country, global citizenship obviously cannot be defined this way.

Contemporary understandings of the concept of global citizenship encompass multiple concepts, such as awareness, responsibility, participation, cross-cultural empathy, international mobility, and personal achievement. Some researchers, primarily those concerned with economics, are likely to adopt a fairly narrow definition of a global citizen as an individual who can live and work effectively anywhere in the world (Noddings, 2005). Others, however, take a broader view, generating a more multifaceted definition of global citizenship. For example, Carter (2005) claims that global citizenship advocates value respect for fellow global citizens, regardless of race, religion or nationality. A recent review of the literature by Schattle (2007) provides a sense of the complexity of this issue, suggesting that there are actually five overlapping categories of global citizenship:

- “Global cosmopolitans” who exhibit openness toward other cultures, peoples and environments” (Urry, 2000, p. 73);
- “Global activists” who campaign on issues such as human rights, poverty and environmental protection;
- “Global reformers” who advocate for governmental and policy change;
- “Global managers” who work in governmental and intergovernmental capacities to resolve global issues;
- “Global capitalists” who work for multinational corporations.

Global Citizenship for Scientists and Engineers. In science and engineering-related fields, the development of a global perspective is deemed essential preparation for scientists and engineers who must understand science in a cultural context and who can succeed when collaborating and competing with scientists from all over the world (Wainwright, Ram, Teodorescu & Tottenham, 2009). Further, according to Fass and Fraser (2009), study abroad experiences emulate the scientific process of constructing understanding about the natural world through observation, measurement, and testing. They contend that participation in a study abroad experience by science students results in the development of the international and intercultural competency skills indicative of global citizens and that these real-world experiences serve as useful preparation for future careers as globally-minded scientists and engineers (Fass & Fraser, 2009).

Not surprisingly, however, such complex definitions and vague expectations of global citizenship expressed by colleges and universities have resulted in an ongoing debate about how this term is employed in the higher education context. Concerns include the level of intellectual legitimacy associated with the pursuit of global citizenship and whether the concept actually generates any new or distinct pedagogical approaches. Of more significance for this study is concern regarding how global citizenship can be reliably and accurately measured as a construct in order to ensure that educational programs, such as study abroad, actually make a difference and contribute to the creation of global citizens. The development of the knowledge, skills, attitudes, and behaviors necessary to either compete successfully in the global marketplace or work toward finding and implementing solutions to problems of global significance are driving factors in the design of most contemporary science and engineering study abroad experiences (Schattle, 2007). Identifying and assessing global citizenship outcomes for science and engineering study abroad program participants can contribute new data and evidence to help resolve this ongoing debate regarding definitions and characteristics of the global citizenship construct.

Intercultural Competence

Globalization and the internationalization of higher education have also prompted post-secondary institutions to consider the development of intercultural competence as a desirable educational outcome. Milton Bennett (1998) defined intercultural competence as the ability to communicate effectively and appropriately in a variety of cultural contexts, requiring culturally sensitive knowledge, a motivated mindset, and appropriate skills. Intercultural competence has also been defined as the ability to recognize multiple perspectives, including one’s own cultural values (Fuller, 2007). Such cultural communication skills are highly desirable in today’s multicultural and multinational marketplace and scientists and engineers are also expected to acquire such skills (Samovar & Porter, 2000; DeWinter, 1997). Moreover, the American Council on Education (ACE) has expressed concern that, in the absence of intercultural competence, the U.S. will be at a competitive disadvantage, with students who are unlikely to succeed in the twenty-first century (ACE, 1995).

It is widely held that study abroad experiences contribute to students' development of intercultural sensitivity and many U.S. universities claim to value intercultural competence (Jenkins & Skelly, 2004). However, few institutions emphasize intercultural skills as an anticipated outcome of internationalization and even fewer have designated methods for documenting or measuring intercultural competence (Deardorff, 2005). Thus, there is increasing pressure on institutions to evaluate the effectiveness of their internationalization efforts. Deardorff (2005) argues that to provide a more thorough and non-biased picture of outcomes, assessments must involve more than survey or self-reporting instruments.

Questions arising from the existing literature focus on the extent to which different types of study abroad programs impact the intercultural development of students and whether different pedagogical approaches aid or hinder such development. Finding answers to these questions may assist with determining more accurately how useful study abroad is for achieving certain learning outcomes, as well as for making meaningful improvements to existing international study programs. The current study used the Intercultural Development Inventory (IDI), which is a validated and widely-used instrument, to assess underrepresented science and engineering graduate students' progress toward intercultural competency as a result of participation in a short-term, faculty-led study abroad experience.

Intercultural Development Inventory (IDI). Based on Milton Bennett's Developmental Model of Intercultural Sensitivity (DMIS; Bennett, 1993), and constructed and tested by Dr. Mitchell R. Hammer and Dr. Milton J. Bennett, this assessment has been widely used since 1998 in both corporate and educational settings in the United States, Europe, and Asia. It measures an individual's orientation toward cultural difference and level of intercultural competence/sensitivity across a developmental continuum for individuals, groups and organizations.

The IDI consists of 50 Likert-type items and 16 demographic questions. The wording and content of the items is based on actual statements made by people from many cultures throughout the world and reflects a range of viewpoints toward cultural differences. Several phases of testing have proven the IDI to be a statistically reliable and valid measure of intercultural sensitivity. The first validation phase, involved the development of an initial 60-item IDI and qualitative interviewing of a culturally diverse sample of 40 individuals to assess content validity. Testing of this instrument with a sample of 228 subjects facilitated identification of six factors that generally align with the DMIS. The second phase of testing involved the addition of items and testing on a sample of 591 culturally diverse respondents. Overall, these various tests demonstrated that the IDI is a robust measure of the core orientations of the intercultural development continuum and that the assessment tool is generalizable across cultures. (Hammer, Bennett & Wiseman, 2003, Hammer, 2011).

More recently, comprehensive testing of the IDI across cultural groups with confirmatory factor analysis suggested the following seven scales: Denial (7 items, α= .66), Defense (6 items, α= .72), Reversal (9 items, α= .78), Minimization (9 items, α= .74), Acceptance (5 items, α= .69), Adaptation (9 items, α= .71), and Cultural Disengagement (5 items, α= .79). The IDI provides several different assessment of an individual’s intercultural development in relation to the DMIS continuum levels. The Perceived Orientation (PO) score, computed using an unweighted formula, reflects where the individual or group places itself along the intercultural development continuum (PO, α= .82). The Developmental Orientation score (DO, α= .83) is computed using a weighted formula and identifies the main or primary orientation of the individual or group along the intercultural continuum. For the purposes of this study, I used the developmental orientation score, which is the perspective that an individual is most likely to use to bridge cultural differences and commonalities. Additional details on the IDI, including reliability and validity information are available on the IDI website (http://idiinventory.com/) and in several associated publications (Hammer et al., 2003; Hammer, 2011).

The IDI is frequently used in research regarding study abroad experiences, especially in the liberal arts and foreign language fields. For example, Anderson, Lawton, Rexeisen and Hubbard (2006) used this instrument to assess intercultural sensitivity of 23 undergraduate business students who participated in a four-week, faculty-led study abroad program in Europe. The researchers administered the IDI before and after the program and preliminary results indicated that short-term programs can have a positive impact on the overall development of cross-cultural sensitivity. The researchers concluded, “by increasing students’ intercultural sensitivity, it is reasonable to expect that they will also be better prepared to address different cultures” (Anderson et. al., 2006, p. 467). However, a comprehensive literature review revealed few studies of science and engineering study abroad that using the IDI to assess cultural competence, despite the acknowledgment that intercultural competence is an important skill for scientists and engineers (Guest et al., 2006; Beckman, Besterfield-Sacre, Kovalcik, Mehalik, LaScola Needy, Reis, Schaefer & Shuman, 2007).

Benefits of Study Abroad

An examination of the literature on college-level study abroad reveals that most overseas programs have several objectives. Typically these focus on academic learning, including the acquisition of new knowledge and skills; professional development by making professional contacts and clarifying career goals; personal growth, with an emphasis on enhanced sense of personal identity, confidence and flexibility; and intercultural outcomes, including cultural sensitivity and improvement of language skills (Anderson, et al., 2006). Many research studies evaluating the impact of study abroad experiences on U.S. college students have found that participants do acquire global-mindedness, grow intellectually, and develop personally (Hadis, 2005).

A number of professional organizations have also acknowledged and documented the benefits of college level study abroad experiences. The Association for International Educators, NAFSA, contends that an educational opportunity outside the United States can be among the most valuable tools for preparing a student to participate effectively in an increasingly interconnected international community that demands cross-cultural skills and knowledge. They claim that studying in other countries and learning other languages provide students with a better understanding of the many similarities we share with other cultures and facilitate an appreciation of our differences. The relationships that are formed between individuals from different countries as part of international education programs and exchanges can also “foster goodwill that develops into vibrant, mutually beneficial partnerships among nations” (NAFSA, 2003, p. 4).

In terms of academic learning, there is evidence that study abroad can enhance the development of disciplinary knowledge and skills. For example, most professionals working in study aboard and international education today embrace the notion that study aboard can enable students “to learn things and learn in ways that aren’t possible on the home campus” (Vande Berg, 2007, p.392). A large-scale study conducted by the Institute for the International Education of Students (IES) reported long-term, positive impacts of college level study abroad experiences on students’ personal, professional, and academic development, influencing issues such as career path, worldview, and self-confidence of alumni (Dwyer & Peters, 2004). Meanwhile, others have documented gains in foreign language learning and cultural knowledge and an increased interest in interdisciplinary studies resulting from participation in study abroad experiences (Lewis & Niesenbaum, 2005). Moreover, several studies have indicated that study abroad provides students with opportunities to critically examine their own national identity and associated traits and their role in the global context (Dolby, 2004).

Participation in, and Benefits of, Study Abroad for Science and Engineering Majors

National organizations and individual researchers have identified various motivations for internationalization of the science and engineering disciplines. As outlined in Chapter 1, these include promoting and maintaining national supremacy on the global stage, tackling some of the most challenging and intractable science-based problems facing the world, and standardizing scientific research methodologies and procedures internationally. Study abroad offers one mechanism by which science and engineering students can acquire some of the globally relevant skills needed to address these concerns. For example, a study of the global perspectives of students who participated in an NSF-funded Research Experience for Undergraduates (REU) reported a number of benefits for U.S. science and engineering students who visited another country and interacted with the local people. This study found that students completing international REU experiences had the opportunity to expand and share their knowledge, forge new relationships, learn about other cultures and languages, and learn different ways to solve and understand scientific problems. Student participants were also reported to have become more interested in both other cultures and learning another language as a result of their study abroad experiences (Guerrero, Labrador, & Perez, 2007).

In a study of engineering students studying abroad by Haddad (1997), a longitudinal survey of alumni indicated that the study abroad experience played a positive role in participants' post-graduation offers of employment and promotion. Meanwhile, the International Engineering Program (IEP) at the University of Rhode Island, which received NSF funding for study abroad experiences through a Program in International Research and Education (PIRE) grant, reported increased placement rates for their IEP graduates. Furthermore, they reported that the majority of their IEP program graduates are employed by firms who work globally (Grandin, 2006).

The Council on International Education Exchange (CIEE) has also examined study abroad for college level science and engineering students, and in particular, has investigated the barriers to students' participation in such programs and suggested strategies for change. Barriers identified include a lack of institutional commitment to study abroad and a lack of the recognition of the value of these experiences for students. Additionally, the inflexibility of the science curricula required at many institutions makes it difficult to fit study abroad into already full schedules and raises concerns about the extra time to degree resulting from study abroad participation and the resulting negative impact on successful admission to highly competitive graduate programs.

Further, a lack of awareness by both science and engineering students and faculty regarding the value of study abroad, coupled with a lack of language skills and foreign expertise of students and faculty, have resulted in limited interest in, and support of, study abroad among both groups. Other barriers include faculty perceptions that their work on study abroad programs is not recognized for promotion or tenure, the lack of science content background among most study abroad professionals, and the lack of existing partnerships between science faculty and study abroad professionals. Finally, there are financial concerns related to balancing exchange numbers and the loss of tuition fees when students undertake programs that are not covered by reciprocity agreements.

Strategies suggested to address these many barriers include: clearly documenting and demonstrating the intrinsic value of study abroad for science students and faculty, adding science study abroad to institutional and departmental missions, providing more flexibility in the science curriculum to encourage study abroad participation, establishing partnerships between science faculty and study abroad professionals and acknowledging study abroad work in the faculty tenure and promotion process (CIEE, 2003).

Participation and Benefits of Study Abroad for Minority Students

Even as overall study abroad participation has increased, American students studying abroad have remained disproportionately White in comparison to the racial composition of college-level students overall (Dessoff, 2006; IIE, 2011; Shih; 2009). Despite substantial efforts to increase the participation of minority students in study abroad, the gap between minority and majority students participating in these programs is actually widening (Dessoff, 2006; Salisbury, Paulsen, & Pascarella, 2011; Shih, 2009). Many reasons are offered to explain the low levels of study abroad participation by African American, Hispanic/Latino(a), Asian American, Native American and other minority groups. Perhaps Marjorie Ganz, Director of the Study Abroad and International Exchange Program at Spelman College, offered one of the most widely accepted explanations when she cited the four Fs; family, faculty, finances and fear (Pickard & Ganz, 2005). Others have expounded upon these ideas and cited additional obstacles and constraints faced by minority students, such as a lack of relevant study abroad programs and misconceptions about the value of study abroad (Brux & Fry, 2009). Although recent research has shed some light on the factors that influence the decision to study abroad (Goldstein & Kim, 2006; Salisbury et al., 2010), a detailed understanding of the outcomes of participation in study abroad by minority groups remains elusive. As Dessoff (2006) states, “we need to present study abroad as normal, generally beneficial, and certainly worth the extra effort and cost” to increase participation in study abroad by underrepresented minority students” (p. 24).

Perhaps because of the low levels of participation in study abroad by minority students, few studies have investigated the associated outcomes for these groups. However, several reports have suggested numerous potential benefits for minority study abroad participants, including positive impacts on employment readiness, the expansion of job opportunities, increases in income potential and development of new career-relevant skills (Ikeda, 2006; Picard, et al., 2009). Advocates also claim that returned study abroad students get better grades and improve their chances of acceptance to graduate, medical and law school (Martinez, 2011). A recent study of 12 McNair scholars who participated in study abroad at the University of Delaware indicated that students cited benefits related to personal growth (maturity), academic focusing, and cultural learning. Interestingly, several students commented that the study abroad experience made them more open to new perspectives, including being more open to issues related to diversity (Gleason, Chieffo & Griffiths, 2005).

Assessment of Study Abroad Participant Learning Outcomes

The press for evidence to document student learning by policy makers, accreditation organizations, and the public has led to a series of national initiatives for outcomes assessments on college campuses. Similarly, college faculty and administrators working with study abroad programs have recognized the need to become much more transparent about the objectives of these experiences, the connection of study abroad to the broader college curriculum, and the assessment of student learning resulting from study abroad experiences (Brewer & Cunningham, 2009).

Despite these demands, surprisingly little empirical research has been conducted regarding the impact of different models of study abroad programs on student learning. Indeed, the entire field of education abroad has historically lacked extensive data documenting its impact on student learning (Bolen, 2007). In the Forum on Education Abroad State of the Field Survey 2009 (FEA, 2010), only 41% of the institutions surveyed reported that they have clearly-stated learning outcomes for each of their study abroad programs and less than half of the institutions surveyed indicated that they have regularly scheduled evaluation procedures in place for each of their education abroad programs.

According to Sutton, Miller and Rubin (2007), three categories of outcomes should be assessed for study abroad programs. They list these as knowledge and skills (cognitive) outcomes, attitudinal (affective) outcomes and life choices. Other researchers have identified potential outcomes in terms of academic learning, personal growth, professional development and intercultural development (Ingraham & Peterson, 2004; Deardorff, 2006). For this study, three major categories of outcomes were examined: academic STEM learning, personal growth and intercultural development. The academic STEM learning category encompasses the development of new knowledge and skills related to science and engineering, as well as the role of these disciplines in the global context. The personal growth category refers to aspects of individual maturity and self-confidence and also includes aspects of professional development and global awareness. Finally, the intercultural development outcome examines the individual’s ability to communicate effectively and appropriately in a variety of cultural contexts, which requires culturally sensitive knowledge, a motivated mindset, and appropriate skills.

Academic Learning Outcomes

Academic learning outcome assessments traditionally associated with study abroad experiences measure student knowledge and skills development in foreign language, global awareness and disciplinary-specific understanding (Engle & Engle, 2003; Deardorff, 2006; Mohajeri Norris & Dwyer, 2005). Since most students who study abroad are liberal arts and foreign language majors, it is understandable that much of the existing research on study abroad impacts has focused on language acquisition and general global awareness (Dolby, 2004; Lambert, 1993).

In terms of language acquisition, a study by Engle and Engle (2003) found that participation in a study abroad experience could have significant impacts on a students learning. In this study, 257 students on a semester-long program completed the Test d'Evaluation de Francais (TEF) in a pre- and post- format. This test measures a student's foreign language acquisition and the researchers found significant increases in pre-post test scores of between 25% and 42% from the beginning to the end of the semester.

Another aspect of academic learning, global awareness, was investigated by Chieffo and Griffiths (2004), using a survey to examine student learning after they completed short-term study abroad experiences of at least four weeks in length. They assessed the global awareness of 1509 study abroad students in four sub-categories: intercultural awareness, personal growth and development; awareness of global interdependence; and functional knowledge of world geography and language. They concluded that short-term programs, even as short as one month, are worthwhile educational endeavors that have significant self-perceived impacts on students' global awareness.

A few studies have examined academic gains beyond language acquisition and level of global awareness. In 2002, Hill and Woodland (2002) investigated the impact of an international experience on student participants' deep learning. They defined deep learning as the "acquisition of higher order skills, such as analyzing, interpreting and evaluating information, rather than simply amassing, reproducing and describing it" (p.

540). This research study focused on 150 students who participated in a semester-long international field course to three destinations in Spain, France and Tunisia. Hill and Woodland evaluated the students' deep learning using weekly questionnaires that examined four broad areas: preparatory lectures/seminars, field exercises, model assessment and dissertation applicability. They concluded that participation in the international course significantly enhanced students' analytical learning abilities and critical thinking skills (Hill & Woodland, 2002). Another study by Hadis (2005) surveyed 95 participants in study abroad programs from the College of New Jersey and Rowan University to assess their level of academic learning. This research study used a pre- and post-trip questionnaire to examine changes in students' self-reported academic learning, global-mindedness, open-mindedness, independence, and international mobility as a result of the study abroad program. The findings indicated a statistically significant correlation between academic learning outcomes and increased levels of independence resulting from a study abroad experience.

Finally, in a comprehensive study, Ingraham and Peterson (2004) examined student learning in study abroad experiences using a broad range of parameters. They noted that there is a "relative scarcity of systematically gathered qualitative and quantitative information that assesses the impact of study abroad" and attempted to develop a broad range of mechanisms to examine intellectual growth, personal growth, intercultural awareness, and professional development (Ingraham & Peterson, 2004, p 83). In this study, the researchers measured "the acquisition of knowledge, skills and attitudes that students need to live and work in the 21st century" using pre- and post-surveys, faculty observations and secondary data analysis of the university's student database (Ingraham & Peterson, 2004, p. 83). A total of 1,104 students who studied abroad on over 40 different programs of varying lengths during the 1999 – 2000 academic year completed the pre and post surveys that included items related to both language learning and academic performance. Faculty observations involved reports of the impact of their program on their students and secondary data sources enabled comparisons between students who had studied abroad with those who had not. Ingraham and Peterson's (2004) findings indicated that study abroad experiences had a positive impact on all parameters of student learning and that the academic learning scores increased as program length increased. Furthermore, while the difference between the pre- and post- program surveys was not significant for the language learning scores, statistical analysis did indicate a significant different between the students' pre- and post- study abroad scores for the academic learning measure. Faculty observations supported these findings, reporting that students gained a significant amount of academic knowledge and some intellectual maturity while participating in the study abroad programs. Using secondary data analysis, Ingraham and Peterson (2004) also concluded that the grade-point average (GPA) of students who study abroad is, on average, higher than that of non-participants. Overall, they concluded that a significant correlation exists between study abroad participation and academic learning measures, such as knowledge and skills acquisition.

Personal Growth Outcomes

A review of studies examining the impact of study abroad participation on personal growth outcomes suggests that several of the most frequently assessed parameters include the development of personal identity and personal confidence, the perception and understanding of different cultures and the effect of the experience on career aspirations. For example, in 2004, Dolby examined the experiences of 26 American undergraduate students, representing a variety of majors, who studied in Australia during the spring semester of 2001 (Dolby, 2004). She interviewed students before departure, during deployment, and several months after they returned to the U.S. Interviews focused on determining students' views regarding the impact of the study abroad experience on their concept of national identity. She found that the most significant outcome for study abroad students was the development of a greater understanding of their own identity as Americans. In fact, this aspect of their personal growth was greater than their development of understanding of other cultures. This research illustrates that while the study abroad experience can affect the development of students' national identity, their perceived interpersonal or intercultural competence may be unaffected.

In the study by Ingraham and Peterson (2004) mentioned above in the academic learning section, findings indicated a significant difference in personal growth between pre- and post-trip surveys for 1,104 students who participated in study abroad programs. The personal growth construct included items related to self-reliance, independence, problem solving and leadership skills, open-mindedness and personal confidence. Ingraham and Peterson (2004) found that students' scores on the personal growth construct increased gradually as the length of the study abroad sojourn increased in much the same way as it did for the academic learning construct. Conversely, these researchers did not find a statistically significant impact of study abroad participation on the professional development construct that examined a student's career plans.

Meanwhile, Drews, Meyer and Peregrine (1996) examined student learning on the affective dimension, investigating the effects of study abroad on participants' conceptualization of other national groups. This study included 94 college students, of whom 36 had studied abroad for at least one semester and 23 were planning to and later did study abroad for at least one semester. The remaining 35 students had not previously studied abroad and were not planning to do so, and these formed the control group. Evaluation of students' perceptions of other national groups included a free association writing task, a semantic differential task and a combination exercise. The researchers collected data from students on two occasions, once at the beginning of fall semester and again at the end of spring semester. Their findings indicated that those who studied abroad were more likely to develop a more "personalized" view of other national groups compared to those who did not study abroad, realizing that members of other nations have pleasant and unpleasant attributes similar to those of members of their own nationality.

The Institute for International Education (IIE) examined the impact of study abroad participation on student career aspirations in a large study that surveyed more than 17,000 alumni of their study abroad programs (Norris & Gillespie, 2009). A goal of the study was to explore the long-term impact of studying abroad on participants' career choices and alumni were asked to respond to a series of ten career-related questions. Their responses indicate that the majority of these alumni believe their study abroad experience had nabled them to gain skills that influenced their career paths and increased their interest in an international career. The IIE concluded that the study abroad experience had affected the career choices of nearly two thirds of respondents and that half of the respondents pursued careers with global aspects (Norris & Gillespie, 2009).

Intercultural Development Outcomes

As mentioned earlier, Bennett (1998) defined intercultural competence as the ability to communicate effectively and appropriately in a variety of cultural contexts, requiring culturally sensitive knowledge, a motivated mindset, and appropriate skills. Intercultural development is the measure of an individual's orientation towards cultural differences, as described in the DMIS (Hammer, et al., 2003).

Several studies have documented gains in cultural knowledge, cultural sensitivity, and interpersonal maturity resulting from completion of study abroad experiences. For example, a study of the development of a global perspective by 14 American undergraduate students during a semester at sea used interviews, analysis of student journals, and participant observations conducted at the beginning and end of the voyage. Findings of this study revealed that, after three months, students developed significantly greater cross-cultural understanding and increased awareness of, and interest in world events (McCabe, 1994). Meanwhile, in a comparison study of 154 students who participated in a one-month long exchange program in Japan and 112 control students who did not travel abroad, Stitsworth (2001) used the California Psychology Inventory to demonstrate that the study abroad experience significantly increased individual flexibility and independence.

Kitsantas (2004) examined the broader impact of study abroad programs on students' cross-cultural skills and global understanding and the role that students' goals for participating in study abroad play in the development of these outcomes. Two hundred and thirty two undergraduate students completed a series of pre- and post-trip assessments, including the Cross-Cultural Adaptability Inventory (CCAI) (Kelley & Meyers, 1995), Study Abroad Goals Scale (SAGS) (Opper, Teichler & Carlson, 1990) and the Global Perspective Survey (Hanvey, 1982). Results indicated that study abroad programs significantly enhanced students' cross-cultural skills and global understanding, which helped prepare them to function in a multicultural world and promote international understanding.

Medina-Lopez-Portillo (2004) found mixed results regarding the impact of two language-related study abroad programs in Mexico on students' levels of intercultural development. This study sample consisted of 28 students, with 18 enrolled in a seven-week long program and 10 in a 16-week program. The students completed the Intercultural Development Inventory (IDI) developed by Hammer, Bennett and Wiseman (2003) both pre-trip and post-trip. Findings of this study indicated that less than one third (31%) of the students in the seven-week program advanced to the next stage in the DMIS, while two thirds (67%) of the students in the 16-week program moved forward one stage in the model. The author concluded that students develop greater levels of intercultural sensitivity on longer study abroad programs (Medina-Lopez-Portillo, 2004). In a more recent study, Anderson et al. (2006) assessed the extent to which a short-term, faculty-led study abroad program affected students' intercultural competence. They administered the IDI to 23 students before they traveled abroad and then four weeks after they returned to the U.S. Their results found no significant difference between the pre- and post-trip IDI scores for students who participated in the four-week study abroad experience.

Conversely, Paige, Cohen and Shively (2004) found that 86 college students who spent a semester abroad in various French and Spanish-speaking countries showed significant improvements in cultural sensitivity on the IDI. Finally, in a study of 187 students, Engel and Engel (2004) found that the majority (52%) of students in a semester-long study abroad program demonstrated significant gains on the IDI and that students in a yearlong program showed even greater gains.

In general, assessments of the impact of study abroad programs on intercultural competence are often inconclusive, limited in their level of applicability, and even contradictory in nature. For example, some researchers have reported that study abroad programs produce gains in intercultural competency (Anderson et al., 2006; Paige et al., 2004), while others found no significant effects (Dolby, 2004; Medina-Lopez-Portillo, 2004). Based on the existing body of research literature, there appears be no significant correlation between the length of a program or the level of exposure to a foreign language and the development of intercultural competence. Two programs studied (Anderson et al., 2006 and Medina-Lopez-Portillo, 2004) were short-term in nature, while the others (Dolby, 2004 and Paige et al., 2004) involved semester-long deployments. Anderson et al. and Dolby both investigated programs in which students studied in English-speaking countries, while Paige et al. and Medina-Lopez-Portillo looked at students who studied in programs with a foreign language component.

Limitations of many of these studies include the facts that they generally utilize small sample sizes and the demographics of study abroad programs are heavily weighted toward white females. Furthermore, in most studies, the students were undergraduates originating from a single U.S. institution and all were completing the same study abroad program as a cohort. Unfortunately, the general lack of information provided regarding the participants' backgrounds, socio-economic status, and prior international experience make it difficult to identify generalized recommendations or conclusions from analysis of this body of literature. Additional studies, which address these many limitations, are needed in order to fill existing gaps in the research.

Participant Learning Outcomes for Science and Engineering Study Abroad Experiences

Although a moderate amount of research evidence is available to document the generally positive impacts of study abroad experiences on students, few studies have investigated the academic, personal, and/or or intercultural competence outcomes resulting from science and engineering-focused study abroad experiences. While the impacts of study abroad participation on students majoring in the life and physical sciences and engineering have not been extensively researched, it is clear from studies of education abroad programs in other disciplines that these experiences can be expected to have positive impacts on students' academic learning, personal growth and intercultural development.

Assessment of Learner Outcomes for Life and Physical Sciences Study Abroad Programs

A wide-ranging literature search located a few studies focusing on science students' experiences in international exchange programs. Guest et al. (2006) surveyed students and faculty about their reasons for studying abroad and the perceived value of their international experiences. Their study included a single survey of first and third year students in both biology and physics, polling approximately 80 students in each of the first year classes and 20 in each of the third year classes. They also surveyed 35 faculty members in the science disciplines. The authors reported that science students are historically underrepresented in study abroad programs and those science students who do participate usually complete study abroad experiences in non-science subject areas. Their student survey results indicated that the majority of students identify cost as the greatest impediment to their participation in study abroad programs.

In this same study, other concerns students cited included a perception that a study abroad experience would interfere with their ability to finish their degrees in a timely manner, that they would have to leave family and friends, and that they would have difficulty with a foreign language while overseas. The authors concluded that students were not well-informed about the opportunities for study abroad or associated costs and opportunities to obtain financial support for participation in these programs. They suggested that faculty should emphasize the advantages of participation in an exchange program, both in terms of academia and personal growth. Interestingly, the faculty survey results indicated that almost all faculty members had a previous international experience and there was strong agreement that these international experiences motivated (82%) and stimulated interest (88%) in their own academic careers. However, these same faculty members did not indicate a strong level of support for a mandatory international exchange experience for their own undergraduate students. This study by Guest et al. (2006) revealed some interesting concerns that may potentially impact the participation of science students in study abroad programs. However, additional research is needed to develop a more comprehensive understanding of this issue.

A study by Bender, Wright and Lopatto (2009) investigated students' self-reported changes in intercultural knowledge and competence associated with three separate undergraduate science-experiences, including two study abroad experiences. They employed pre- and post- surveys to assess students' motivations for participating in a domestic undergraduate biology research program (UBRP), an international semester at sea program (SAS) or a biomedical research abroad program (BRAVO). The surveys also assessed students' self-reported learning and cultural gains resulting from these experiences. In total, 32 students completed the surveys; 9 from the BRAVO program, 6 SAS students and 17 from UBRP.

Results of this study indicated that students in the BRAVO and SAS programs were highly motivated by the international scope of their programs and expressed a desire "to learn more about the world" and "experience a different society and environment" (Bender et al., 2009, p. 311). In terms of academic gains, the SAS students reported comparable or greater gains on three of 21 items (becoming part of a learning community, skill in oral presentations and self-confidence). Meanwhile, BRAVO students reported comparable or higher gains in nine areas (clarifying career goals, skill in interpretation of results, tolerance for obstacles faced in the research process, readiness for more demanding research, understanding the need for supporting evidence, skill in science writing, self-confidence, learning to work independently and becoming part of a learning community). An assessment of personal growth indicated that the BRAVO students had changed the most, had the highest levels of self-confidence and had the most increased awareness of global issues.

A more recent study by Lumkes, Hallett and Vallade (2012) examined the knowledge and attitudinal outcomes of 15 agricultural students participating in a two-part course entitled China: Globalization, Agriculture and Environment. The first part of the course was in the classroom and the second part was a 16-day study abroad course in China. Using a pre-post questionnaire, the researchers found that the study abroad experience contributed minimally to the students' knowledge of Chinese agriculture and environmental issues or their understanding of the general nature of the global economy. However, these same students demonstrated profoundly altered cultural awareness and global awareness as a result of the study abroad experience. Thus, the most tangible learning outcomes resulting from this experience were not in the realms of globalization, agriculture or the environment, but instead were associated with the cultural and personal development of participants.

Assessment of Learner Outcomes for Engineering Study Abroad Programs

Surprisingly, despite the relatively low numbers of engineering students participating in study abroad opportunities, there have been more studies investigating these programs and their associated outcomes than in the life and physical sciences. In his remarks to the National Academy of Engineering, Wulf (2004), a former assistant director of the National Science Foundation, contended that engineers must learn to operate in a "global, cultural and business context" (p. 31). He argued that, in the future, engineers must understand other cultures, be able to speak other languages and communicate with people from other disciplines as well as other countries.

An early assessment of a study abroad program in engineering at Kettering University reported increases in students' confidence and knowledge about the world and broader technical understanding of their field (Nasr, Berry, Taylor, Webster, Echempati & Chandran, 2002). This study assessed the learning outcomes of undergraduate students who studied abroad in one program in England or one of two programs offered in Germany. Assessments included reviews of student portfolios (containing assignments, reports, and projects) and the results of a student competency matrix (end-of-course outcomes-based survey). Students also wrote an essay documenting the usefulness and contribution of the course to their professional growth. Nasr et al. (2002) concluded that more comprehensive assessment and evaluation of programs would make study abroad programs a more convincing option for engineering faculty and would benefit students by developing more useful study abroad options.

In 2007, Parkinson reported the results of a survey of U.S engineering study abroad programs designed to understand the types of programs on offer, the challenges associated with these programs, and best practices associated with these programs. This review of 25 programs revealed a variety of program-types from short-term field-trips to dual-degree programs during which students obtain two degrees, one from the home university and one from the abroad university. Challenges identified included issues related to recruiting students and scaling up programs to serve larger numbers of students, recruiting faculty, recruiting parental support, and assessment of learning outcomes. Recommended best practices included the need to have a suite of integrated programs, with a clear set of desired outcomes and proactive recruitment of students. Parkinson recommended that each program be led by several faculty members who are rewarded for their efforts financially and/or with professional recognition, including via the tenure and promotion system. Regarding students, he argued that students in these programs must be prepared before they go abroad and should be familiar with other countries and cultures if they are to remain competitive in the global engineering community. At the institutional level, Parkinson also identified crucial elements of support for study abroad, including the need for long-term commitment by college leadership and the establishment of an integrated approach coordinated by a centralized office to take advantage of any university infrastructure already in place.

Finally, Strauss and Terenzini (2007) conducted a study of the effects of engineering students' in- and out-of-class experiences on their analytical and group skills. They surveyed 4,198 graduating engineering students on 39 U.S. campuses to identify the student activities and experiences that contributed to their development of analytical and group skills. Statistical analysis indicated that the study abroad experience did not exert a significant effect on the development of these skills for graduating engineering majors. However very few students who completed the survey had participated in international study experiences and the authors suggested this might have biased the results of this research in relation to the impact of study abroad.

Summary

The general lack of existing student outcomes assessment research data in study abroad contexts is compounded by the fact that few such programs currently exist for science and engineering students and issues associated with a lack of consensus between faculty and administrators regarding the goals of study abroad programs. And yet, there is a clearly established rationale for students to participate in study abroad and acquire the knowledge, skills, and perspectives they will need for careers in science and engineering in the global environment. Grandin (2006) suggests that engineers, and one would also assume scientists, need to be equipped with innovative technical skills and knowledge, as well as personal and communication skills, to be competitive in the global scenario. He suggests that study abroad can provide such experience for engineering students. Furthermore, it is clear from the few studies that have been conducted, that science and engineering students do indeed develop some of these desirable skills and traits as a direct result of their participation in a study abroad program (e.g., Bender et al., 2009; DiBiasio & Mello, 2004). However, these studies do not provide a comprehensive picture of the academic STEM learning and personal growth outcomes of science and engineering students participating in study abroad experiences and, in particular, they do not address issues of intercultural competence or participation by graduate students. Addressing this research gap is necessary if we want to advocate with faculty and program administrators for increased participation of science and engineering students, especially minority and graduate students, in study abroad.

Based on the documented need for additional research in the specific areas discussed in this review of the literature, this research study aimed to investigate some specific questions regarding the academic STEM learning and personal growth of underrepresented science and engineering graduate students participating in study abroad programs. In order to do so, I developed a comprehensive outcomes assessment instrument to investigate the academic STEM learning and personal growth of science and engineering students who participate in study abroad programs.

Additionally, this study examined the intercultural development of underrepresented science and engineering graduate students participating in study abroad using the pre-existing IDI. Last but not least, an examination of the extent that actual implementation of selected science and engineering-related study abroad programs align with students' perceived learning outcomes after the trip provided the context within which to develop recommendations for future design and delivery of these courses.

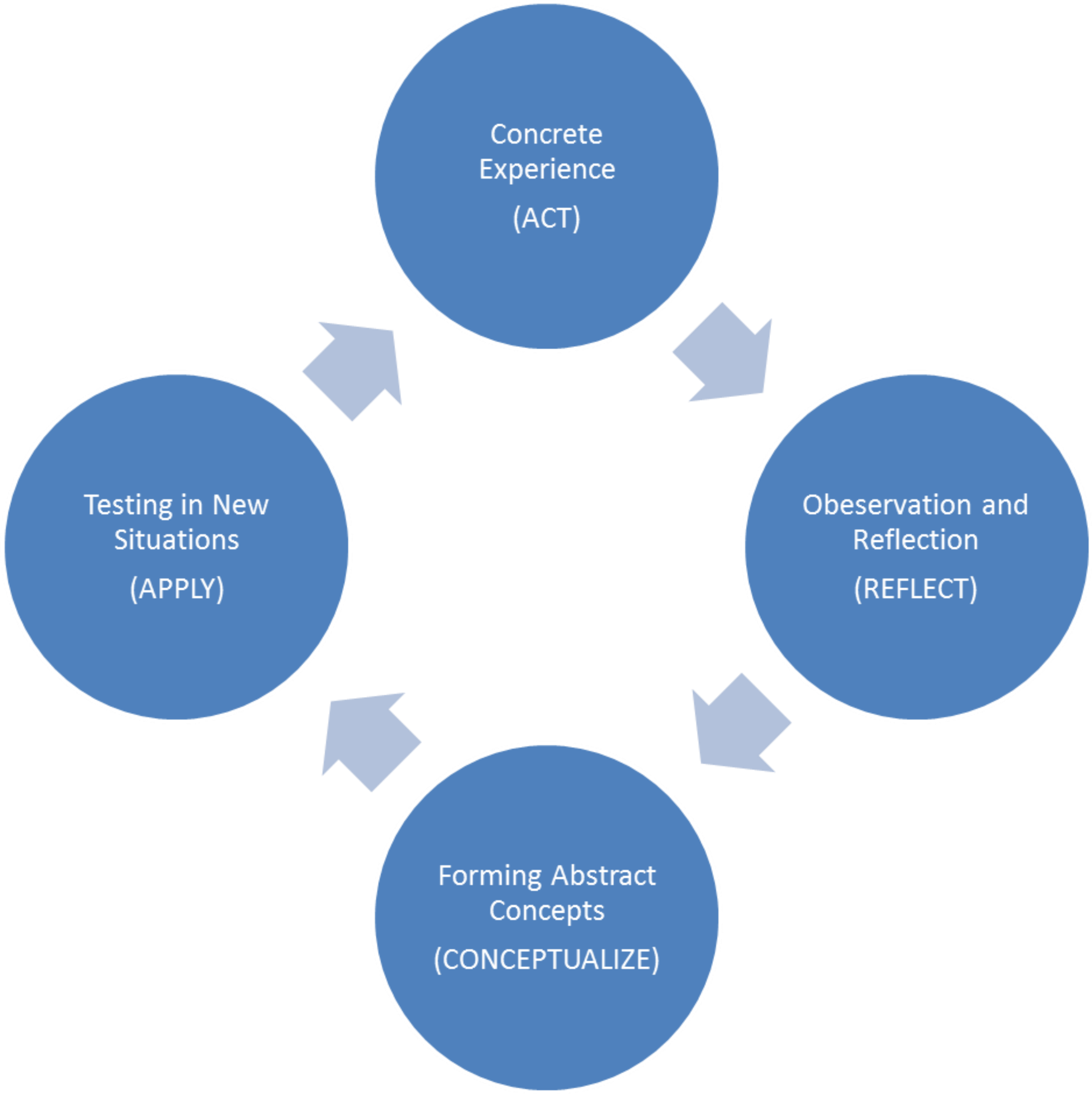

Figure 2-1 Kolb's Experiential Learning Cycle [Adapted from Kolb, D., & Fry, R. 1979. Experiential learning theory and experience in liberal arts education: New directions for experiential learning. San Francisco CA: Jossey Bass.]

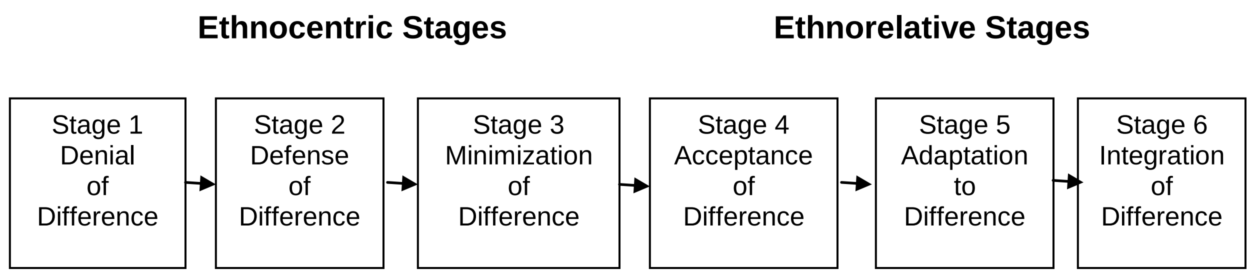

Figure 2-2. Developmental Model of Intercultural Sensitivity [Adapted from Bennett, M. J. 1993. Toward ethnorelativism: A developmental model of intercultural sensitivity. In R. M. Paige (Ed.), Education for the intercultural experience (pp. 21-71). Yarmouth, ME: Intercultural Press.

CHAPTER 3
METHODOLOGY

The primary purpose of this research study was to examine the academic STEM learning, personal growth, and intercultural development outcomes of current graduate students who participated in a series of science and engineering-related study abroad experiences at the University of Florida and compare their outcomes with an equivalent group of non-study abroad graduate students at the same institution. In the process, it was necessary to develop and validate a new instrument for the assessment of academic STEM learning and personal growth outcomes for use specifically with participants completing graduate-level science and engineering study abroad programs.

A second purpose of this study focused on determining which components of the actual study abroad experiences enhanced and/or limited the self-reported academic STEM learning, personal growth, and intercultural development outcomes of study abroad participants. Finally, based on these findings and an extensive review of the literature, I identified best practices and recommendations for the successful design, implementation and evaluation of study abroad programs in the science and engineering disciplines.

Although study abroad experiences focusing on the liberal arts and foreign languages have been examined extensively (Cheiffo & Griffiths, 2004; Dolby, 2004; Engle & Engle, 2003; Ingraham & Peterson, 2004), few investigations of science and engineering-related study abroad experiences have been conducted. Thus, the intention of this study was to provide new insight into the impacts of science and engineering-related study abroad programs on participants and offer guidance regarding strategies and best practices for the development, implementation and evaluation of more effective science and engineering-related study abroad programs.

The first part of this chapter details the study's methodological framework, research questions, study setting, study population and recruitment strategies, and institutional review board approval. The second part elucidates the methods I used to collect the data related to each research question. The final part of this chapter describes the quantitative and qualitative data analysis methods I used to document the academic STEM learning, personal growth and intercultural development outcomes of graduate students participating in selected science and engineering-related study abroad programs. This last section of the chapter also details the development and validation procedures used to create the academic STEM learning and personal growth outcome assessment instrument used this study.

Methodological Framework

A constructivist approach to the analysis of study abroad experiences must deal with the role of individual consciousness and experience as students create their own understanding of the world. Indeed, Ruggie claims that "constructivism is about human consciousness and its role in international life" (Ruggie, 1998, p. 856). Constructivists therefore need methods that can capture the individual meaning-making at the core of their approach.

This study used a mixed-methods approach, with a combination of quantitative assessment instruments and qualitative analyses of students' reflective writing assignments and study abroad program implementation observations that aligned with the over-arching experiential-constructivist theoretical framework. The quantitative survey instruments were used to determine the nature and extent of changes in targeted outcomes resulting from participation in the study abroad experiences, while the qualitative analyses of written student reflections and on-site observations provided additional supporting evidence and potential explanations regarding the factors influencing participant outcomes.

A particular challenge for studying the impact of study abroad experiences on participants is the inherent belief that students will naturally increase in maturity during the course of their participation in an international experience. As a result, I needed to develop a research design that provided as much control as possible for factors posing threats to internal validity. Thus, I used a pre- and post-trip evaluation design and selected an equivalent post-trip comparison group of non-study abroad participants.

This study was completed in four stages, with the development and validation of the academic STEM learning and personal growth outcome assessment instrument for science and engineering study abroad participants as the first stage. This stage included a preliminary focus group interview with students prior to their participation in the science and engineering study abroad programs, a review of the current literature on study abroad outcomes, a review of each selected study abroad program's syllabus, and personal consultations with international education and evaluation experts. These sources collectively provided guidance for the initial development of the assessment instrument. Implementation of the draft assessment instrument in a pilot study, together with a review of the data generated by several experts in the field, provided the opportunity to further test and refine the assessment instrument before it was officially used for data collection. Reliability and validation of the assessment instrument were further examined in conjunction with the next stage of the study.

The second stage of the study used the assessment instrument developed during stage one to pre- and post-assess participating students' self-reported academic STEM learning and personal growth outcomes related to their science and engineering study abroad experiences. A second existing survey instrument, the Intercultural Development Inventory (IDI), developed by Milton Bennett (1993) was used to assess the impact of study abroad experiences on life and physical science and engineering students' levels of intercultural development. In this stage, I also compared the post-trip academic STEM learning, personal growth and intercultural development outcomes of life and physical science and engineering study abroad participants with those of an equivalent group of science and engineering graduate students of similar demographic and educational backgrounds, who did not participate in the study abroad programs.

Stage three of this study involved qualitative analyses of study abroad participants' post-trip reflective writing assignments and on-site observations of the actual implementation of the science and engineering-related study abroad programs studied. As a required component of the syllabus for each study abroad course, students submitted a reflective writing assignment at the end of their study abroad programs in which they discussed their personal perceptions of the trip, including their perceived learning outcomes. I conducted observations and generated field notes during the implementation of four different activities on each science and engineering-related study abroad program: 1) during the pre-departure orientation; 2) during visits to scientific institutions (universities and/or government research facilities); 3) during visits to private sector science and engineering facilities; and 4) during scheduled cultural activities.

In stage four of the study I used all of the data generated during stages two and three to identify best practices for study abroad experiences in the science and engineering disciplines. These include recommendations for program design and implementation and suggestions regarding appropriate techniques and instruments for assessing the academic STEM learning, personal growth, and intercultural development outcomes for students (both undergraduate and graduate) who participate in science and engineering-related study abroad experiences.

Research Questions

As discussed in the previous section, this research study had four distinct stages and the first three stages directly aligned with the following research questions (Table 3-1):

1. How can researchers and practitioners effectively assess the academic STEM learning and personal growth outcomes of life and physical science and engineering graduate students who participate in science and engineering-related study abroad programs?

2. What are the self-reported academic STEM learning, personal growth, and intercultural development outcomes for graduate science and engineering students who complete science and engineering-related study abroad programs? To answer this question, the following sub-questions were posed:

    a. What are the self-reported academic STEM learning, personal growth, and intercultural development outcomes for underrepresented graduate students in life and physical science and engineering who participate in science and engineering-related study abroad experiences?

    b. Do the perceived academic STEM learning, personal growth, and intercultural development outcomes differ for underrepresented life and physical science and engineering graduate students who participate in study abroad experiences compared to those who do not?

3. Which specific components of science and engineering-related study abroad programs enhance and/or limit the impact of these programs on the academic STEM learning, personal, and intercultural development of participants?

Study Setting

This study was conducted at the University of Florida in conjunction with four UF-sponsored science and engineering study abroad programs. Historically, annual participation in study abroad programs at UF has totaled less than 100 life and physical science students and fewer than 100 engineering students per year. In addition, the majority of science and engineering students who complete study abroad programs at UF do not complete science and engineering-related programs. In 2008-2009, 77 UF students participated in five science and engineering-related study abroad programs (Figure 3-1). Sixty-five of these students were undergraduates and 10 were graduate students. Thirty-six students were from the physical or life sciences, 24 were from engineering, and five were from agriculture. The remaining students were from business and management (two undergraduates), social sciences (five undergraduates) and other non-declared majors (three undergraduates and two graduate students).

In 2011, the South East Alliance for Graduate Education and the Professoriate program (SEAGEP), funded by the National Science Foundation Alliance for Graduate Education and the Professoriate (NSF-AGEP), developed four new study abroad opportunities specifically targeting underrepresented science and engineering graduate students. This series of new international study programs was designed to meet the need for global experience at the graduate level. The SEAGEP comprehensive international experiences provide students with opportunities to develop global competencies that give them a competitive edge in their preparation for, and pursuit of, academic careers. The programs studied were between 10 and 12 days in length and, during their time in country, students had the opportunity to visit science and engineering educational and research facilities, meet with researchers, faculty and students at their host institutions, and participate in organized cultural activities (Table 3-2).

The development of the assessment instrument for self-reported academic STEM learning and personal growth outcomes of science and engineering study abroad participants occurred on the UF campus prior to implementation of these new SEAGEP international programs. Initial pilot testing of this instrument took place in conjunction with the first SEAGEP science and engineering study abroad program to Chile in March 2011. Administration of a refined version of this assessment instrument as well as the intercultural development inventory (IDI) occurred on the UF campus before and after the three subsequent study abroad programs to China, South Africa, and Brazil in spring and summer 2011. The assessments followed a pre/post format for each program and were administered approximately one week prior to departure on the study abroad program and again approximately two weeks after return to the U.S. Data for the comparison group were collected on the UF campus during fall 2011. These students also completed the assessment instrument for self-reported academic STEM learning and personal growth outcomes and the IDI assessment.

The analysis of program artifacts, including syllabi and students' reflective writing assignments, also took place on the UF campus following each study abroad program. Finally, I completed on-site observations of program implementation on multiple deliveries of a single course syllabus, "Science and Engineering in a Global Context," in three different countries (China, South Africa, and Brazil) with three different groups of students in May, June, and July, 2011.

Study Populations

A total of 76 graduate life and physical science and engineering students participated in this study. The SEAGEP program specifically serves minority students in the STEM disciplines and thus, the students in this study were also from underrepresented minority groups. However, as mentioned earlier, it is not the explicit purpose of this research study to investigate the impacts of study abroad participation on minority students. Rather, this group served as a convenience sample and was selected based on their participation in the study abroad programs, and not on their minority status. The following sections present the different study samples used to address each of the research questions:

Research Question 1

How can researchers and practitioners effectively assess the academic STEM learning and personal growth outcomes of life and physical science and engineering graduate students who participate in science and engineering-related study abroad programs?

Participants in the initial instrument development phase of the research study (stage 1) were enrolled in the UF science and engineering study abroad program entitled “UF in Chile –Science and Engineering in the Global Context” that was completed in March 2011. Participants in the subsequent instrument validation and reliability-testing phase (stage 2) were the same as the study sample used for research question 2, detailed below.

Research Question 2

What are the self-reported academic STEM learning, personal growth and intercultural development outcomes for graduate science and engineering students who complete science and engineering-related study abroad programs?

For the assessment of academic STEM learning, personal growth, and intercultural development in relation to science and engineering study abroad programs, four distinct groups of students were recruited, three of which included study abroad participants from the following “Science and Engineering in the Global Context” programs:

a. UF in China, May 2011, research study participants; n = 15
b. UF in South Africa, June 2011, research study participants; n = 9
c. UF in Brazil, July 2011, research study participants; n = 9

These three groups of 33 total students formed the study sample for the examination of study abroad participant outcomes outlined in research question 2a.

The fourth group consisted of 32 underrepresented graduate life and physical science and engineering students who did not participate in any of the study abroad programs. I recruited these students to provide a comparison group for the study and they, together with the 33 study abroad participants, formed the study sample used to investigate research question 2b.

Research Question 3

Which specific components of science and engineering-related study abroad programs enhance and/or limit the impact of these programs on the academic STEM learning, personal growth and intercultural development of participants?

I conducted onsite observations of the three study abroad programs to China, South Africa and Brazil and analyzed participants’ post-trip reflective writing assignments to address research question 3. Therefore, the 33 participants of these three study abroad programs formed the study sample for this phase of the study.

Participant Recruitment

I received initial permission to conduct this research study from the lead faculty working with the SEAGEP program at UF. In addition, the SEAGEP faculty director gave me permission to make direct contact with graduate students enrolled in the study abroad programs, and the SEAGEP-affiliated students who did not participate in the programs but were therefore eligible to join the study comparison group. Initially, I solicited all study abroad participants via email, explaining the purpose of the research and detailing the students' commitments. I included the informed consent with this initial email (Appendix B). A short face-to-face meeting with the study abroad participants at the beginning of each separate pre-departure orientation session followed this initial contact. During this meeting, I provided an overview of the research study and asked students to indicate their willingness to participate in the study by signing and submitting the informed consent forms.

For UF in Chile, 11 underrepresented science and engineering graduate students were enrolled in the program and all agreed to participate in the study. For UF in China, UF in South Africa, and UF in Brazil, all 35 science and engineering students enrolled in the programs initially agreed to participate in the research study and completed the informed consent forms. However, one student subsequently elected not to participate in the study and I excluded another student based on the demographic information collected. Thus, the total number of study abroad participants in the research study was 33.

For the comparison group, I asked study abroad program participants to assist with recruitment by identifying a counterpart in their discipline with similar demographics (ethnicity and gender). This selective recruitment approach ensured that the comparison group matched the group that participated in the study abroad program as closely as possible. Following identification of potential comparison group members by the study abroad program participants, I contacted each candidate via email to confirm his/her willingness to participate in the study and asked them to sign and return the informed consent form and complete the assessments electronically. The resulting 32 comparison group students were also all graduate students pursuing doctoral degrees in science or engineering.

Institutional Review Board Approval

I obtained Institutional Review Board (IRB) approval prior to the initiation of this study (Appendix A). This included approval to conduct an initial focus group meeting and administer the new academic STEM learning and personal growth assessment instrument and the existing IDI in pre- and post-trip formats. In addition, the IRB approved the administration of these assessment instruments to the comparison group of non-study abroad graduate students. Furthermore, I received approval to conduct on-site observations of program implementation and to review student-generated reflective writing assignments. Signed permission was obtained from each student before participation in any data collection phase of the study. I provided participants with copies of their completed informed consent forms to keep for future reference and kept original consent forms in a locked filing cabinet.

Data Collection

In this section, I provide details about the data collection activities for each of the three research questions. These data collection activities occurred between February and November 2011.

Research Question 1

How can researchers and practitioners effectively assess the academic STEM learning and personal growth outcomes of life and physical science and

engineering graduate students who participate in science and engineering-related study abroad programs?

Initial development of the assessment instrument for academic STEM learning and personal growth outcomes involved four components: 1) a review of the current literature on study abroad outcomes, 2) a student focus group, 3) a review of the study abroad syllabi for each program implemented and 4) personal consultations with international education and evaluation experts. Information from all of these components was then used to develop a draft version of the assessment instrument. Next, pilot testing of the first draft of this instrument occurred in conjunction with the UF in Chile program in March 2011. Following pilot testing, expert reviews of the pilot test results provided guidance for the revision of the assessment instrument before use in later stages of the study. The following sections provide detailed information about each of the four components involved in the development of the assessment instrument for academic and personal growth outcomes.

Part 1: Draft assessment instrument development

Literature review. The lack of a pre-existing, valid and reliable instrument for assessing perceived student academic STEM learning and personal growth outcomes resulting from participation in science and engineering study abroad programs necessitated the development of a new tool for use in this study. I obtained initial guidance from a review of the literature describing several existing survey instruments developed for the general assessment of outcomes reported by students completing non-science and engineering-related study abroad and international experiences. The full literature review that informed the development of the assessment instrument is available in Chapter 2.

Student focus group. A preliminary focus group interview helped me identify potential items for inclusion in the assessment instrument for academic STEM learning and personal growth outcomes. I conducted this focus group in February 2011 with six graduate students enrolled the UF in Chile study abroad program. The focus group convened approximately four weeks before trip departure. I asked students the following five questions in order to develop a clearer understanding of perceived expectations and anticipated outcomes associated with their upcoming study abroad experience:

1. Why did you decide to participate in a study abroad program?
2. Why did you choose to participate in a science and engineering-focused study abroad program?
3. What are your expectations for this study abroad program to Chile?
4. What do you hope to gain personally and professionally as a result of your participation in the study abroad program?
5. Do you consider international activities to be an important component in science and engineering education overall?

Syllabus review. "The first aspect of outcomes assessment involves deciding/identifying the goals, objectives or competencies the institution or program wishes to assess" (Bolen, 2007, p.1). To this end, I reviewed the program syllabus for the three SEAGEP international programs and incorporated their specific stated objectives into the study abroad assessment tool I developed. Specific objectives in the syllabus for the SEAGEP science and engineering study abroad experiences included:

- to learn about the history, culture, and traditions of the host country
- to develop an understanding of the differences in STEM education and research cultures between the U.S. and the host country
- to investigate one of the four research topics below with an assigned team:
    - Science and Technology

    - Science Communications
    - Technology Transfer
    - Education
- to network with students, faculty, researchers and government agencies abroad
- to present an oral research presentation in the host country.

Expert consultation. Beyond reliance upon existing literature regarding the objectives and outcomes of college level study abroad programs, development of the new assessment instrument also drew upon the experience and advice of three individuals with expertise in this area. Conversations with faculty members who have multiple years of experience as science educators, study abroad program leaders and international educators provided significant input into the development of items for inclusion in the assessment instrument. These experts collectively noted that previous study abroad participants they personally worked with developed both academically and personally as a result of their participation in an international program. Specific outcomes cited by these experts included the fact that study abroad participants:

1. sometimes change their majors and areas of research focus as a result of the experience
2. develop persistent networks and lasting ties with scientists from their host countries and conduct on-going collaborative research.

These experts all acknowledged that evidence of these program impacts was primarily anecdotal in nature and all of them also acknowledged the need for a more formal, valid and reliable assessment instrument for documenting the academic STEM learning and personal growth impacts of study abroad experiences on participants.

Following the completion of these four components outlined above, I used the data and information collected to develop a draft assessment instrument containing 53 items.

I conducted pilot testing of this draft instrument for assessing the academic STEM learning and personal growth outcomes on the UF in Chile program as described below.

Part 2: Draft instrument pilot testing

Pilot testing of the draft assessment instrument occurred in March 2011 in conjunction with the UF in Chile study abroad program. This pilot test provided an opportunity to:

1. review the academic STEM learning and personal growth outcome assessment instrument for feasibility of use and clarity/quality/appropriateness of individual items
2. identify potential issues related to administration or completion of the assessment.

During this phase, students completed the electronic assessment instrument (Zoomerang) online approximately one week prior to their study abroad program departure and again approximately two weeks after their return to the U.S. Pilot test participants were the 11 science and engineering graduate students enrolled in the UF in Chile study abroad program. The students completed the draft assessment instrument and their responses were analyzed in the expert review phase, as described below.

Part 3: Expert review of pilot test results and assessment instrument revision

Two experts in evaluation and assessment methodology and survey design, science education and international education reviewed results of the pilot test of the draft assessment instrument. They examined each item and the student responses on the pilot test to determine if the data collected provided useful data for the assessment of academic STEM learning and personal growth outcomes. This feedback provided guidance for revision of the outcome assessment instrument, including elimination/revision of individual items to enhance clarity and student understanding.

Research Question 2

What are the self-reported academic STEM learning, personal growth and intercultural development outcomes for graduate science and engineering students who complete science and engineering-related study abroad programs?

The study design facilitated the investigation of academic STEM learning, personal growth and intercultural development outcomes for participants in the study abroad programs, and the investigation of how these outcomes compared with a group of non-study abroad students. The following sections provide details for the data collection procedures for each of the sub-questions:

Research Question 2a

What are the self-reported academic STEM learning, personal growth and intercultural development outcomes for underrepresented graduate students in life and physical science and engineering who participate in science and engineering-related study abroad experiences?

I used two quantitative assessment instruments to determine the pre- and post-trip academic STEM learning, personal growth and intercultural development outcomes of the study sample. Comparisons of completed pre- and post-trip assessments were then used to determine changes in these targeted outcomes resulting from participation in study abroad experiences. The following sections provide detailed information about the two data collection instruments and the procedures for each.

Academic STEM learning and personal growth assessment instrument. The instrument used to assess the academic STEM learning and personal growth outcomes of study participants was developed in the first stage of this research study as described above. This 45-item assessment instrument included 20 items designed to assess students' self-perceived gains in STEM-related academic knowledge/skills, 17 items designed to assess their self-perceived levels of personal growth and 8 demographic items designed to provide useful background data regarding study participants (Appendix C).

Intercultural Development Inventory. The second assessment instrument used to document the intercultural development outcomes of study participants was the commercially available Intercultural Development Inventory (IDI). Based on Milton Bennett's Developmental Model of Intercultural Sensitivity (DMIS; Bennett, 1993), and constructed and tested by Dr. Mitchell R. Hammer and Dr. Milton J. Bennett, this assessment has been widely used since 1998 in both corporate and educational settings in the United States, Europe, and Asia. It measures an individual's orientation toward cultural difference and commonality and is a statistically reliable, valid measure of intercultural sensitivity (Hammer, 2011). Prior to conducting this study, I completed the Qualified Administrator training seminar with IDI, LLC. Additional background information about the development and validation of this instrument is available in Chapter 2 and Appendix D.

Data collection procedures. Participants completed both pre-trip assessments following the pre-departure orientation for each study abroad program, which occurred approximately two weeks prior to departure. Participants then completed the two post-trip assessments approximately two weeks after their return to the U.S. However, in some cases post-trip assessments were not completed until up to four weeks after program completion, as not all students returned immediately to the U.S after finishing their study abroad experiences.

Both assessment instruments were administered in an electronic format and I sent the appropriate links to each student individually via email, with the request to complete both pre assessments and both post-assessments within one week of receipt of my email. Initially I asked students to fill out their names on each survey to facilitate the comparison of pre- and post-trip responses. However, as described in the IRB, I immediately deleted each participant's name and replaced each with a code to ensure participant anonymity.

Research Question 2b

Do the perceived academic STEM learning, personal growth and intercultural development outcomes differ for underrepresented life and physical science and engineering graduate students who participate in study abroad experiences compared to those who do not?

The comparison group of 32 science and engineering graduate students who did not participate in a study abroad program completed the same two assessment instruments as the study abroad participants using the same electronic format. However, since there was no need to compute gain scores for this comparison group, students in the comparison group only completed each instrument once during the fall of 2011.

Research Question 3

Which specific components of science and engineering-related study abroad programs enhance and/or limit the impact of these programs on the academic STEM learning, personal growth and intercultural development of participants?

As mentioned in Chapter 2, the over-arching theoretical framework guiding this study was experiential-constructivism, defined as a theory of learning where humans construct meaning from current knowledge structures and experiences. According to Crotty (2003), constructivism "is the view that all knowledge, and therefore all meaningful reality as such, is contingent upon human practices being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context" (p. 42). Constructivist inquiry starts with the experience and asks how participants construct meaning of the event. However, previous studies have indicated that there is often a lack of connection between stated goals for study abroad programs and the actual educational experience as perceived by program participants (Skelly, 2009). I decided that it would therefore be important to observe and document the actual implementation of these programs to determine which specific components of the study abroad experience enhanced and/or limited the students' ability to make meaning out of their experiences.

The program observation component of this study provided an opportunity to examine three alternate deliveries of the same syllabus by several different faculty members in three different international settings (China, South Africa and Brazil: Appendix F). In this stage of the study, I examined the implementation of the program and the students' associated meaning-making processes during four specific activities for each study abroad course: pre-departure orientation; research facility visit; commercial facility visit and cultural activity. These observation sessions lasted between one to two hours and I recorded detailed field notes for each session. As much as possible, I assumed the role of non-participant observer during these activities and refrained from interacting with the students, faculty or guest speakers (Appendix E Observation Protocol).

As described in earlier sections of this chapter, I also collected students' reflective writing assignments following completion of each study abroad program. These enabled me to obtain additional descriptive details regarding each participant's perceptions of how the study abroad experience contributed to their personal learning and growth.

Data Analysis

Research Question 1

How can researchers and practitioners effectively assess the academic STEM learning and personal growth outcomes for life and physical science and engineering graduate students who participate in science and engineering-related study abroad programs?

Initial data collected during the literature review, focus group session, syllabus review and personal consultation with international education and evaluation experts was used to formulate a draft of the academic STEM learning and personal growth outcome assessment instrument used in this study. A review of existing study abroad outcome assessment instruments and a comparison of different assessment instrument formats helped guide decisions related to my own instrument design, content and format as well as procedures for analyzing completed assessments.

Reliability analysis and validation of the academic STEM learning and personal growth assessment instrument was conducted using data from both the 33 study abroad program participants and the 32 comparison group students who completed the instrument. The following sections provide detailed information about the reliability analysis and validation procedures for the academic STEM learning and personal growth assessment instrument.

Reliability. I determined internal consistency reliability of the academic STEM learning and personal growth assessment instrument using the Cronbach's Alpha coefficient. This reliability analysis provides information regarding the extent to which items in the same scale are related to each other. Thus, the Cronbach's alpha reliability coefficient measures internal consistency within an instrument and is based on average inter-item correlations. A total sample of 65 students completed the academic STEM learning and personal growth assessment (33 participants and 32 comparison group members) for the reliability analysis. For purposes of this study, I considered all Cronbach's alpha values above 0.7 as acceptable. In addition to calculating the internal consistency reliability of the entire instrument, internal reliability values for individual academic STEM learning and personal growth scales and for associated sub-scales within each of these constructs were also computed.

Validity. I used a three-stage process involving a blend of expert advice and qualitative research methods to document the content, and construct validity of the academic STEM learning and personal growth outcome assessment instrument.

Content validity. Content validity, which assesses the extent to which an instrument covers the full range of meaning for a measured concept, was determined first. Activities conducted to establish content validity included:

- Review by three experts in the fields of science education and international education and study abroad;
- Review of the peer-reviewed literature to ensure that the concepts included in the instrument are consistent with desired/reported outcomes for other study abroad programs.

An iterative process involving item development, review by experts, pilot testing, additional expert review and item revisions/deletions/additions and implementation helped to ensure the appropriate assessment of targeted concepts. During this process, several items initially included in the instrument were modified, re-ordered or removed. See Chapter 4 for a more thorough description of the instrument revision process.

Construct validity. Construct validity is the extent to which a scale measures or assesses the concepts it was designed to measure. In this study, construct validity was established using three different data sources:

1. a review of the literature describing similar outcome measures used in evaluations of the impact of study abroad programs on participants,

2. statistical analysis of pre and post test data ,

3. an examination of the alignment between the content of a selection of students' reflective writing assignments and the academic STEM learning and personal growth outcome construct scores on their completed post-trip assessment instruments.

Literature review. As described above in the data collection section for research question one, development of individual items and grouping of items into constructs and sub-constructs was based on a review of the literature regarding targeted academic learning and personal growth outcomes assessed using similar survey-type instruments in evaluations of other study abroad programs.

Statistical analysis of pre and post-test data. Parametric testing of completed pre and post academic STEM learning and personal growth outcome assessments for study abroad participants was used to determine if the constructs and sub-constructs measured change in the concepts as designed. The specific statistical analysis used are described in Chapter 5.

Analysis of reflective writing and assessment instrument response alignment. Finally, in terms of construct validity, I reviewed a selected sample of the students' writing assignments, in which they were prompted to reflect upon their experiences and discuss their own perceptions regarding what they learned and how they grew as a result of participation in the study abroad program. Six writing assignments were selected for review: three for students who had the highest scores on the academic STEM learning and personal growth assessment and three for students who scored the lowest on the quantitative assessment. The writing assignments were coded using a priori codes that aligned with the concepts and sub-scales assessed on the instrument. These coded writing segments were then compared with the students' scores on the academic STEM learning and personal growth post-trip assessments.

Research Question 2

What are the self-reported academic STEM learning, personal growth and intercultural development outcomes for graduate science and engineering students who complete science and engineering-related study abroad programs?

For analysis of the IDI, 31 pre- and post-trip scores were collected from the study abroad participant group and 30 IDI scores were collected from the comparison group. Both the IDI and the academic STEM learning and personal growth instruments uses Likert-type items to ascertain changes in perceived outcomes resulting from participation in a study abroad experience. All of these data sets were analyzed using multivariate statistical analyses with SPSS software to determine changes in self-reported academic STEM learning, personal growth, and intercultural development outcomes after participation in the science and engineering study abroad programs and in comparison with non-study abroad groups. Statistical analyses included paired t-tests to compare the pre- and post-trip scores of study abroad students, independent t-tests to compare study abroad participants' scores with non-study abroad participant scores, and ANOVAs to investigate the effect of students' discipline and participation in the specific trips (China, South Africa and Brazil) on the academic STEM learning, personal growth and intercultural development outcomes. Additional details regarding the statistical analyses are presented in Chapter 5. The following sections provide details regarding the data analysis procedures used for each of the sub-questions:

Research Question 2a

What are the self-reported academic STEM learning, personal growth and intercultural development outcomes for underrepresented graduate students in

life and physical science and engineering who participate in science and engineering-related study abroad experiences?

Descriptive statistics (means, standard errors and standard deviations) for completed pre and post-trip assessment instruments completed by the 35 study abroad participants were calculated for each of the academic STEM learning, personal growth and intercultural outcome constructs and sub-constructs. Mean scores were calculated by averaging of all responses for a particular construct and for each sub-construct. Mean scores were also computed for the responses by discipline and trip on each construct and sub-construct.

Inferential statistics in the form of paired t-tests were used to determine the significance of changes in pre- and post-trip scores on both the academic STEM learning and personal growth assessment instrument and the IDI. In all cases, a 95%confidence level was used (α=0.05) to determine significance. I also conducted one-way within subjects ANOVAs to compare the potential effect of students' disciplines (science or engineering) and their participation in a particular trip (China, South Africa or Brazil) on the academic STEM learning, personal growth and intercultural development outcomes.

Research Question 2b

Do the perceived academic STEM learning, personal growth and intercultural development outcomes differ for underrepresented life and physical science and engineering graduate students who participate in study abroad experiences compared to those who do not?

To answer this question, descriptive statistics (means, standard errors and standard deviations) were calculated on the complete instrument, constructs, and sub-constructs of the academic STEM learning and personal growth and IDI assessments completed by the 32 students in the comparison group. Inferential statistics (independent sample t-tests) were used to determine the significance of differences in academic STEM learning, personal growth and intercultural development post-trip scores of study abroad participants and scores on that same instrument for students in the comparison group. In all cases a 95% confidence level was used ($\alpha=0.05$) to determine if differences between scores of the two groups were significant.

Research Question 3

Which specific components of science and engineering-related study abroad programs enhance and/or limit the impact of these programs on the academic STEM learning, personal growth and intercultural development of participants?

The field notes generated during observations of four different study abroad program activities as well as the students' post-trip reflective writing assignments were analyzed using qualitative methods. According to Bogdan and Biklen (1992), the "rough materials researchers collect from the world they are studying; they are the particulars that form the basis of analysis" (p. 106). I selected general content analysis as a method for condensing and summarizing the raw text data from both of my qualitative data sources and for establishing links between the research objectives and the summary findings emerging from analysis of the raw data.

Students' post-trip reflective writing assignments and field notes of program observations served as the primary data sources for examination of the how the actual implementation of study abroad programs enhanced and/or limited the students' academic STEM learning, personal growth and intercultural development outcomes. During the analysis phase I initially familiarized myself with the raw data by reading each set of observation field notes and each writing assignment twice, during which I recorded preliminary summary notes. Text segments containing meaning units were identified and initial codes for each type of meaning unit were assigned. Subsequently, I combined these codes into pre-determined categories linked to my research study goals and the study abroad programs' stated course objectives. The categories of interest identified in this study specifically related to the larger constructs of academic STEM learning, personal growth, and intercultural development. Sub-categories within these constructs included:

- Academic STEM learning
    - Skills/disciplinary knowledge
    - Language/communication skills
    - Socio-cultural aspects of science
- Personal Growth
    - Career goals
    - Confidence/maturity
    - Global awareness
- Intercultural Development
    - Understanding and appreciation of own culture
    - Knowledge and understanding of other cultures.

Once categories within constructs were identified and raw data were coded to align with these categories, I then compared the occurrence and frequency of occurrence of each category in both the students' reflective writing assignments and my own program observations field notes. These qualitative data sources were then compared to students' gain scores on both the academic STEM learning and personal growth assessment instrument and the IDI. All of these analyses focused on the extent to which actual program implementation enhanced or limited the academic STEM learning, personal growth or intercultural development outcomes of participants. In particular, I identified the extent to which various programmatic components provided opportunities for students to engage in activities that promoted each of the outcomes of interest. This analysis facilitated the identification of best practices for the design, implementation, and evaluation of science and engineering–related study abroad programs by highlighting specific program components that provide the most effective strategies for achieving desired outcomes.

Subjectivity Statement

I was born in Northern Ireland at the beginning of what we euphemistically describe as “The Troubles” and my childhood memories contain images of violence and unrest. Fortunately, I also lived in a country with an excellent educational system, which enabled me to escape into books and eventually to college. During my early years in school, I was fortunate to have several teachers who stimulated my interest in learning by engaging me in an interactive learning process. One teacher in particular, Mrs. Wyness, in geography, had a huge impact on me, encouraging me to explore the world and learn more about its physical and biological systems as well as its people and their cultures. As a direct result of her influence and that of my parents, who, while not college graduates themselves, always encouraged my academic endeavors, I became the first person in my family to go to college. Initially, I studied geography, before going on to complete a master’s degree in environmental science.

Throughout my teen years I had opportunities to travel and took advantages of opportunities these experiences offered to make first-hand observations of other regions, systems, and peoples that I was learning about in the classroom. During these years, I leapt at every opportunity to explore a new part of the world. Trips to Europe, Asia, Australia, and the United States furthered my education through experience. During my undergraduate studies, my degree program required several fieldtrips to overseas destinations, which further reinforced my belief that first-hand observation and experience is a critical component in science education.

In my position at the University of Florida International Center, I have heard many student accounts of the life-changing impact of their study abroad experiences. However, I have also become aware of how lucky I was to have many opportunities to travel and study science in foreign contexts. In particular, I noticed that science and engineering students were significantly underrepresented in study abroad programs and began to investigate opportunities to create new programs for these disciplines.

In 2005, I participated in a two-week study abroad program that took pre-service science and social study teachers to Costa Rica and I co-led a four-week program for science and engineering graduate students to South Africa in 2009. In both cases, I observed that students were highly engaged in their international experience and subsequent feedback indicated that the students felt the experience was both academically and personally rewarding. For example, three dissertation chapters, two manuscript publications and several on-going research collaborations were directly attributed to the South African trip by the students completing this program.

As a result of these specific experiences, and in the context of the increased funding opportunities for the development and implementation of science and engineering-related study abroad programs and the existing lack of research documenting actual learning outcomes for science and engineering students participating in study abroad, I decided to focus this study on those issues.

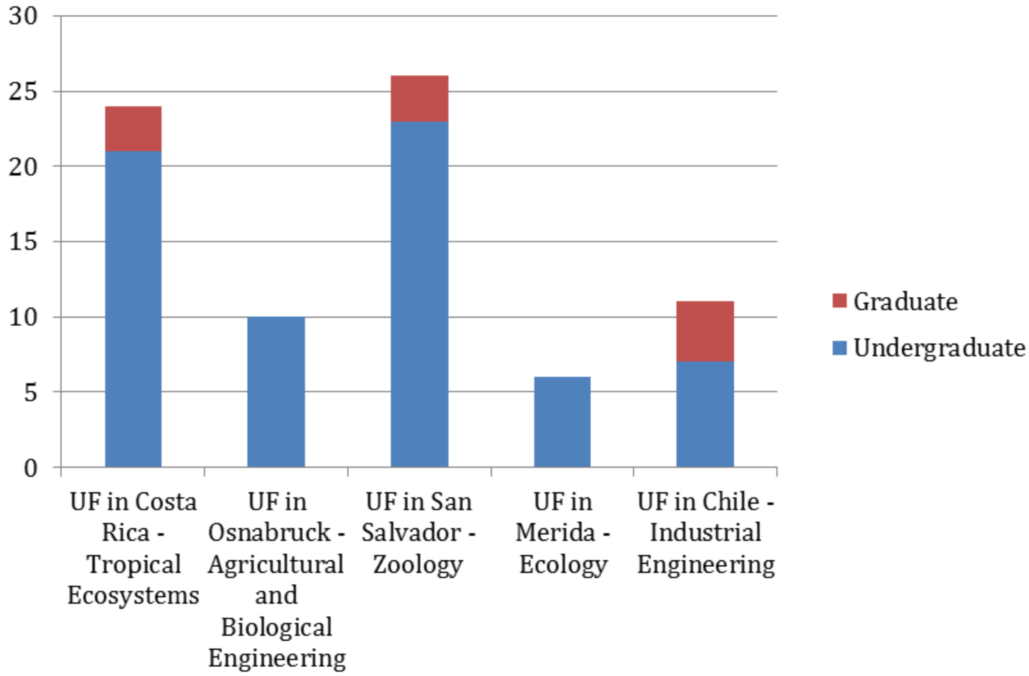

Figure 3-1. Student participation in University of Florida STEM study abroad programs in the 2008-2009 academic year

Table 3-1. Alignment of research questions to research design

Research Stages	Research Question	Participant Criteria	No. of Participants	Data Sources
Stage 1	How can researchers and practitioners effectively assess the academic STEM learning and personal growth outcomes for life and physical science and engineering graduate students who participate in science and engineering-related study abroad programs?	Life and physical science and engineering graduate students enrolled in the UF in Chile study abroad program	n = 11	Literature review Focus group Study abroad syllabus Expert consultations Pre- and post-trip participant responses on the assessment for academic STEM learning and personal growth outcomes
Stage 2	What are the self-reported academic STEM learning, personal growth and intercultural development outcomes for graduate science and engineering students who complete science and engineering-related study abroad programs?	Life and physical science and engineering graduate students enrolled in the UF in Brazil, China and South Africa study abroad programs	n = 33	Pre- and post-trip participant responses on the assessment for academic STEM learning and personal growth outcomes Pre- and post-trip participant responses on the IDI
		Life and physical science and engineering graduate students who did not participate in the study abroad programs	n = 32	Participant responses on a single administration of the academic STEM learning and personal growth outcomes assessment and on the IDI

Table 3-1. Continued

Research Stages	Research Question	Participant Criteria	No. of Participants	Data Sources
Stage 3	Which specific components of science and engineering-related study abroad programs enhance and/or limit the impact of science these programs on the academic STEM learning, personal growth and intercultural development of participants?	Participants from a prior stage of the research	n = 33	Program observations of the UF in Brazil, UF in China and UF in South Africa study abroad programs Participant post-trip reflective writing assignments

Table 3-2. SEAGEP science and engineering in the global context study abroad programs

Program	Dates	Locations	Visit Highlights
UF in Chile	March 4 – 14, 2011	Santiago & Valparaiso	Pontifica Universidad Catolica de Chile in Santiago and Valparaiso
			Federico Santa María Technical University in Valparaiso
			U.S. Embassy Science, Technology and Health Section
			Energy Biotechnology Center
			Colbun Hydroelectric power plant
			La Farfana landfill and biogas facility
			Winery industry visit
			Cultural tour of Santiago
			Visit to Pablo Neruda's Museum & burial site at Isla Negra
			Visit to mountain resort and craft market
UF in China	May 6 – 18, 2011	Beijing, Tianjin & Shanghai	Tsinghua University
			Beijing University of Science and Technology
			China Agricultural University
			Bullet train to Tianjin
			Noodle factory
			Suzhou Industrial Park
			Silk factory
			Cultural tour of Forbidden City
			Theatre and opera performances
			Tianjin cultural street market
			Cultural tour of Great Wall, Imperial Tombs, Summer Palace and Olympic Park
			Cultural tour of Master-of-Nets Garden and Ancient Canal in Suzhou
			Cultural tour of Shanghai & China Expo

Table 3-2. Continued

Program	Dates	Locations	Site Visits
UF in South Africa	June 10 -22, 2011	Johannesburg, Pretoria, Polokwane, Phaloborwa & Nelspruit	University of Pretoria
			Tshwane University of Technology
			Council for Scientific and Industrial Research
			Innovation Hub in Pretoria
			Pretoria Zoo research facilities
			USDA Offices at U.S. Embassy
			Visit to Ministry of Agriculture research sites
			Meeting with South Africa National Parks social scientist
			Cultural tour of SOWETO in Johannesburg
			Tour of Cullinan Diamond Mine
			Game drives in Krugar National Park
UF in Brazil	July 23 – August 2, 2011	Sao Paulo, Nazare Paulista, Piracicaba & Campinas	University of Sao Paulo
			University of Campinas
			Instituto de Pesquisas Ecologicas (Ecological Institute)
			UNICA (Brazilian Sugarcane Industry Association)
			FAPESP (Foundation for Research Support of Sao Paulo)
			ETH Bioengergia
			CTC Center for Sugarcane Technology
			Visit to sugar and ethanol plant
			Visit to Bovespa (Sao Paulo stock exchange)
			Visit to Atlantic rainforest park at Jureia
			Cultural tour of Sao Paulo downtown Soccer game in Sao Paulo

CHAPTER 4
DEVELOPMENT AND VALIDATION OF AN INSTRUMENT FOR ASSESSING ACADEMIC LEARNING AND PERSONAL GROWTH OUTCOMES OF SCIENCE AND ENGINEERING GRADUATE STUDENTS PARTICIPATING IN STUDY ABROAD PROGRAMS

During the 20th century, many U.S. colleges and universities established both short and long-term study abroad programs, and these experiences have become an increasingly important mechanism for the internationalization of college students. By 2000, the Institute of International Education reported that approximately 154,168 college and university students have participated in study abroad programs, and that number increased significantly in the first decade of this century, with a record number of 270,604 U.S. college students studying abroad during the 2009/2010 academic year (IIE, 2011). However, historically, participants in college study abroad programs have largely been students majoring in liberal arts and business studies with limited participation by students majoring in science, technology, engineering and mathematics (STEM) disciplines. In 2009/2010, only 34,908 STEM majors participated in college study abroad programs and the *Commission on the Abraham Lincoln Study Abroad Fellowship Program Report* (2005) declared that students majoring in the sciences and engineering are among the most underrepresented groups in college study abroad programs (IIE, 2011). As these numbers clearly illustrate, in the U.S. very few science and engineering majors participate in international learning experiences during their college careers (IIE, 2009).

I contend that study abroad experiences for undergraduate and graduate students majoring in the science and engineering disciplines are a critically important tool for supporting and promoting the internationalization of these fields of study. I further argue that providing science and engineering majors with early/pre-career study abroad experiences in their fields can significantly contribute to the development of scientists and engineers who are equipped with globally-relevant habits of mind, knowledge, and skills. To date, however, few published studies exist to provide concrete guidance regarding strategies and best practices for the design and implementation of effective science and engineering-related college study abroad programs. Similarly, very few studies focusing on appropriate and valid methods for assessing the academic STEM learning and personal growth outcomes of science and engineering students participating in college/university level study abroad programs exist in the literature.

Background

Importance of Study Abroad Experiences for College Science and Engineering Majors

The importance of developing a globally competent cadre of scientists and engineers has been articulated in several recent government publications, such as *America's Pressing Challenge: Building a Stronger Foundation*, which argues that "it is absolutely essential for our Nation's long-term prosperity and security that we remain a world leader in science and technology" (NSF 2006, p. i). To achieve this goal, Dr. Arden L. Bement, Jr., Director of the National Science Foundation (NSF) from 2004 to 2010, declared that "U.S. scientists and engineers must be able to operate in teams comprised of partners from different nations and cultural backgrounds" if they are to confront the many challenges in this increasingly global society (Bement, 2005, p. 2). Furthermore, the Domestic Policy Council, in American *Competitiveness Initiative: Leading the World in Innovation* claims, "sustained scientific advancement and innovation are key to maintaining our competitive edge" (Domestic Policy Council 2006, p.1). Sigma Xi (2007), a scientific research society, has also stated that success in the global economy requires the U.S. to help its scientists and engineers achieve global competence.

In 2006, the National Science Foundation (NSF) convened a working group of scientific researchers, science educators, and science and engineering-based industry representatives to discuss and develop a plan for addressing the challenge of assuring a globally competent U.S. science and engineering workforce. This group identified a list of core "global" competencies required by scientists and engineers in addition to the basic education and training they typically receive in their chosen scientific disciplines. These included general professional competences, such as communication and social skills, cognitive skills, creativity and ingenuity, and the ability to work in teams or to unite individuals possessing diverse skills to a common purpose (Sigma Xi, 2007). The specific global competencies for scientists and engineers identified were:

- The knowledge, ability, and predisposition to frame scientific questions and seek answers with people who have perspectives different than their own;
- The ability to work with scientists and engineers from other countries and to understand their social and intellectual approaches to science and discovery and how they approach or bound problems differently;
- The motivation to pursue knowledge in different contexts and cultures;
- The ability to work in the dense networks that are evolving around the globe to share experiments, equipment, and results.

Downey, Lucena, Moskal, Parkhurst, Bigley, Hays, Jesiek, Kelly, Miller, Ruff, Lehr, and Nichols-Belo (2006) define global competence for scientists and engineers as "the knowledge, ability, and predisposition to work effectively with people who define problems differently than they do" (p. 110). U.S. scientists and engineers must therefore understand the social and cultural contexts in which they will work in the future and, consequently, institutions of higher education must create environments where global engagement and international collaboration in science and engineering are an integral component of both teaching and research. Study abroad experiences offer one mechanism by which science and engineering students can acquire some of the globally-relevant skills needed to address these concerns.

Goals of College Level Study Abroad

Many colleges and universities promote study abroad programs as opportunities for students to experience another country, acquire new knowledge and skills needed to become productive and successful members of the global community, broaden their worldview, and increase their intercultural awareness to promote cross-cultural understanding (Anderson et al., 2006; Black & Duhon, 2006). An examination of the literature on the general goals of college level study abroad reveals that most overseas programs have several objectives for participants. Typically, these focus on academic STEM learning in a particular content area, including the acquisition of new knowledge and skills; professional development in the form of facilitating professional contacts and clarifying career goals; personal growth, with an emphasis on an enhanced sense of personal identity, confidence and flexibility; and intercultural outcomes, including cultural sensitivity and improvement of language skills (Anderson, Lawton, Rexeisen & Hubbard, 2006). There is a widely held expectation that study abroad experiences enhance participating students' on-campus learning, with opportunities to gain disciplinary and professional knowledge in a cultural context "which informs their work with nuances of first-hand research, moving it beyond the intellectual" (Bolen & Martin, 2005, p.xi).

In the science and engineering disciplines, objectives for study abroad participants include the development of global competence, acquisition of new knowledge and skills and the understanding needed to tackle global issues and protect national interests (DeBoer, 1991; Parkinson 2007). Some researchers have further suggested that in an era of increasing globalization, study abroad offers science and engineering students the opportunity to develop specific skills to enable them to work across borders and in multi-cultural and multi-national teams (Charlton & Andras, 2006; Guest, Livett & Stone, 2006). According to Daunert (2009), “the scientists of today and tomorrow need to be able to function in such a global environment and for what we need to prepare them adequately” (p. 2). However, other researchers have argued that, as an intrinsically international activity that is culturally neutral, there is no value-added by completion of a study abroad experience by science and engineering majors.(DeWinter, 1997; Van Eyck, Van Toll, Wattiaux & Ferrick, 2012).

Impacts of College Level Study Abroad Participation

The following discussion examines the reported impacts of study abroad participation on several groups of students, including research on the general student body and on science and engineering majors in particular.

General student participants

In terms of academic STEM learning, there is evidence that college level study abroad experiences enhance the development of disciplinary knowledge and skills. For example, most professionals working in study abroad and international education today embrace the notion that these initiatives can enable students “to learn things and learn in ways that aren’t possible on the home campus” (Vande Berg, 2007, p.392). A large-scale study conducted by the Institute for the International Education of Students (IES) reported long-term, positive impacts of study abroad on students’ personal, professional, and academic development, influencing issues such as career path, worldview, and self-confidence of alumni (Dwyer & Peters, 2004).

Meanwhile, others have documented gains in foreign language learning and cultural knowledge and an increased interest in interdisciplinary studies resulting from participation in study abroad experiences (Lewis & Niesenbaum, 2005). Many colleges and universities also promote study abroad programs as opportunities for students to experience another country, broaden their worldview, increase their intercultural awareness, and enhance their personal growth and social adjustment (Anderson et al., 2006; Black & Duhon, 2006; McLeod & Wainright, 2009).

Further, according to Dolby (2004), study abroad experiences provide students with the opportunity to examine their own national identity and associated traits and their role in the global context. Many research studies evaluating the impact of study abroad experiences on U.S. college students also report that participants acquire global-mindedness, develop enhanced levels of global awareness, grow intellectually, and develop personally (Cheiffo & Griffiths, 2004; Hadis, 2005). Evidence now exists to substantiate the argument that study abroad can be a powerful learning and personal growth experience, influencing students' attitudes, intercultural skills, discipline-specific learning, and general views regarding the value of education abroad (Paige, Cohen, & Shively, 2004).

In fact, some studies even suggest that study abroad experiences can be more effective than classroom learning for culturally mediated outcomes such as international business environments (Peppas, 2005). However, most studies documenting outcomes for study abroad participants focus on programs that are discipline-general, rather than discipline-specific and the students are most often from traditional study abroad disciplines, such as foreign languages, humanities, and business studies.

Science and engineering participants

Anecdotal evidence suggests that participation in science and engineering-related study abroad programs directly contributes to the development of the knowledge, skills and behaviors of a globally competent scientist or engineer. In turn, study abroad faculty and administrators assume that the knowledge and skills acquired by students on international programs will have a direct impact on the career paths of these individuals (IIE, 2009). However, there have been very few empirical investigations of the benefits of study abroad in the science and engineering disciplines. One study of the global perspectives of students who participated in NSF-funded Research Experiences for Undergraduates (REU) reported multiple outcomes when U.S. STEM students visited another country and interacted with the local people (Guerrero, Labrador, & Perez, 2007). This same study found that students completing REUs had the opportunity to expand and share their knowledge, forge new relationships, learn about other cultures and languages, and learn different ways to solve and understand problems. As a result of their study abroad experiences, these students were also reported to have become more interested in other cultures and in learning another language (Guerrero et al., 2007).

In a study of engineering students studying abroad by Haddad (1997), a longitudinal survey of alumni indicated that the study abroad experience played a positive role in their post-graduation offers of employment and promotions. Meanwhile, the International Engineering Program (IEP) at the University of Rhode Island, which has also received funding from the NSF through a Program in International Research and Education (PIRE) grant, reported increased placement rates for IEP graduates. Furthermore, they reported that firms who work globally employ the great majority of their IEP program graduates (Grandin, 2006).

A more recent study by Bender, Wright and Lopatto (2009) investigated science students' self-reported changes in intercultural knowledge and competence associated with three undergraduate science-related study abroad experiences. They reported gains in students' self-reported learning and cultural concepts, such as increased levels of self-confidence, enhanced communication skills, clarification of career goals, readiness for and understanding of scientific research and increases in ability to work independently and as part of a learning community.

Study Justification

Despite evidence documenting the benefits of college level study abroad experiences, a recent investigation by IIE and the Association of International Educators' (NAFSA) found that less than one third of universities currently assess academic achievement or personal development outcomes of their study abroad alumni and even fewer measure intercultural competence (15%) or career-related outcomes (10%) (Durrant & Dorius, 2007). Meanwhile, college faculty and administrators working with study abroad programs acknowledge an increasing need to assess the effectiveness of their programs, document student outcomes resulting from these experiences, and connect study abroad experiences to the broader college curriculum (Bolen, 2007; Brewer & Cunningham, 2009). In 2002, an article in the *Chronicle of Higher Education* entitled "Colleges needed better ways to assess study-abroad programs" contended that a minimum set of standards and comprehensive program assessment are essential in order to demonstrate the benefit of study abroad programs

(Gillespe, 2002). At the same time, Engle and Engle (2003) argued that college level study abroad educators and administrators should “re-orient their focus from an appraisal of the sheer numbers of students participating in international education to the quality of their experiences abroad” (p.1).

In the science and engineering disciplines, the fact that few study abroad programs currently exist for students and the lack of consensus regarding the goals of such programs also contributes to the general lack of academic and personal outcomes assessment research data. Yet, clear emerging evidence exists to support the hypothesis that students participating in college level study abroad experiences can acquire the knowledge, skills, and perspectives they need to succeed in global science and engineering-related careers.

The Institute of International Education clearly articulated this need in their recent publication, *Promoting Study Abroad in Science and Technology Fields* (IIE, 2009). Their recommendations included the need for studies to identify the underlying motives for a scientist’s or an engineer’s desire for an international experience, research to identify the impacts of these experiences on the careers of scientists and engineers, and investigations linking the characteristics of global competence to professional competence and the development of science and engineering knowledge, skills and behaviors. The IIE report specifically called for “the development of systematic monitoring, assessment and evaluation tools to compare the impact of international experiences across institutions and programs” (IIE, 2009 p. 27). The assessment instrument developed in this study can be used to address these needs and facilitate the identification of perceived student outcomes, both personal and academic, associated with study abroad experiences in the science and engineering disciplines. This instrument can also be useful to faculty and administrators interested in creating and comparing the relative effectiveness of different types of science and engineering-related study abroad experiences and examining the positive impacts of these programs on science and engineering student participants.

Purpose of the Study

This study was designed to develop a valid, reliable, and easy-to-use research-based instrument for the assessment of the impacts of college level short-term study abroad experiences on science and engineering graduate students. The instrument developed in this study can provide university and college administrators, science and engineering faculty, government funding agencies, and students and their families with a clearer understanding of the academic and personal benefits associated with participation in these programs. The electronic survey-type assessment instrument developed in this study was tailored to the unique needs, interests, and desired learning outcomes of students majoring in science and engineering disciplines. As part of the evaluation process, the assessment instrument was administered to study abroad participants as well as a comparable group of science and engineering graduate students who did not study abroad in order to document the “value-added” benefits of these international experiences. Finally, in addition to documenting the academic STEM learning and personal growth impacts of study abroad experiences on science and engineering majors in general, this instrument can be used to highlight differences in the relative impact of study abroad experiences on different types of students. These differences include: life and physical science students versus engineering students, students with differing levels of prior international travel experience, students from different ethnic and racial backgrounds, and students with and without preexisting knowledge of their destination country's culture and language.

The broader target audience for the resulting outcome assessment instrument is college level students majoring in the science and engineering disciplines (both undergraduate and graduate level) and the faculty and administrators who develop and implement study abroad programs for these students. In particular, I anticipate that the development of a valid and reliable research-based instrument for assessing the academic STEM learning and personal growth impact of science and engineering-related study abroad programs will be of broad applicability for many universities and colleges as they attempt to internationalize their curricula and programs and expand study abroad offerings beyond the fields of liberal arts and business.

Study Sample

This study was conducted at the University of Florida, in conjunction with the South East Alliance for Graduate Education and the Professoriate (SEAGEP). The SEAGEP program is a comprehensive professional development program funded by the National Science Foundation to increase minority representation among science technology, engineering and mathematics (STEM) faculty. The SEAGEP program is an alliance between three universities in the southeastern U.S. and is open to, and provides support for, all STEM graduate students from underrepresented ethnic minority groups at the University of Florida, University of South Carolina and Clemson University.

During 2011, SEAGEP implemented a series of new international initiatives for these graduate students to address the need for global experience at the graduate level. These comprehensive international experiences provided students with opportunities to develop global competencies that would give them a competitive edge in their preparation for and pursuit of academic careers. These programs were approximately 12 days in length and during their time in country, students had the opportunity to visit science and engineering educational and research facilities, meet with researchers, faculty and students at the host institutions, and participate in organized cultural activities. Students completing four of these international SEAGEP programs participated in this study:

a. "UF in Chile – Global Science and Engineering" March 2011
b. "UF in China – Global Science and Engineering" May 2011
c. "UF in South Africa – Global Science and Engineering" June 2011
d. "UF in Brazil – Global Science and Engineering" July 2011.

Forty-six SEAGEP-affiliated students enrolled in these four study abroad programs in 2011, with 11 visiting Chile, 15 visiting China, and 10 visiting South Africa and Brazil respectively. I invited students to participate in the research study via email, as described in the participant recruitment section of Chapter 3. Initially, all students agreed to complete the pre-trip and post-trip Academic STEM learning and Professional Growth Outcome Assessment and signed the informed consent forms at the pre-departure orientation sessions for each trip. However, one student subsequently elected not to participate in the research study and i decided to exclude another student based on the demographic information collected. Thus, the total number of study abroad participants in the research study was 44.

In addition, I recruited a comparison group of 32 minority science and engineering graduate students to participate in this study. These students did not participate in the SEAGEP international programs. Study abroad participants assisted with recruitment of the comparison group, identifying a counterpart in their discipline with similar demographics (ethnicity and gender). This selective recruitment approach ensured that the comparison group matched the group that participated in the study abroad program as closely as possible. The demographic data for all research study participants is available in Table 4-1.

Study Design

This study utilized a two-phase design, with the UF in Chile program students participating in the pilot phase of assessment instrument development and the UF in China, Brazil and South Africa students and the comparison group students participating in the final validation and testing phase of the research study.

Pilot Phase

The initial development of the assessment instrument involved a review of the current literature on study abroad outcomes, personal consultations with international education and evaluation experts, a student focus group and a review of the study abroad syllabus for the SEAGEP programs. The testing of this draft instrument occurred in conjunction with the UF in Chile program in March 2011. Of the 11 students enrolled in this program, three were male and eight were female. Eight students were studying engineering, while three were life and physical science students. In terms of ethnicity, there were five Black/African/African American and six Hispanic/Latino/Spanish students. Finally, following pilot testing, expert reviews of the data collected provided guidance for the refinement of the assessment instrument.

Validation and Testing Phase

Reliability analyses and validation of the assessment instrument developed and refined during the pilot phase of the study involved a total of 65 students from the UF in China, Brazil and South Africa programs as well as students in the comparison group.

This study sample was comprised of 29 male and 36 female students, with 30 from engineering and 35 from the life and physical science disciplines. There were 34 Black/African/African American students, 30 Hispanic/Latino/Spanish students, and 1 American Indian or Alaskan Native. Statistical analysis using Cronbach's alpha was used to establish the internal consistency reliability of the instrument. I examined content and construct validity using the survey data, expert reviews, and students' reflective writing assignments for the study abroad program.

Pilot Phase

Development of Draft Outcome Assessment Instrument

The lack of a pre-existing, validated survey instrument for assessing perceived student academic STEM learning and personal growth outcomes resulting from participation in science and engineering study abroad programs necessitated the development of a new instrument for use in this study. A review of the current literature pertaining to outcomes assessment for study abroad programs provided initial guidance for the development of the new instrument. This was supplemented by the personal experience of the researcher, information gathered in a focus group with six students from the UF in Chile program and a review of the syllabus for the "Science and engineering in the global context" SEAGEP study abroad course (Appendix F).

Literature review on outcomes assessment in study abroad

A review of study abroad survey instruments and the comparison of survey types by Durrant and Dorius (2007) provided a useful perspective on the current instruments used for evaluation of student learning outcomes and provided background information for decisions related to the type of instrument to use and related analyses of data for this study. They found that advantages of web-based survey instruments included a reduction in respondent completion time, increased response accuracy and ease of administration and analysis. The biggest drawbacks of web-based surveys related to lower response rates when compared to paper surveys. However, Durrant and Dorius also determined that paper surveys are less useful for large-scale assessment projects and do not facilitate statistical analysis and widespread dissemination of results as well as web-based surveys. Thus, Durrant and Dorius (2007) selected web-based surveys as their instrument of choice and I elected to do the same for this study.

In the United States, the regional accrediting agencies for institutions of higher education have developed guidelines for demonstrating student learning through academic assessment. Immetman and Schneider (1998) contended that similar domains of knowledge acquisition (cognitive), attitudes and values (affective) and skills (behavioral) acquisition are appropriate for the assessment of study abroad programs. They proposed a focus-group methodology rather than surveys to explore student learning in study abroad programs with reference to these domains of educational objectives. In the current study, while I have elected to develop a quantitative assessment instrument, I did draw upon the overall framework for assessing different domains of learning proposed by Immetman and Schneider and used several of their suggested questions for the focus group to guide the development of the study abroad assessment instrument for science and engineering.

With regard to the content of specific items on the assessment instrument, I also reviewed several relevant research studies for guidance. A broad assessment the impact of study abroad experiences on student learning was conducted by Michigan State University (MSU) in the summer of 2000 (Ingraham & Peterson, 2004). This study included a self-reported measurement of participant intellectual and personal growth as well as intercultural awareness. While not specifically focused on the STEM disciplines, the researchers utilized a 33-item pre-departure and post-study abroad survey instrument as a method of data collection. These Likert-scale items and several open-ended questions addressed aspects of perceived academic development and personal growth and intercultural awareness. Several items from this survey were included in the preliminary version of the study abroad assessment instrument I developed for use with science and engineering graduate students.

Similarly, a large-scale assessment of student attitudes after participation in a short-term study abroad program at the University of Delaware examined the development global awareness using a pre-test, post-test instrument (Chieffo & Griffiths, 2004). These researchers measured global awareness in four different categories, including personal growth and development, intercultural awareness, awareness of global interdependence, and functional knowledge of world geography and language. Given the science and engineering focus of this study, I only focused on two of these categories of global awareness when examining the cognitive and affective impacts of the study abroad experience: personal growth and development and general global awareness.

More recently, Braskamp, Braskamp and Merrill (2009) investigated global learning and development of undergraduate students completing study abroad experiences. Their pretest-posttest design utilized the Global Perspective Inventory (GPI) to measure changes in students' global perspectives resulting from a semester-long study abroad program. The GPI measures three major developmental domains:

cognitive (epistemological, awareness, knowledge), intrapersonal (identity, attitudes, emotion) and interpersonal (behavior, skills and social responsibility). The results of this study suggested that study abroad participation can promote global learning and development in all three domains. Given the documented effectiveness of this instrument, selected items from the GPI that were particularly appropriate for use with science and engineering-related study abroad experiences were incorporated into the preliminary academic STEM learning and personal growth assessment instrument.

As mentioned earlier, little research has been conducted to document participant outcomes specific to science and engineering-related study abroad experiences. However, in 2009, Bender, Wright and Lopatto conducted a study to examine University of Arizona (UA) students' self-reported changes in intercultural knowledge and competence associated with three undergraduate science-related study abroad experiences. This study also used a survey at the beginning and conclusion of the study abroad experiences and was adapted from the Survey of Undergraduate Research Experiences (SURE) and another survey developed at Grinnell College to assess student learning outcomes resulting from participation in study abroad programs. Our study included an examination of students' pre-trip expectations for their international experience as well as their perceived post-trip learning gains, thus some items from the University of Arizona study abroad survey were adapted for use in our academic STEM learning and personal growth assessment instrument.

When developing items for the assessment instrument I also examined targeted outcomes identified for engineering baccalaureate graduates by the Accreditation Board for Engineering and Technology (ABET, 2000). These target outcomes include a set of six professional skills, of which three pertain directly to study abroad experiences:

- the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
- an ability to communicate effectively;
- knowledge of contemporary issues.

Items focusing on these three outcomes were also included in our draft assessment instrument.

Personal experience and expert consultations

Beyond reliance upon existing literature to determine the objectives and targeted learning outcomes of study abroad experiences, development of a new outcome assessment instrument specifically focused on science and engineering-related study abroad experiences was also informed by the direct real-world experience and advice of several college level study abroad experts. This author used her own personal experience, both as a trained scientist and as a participant and facilitator of previous study abroad programs, to guide the selection of concepts and development of individual items for the assessment instrument. In addition, three faculty members with multiple years of experience as science educators, study abroad program leaders, and international educators provided significant input regarding the format and content of the assessment instrument. They collectively noted that previous study abroad participants they have personally worked with developed both academically and personally as a result of their participation in an international program. Specifically, these experts noted that some students completing study abroad programs have changed their majors and areas of research focus, developed long-term collaborative networks with scientists from their host countries, and conducted on-going collaborative research as a result of their study abroad experiences. Since most of this supporting evidence is anecdotal in nature, all of these experts also acknowledged the need for a science and engineering-focused outcome assessment instrument to document the type and extent of academic STEM learning and personal growth impacts of study abroad experiences on participants.

Focus group

To provide guidance for the development of the assessment instrument, I conducted a preliminary focus group interview to document student expectations prior to their participation in a science and engineering-related study abroad program. This focus group was conducted at UF in February 2011 and consisted of six graduate students enrolled in the “UF in Chile – Global Science and Engineering” program. Students were asked the following series of questions in order to develop a clearer understanding of their expectations and anticipated outcomes for the study abroad experience:

1. Why did you decide to participate in a study abroad program?
2. Why did you choose to participate in a science and engineering-focused study abroad program?
3. What are your expectations for this study abroad program to Chile?
4. What do you hope to gain personally and professionally as a result of your participation in the study abroad program?
5. Do you consider international activities to be an important component in science and engineering education overall?

The student responses to the five questions were analyzed to provide guidance for the development of questions for both the academic STEM learning and personal growth aspects of the assessment instrument.

Academic expectations. Students mentioned that they decided to participate in the program for several academic reasons, including an interest in the topic of the program and/or the geographic region, and a desire to observe real-world applications in their various disciplines and understand their research in the global context. In response to question one, all six students indicated their interest in academic STEM learning with responses such as:

> I am interested to see projects on Energy (in Chile) and how my discipline is being applied.
>
> This is an opportunity to learn from other researchers in other regions.
>
> I am interested in Latin American countries and hope to conduct future research in Brazil.
>
> I do research on streams and rivers and am interested in the environmental impacts in South America.
>
> I want to see how Chile are addressing the issue of arsenic remediation.
>
> I am interested in Latin America generally and hope to do research in Brazil.

In response to the second question, one student indicated that he would have been interested in the study abroad program; even if the content focus was not science and engineering. However, three of the six students indicated that the science and engineering focus and the NSF backing were important factors in their decision to participate. One student indicated that this focus “put it over the top for me,” while another said it was “easier to sell to my advisor,” and the third stated “the NSF association was important". A fourth student responded that the geographical location was the most important draw for him.

In response to the third question, two students indicated that they hoped to make contacts with researchers in Chile and learn more about the specific content topics of focus on the trip. Four of the six students indicated that they were hoping to observe the educational and research systems of another country and understand how science and engineering are applied in that country. They also hoped to develop a better understanding of how their own area of research applied in other contexts and learn about the technology and skills used by their peers overseas. The following are quotes from students illustrating their expectations in relation to the academic impact of the study abroad program.

> As a future professor, I think it is important to think bigger, think globally, but that is hard to conceive as a graduate student.
>
> I hope to observe how research is conducted in a foreign country.
>
> I hope to compare the education systems.
>
> To see applications of science and how my research might fit there.

Finally, in response to question four, one student indicated that he hoped to learn new skills and techniques and observe how research is approached differently in Chile.

Personal expectations. The majority of the students mentioned their desire to learn more about other cultures and interact with local people during their visit, though this was not a predominant expectation for the group. The following direct quotes illustrate students' personal expectations for their study abroad experience:

> I really like to travel and learn about different cultures.
>
> I am looking forward to experiencing the culture in Chile.

I am excited to wake up somewhere new and see new things.

All the students indicated that they valued the opportunity to participate in an international opportunity, which would not only help them develop an understanding of the destination country and culture, but would also enable them to empathize with the international students they work with here in the U.S. For example, one student expressed the expectation that she would develop a better understanding of international students here in the U.S.

> I want to go and see other cultures and understand international students better to improve my relationships with them.

Syllabus review

“The first aspect of outcomes assessment involves deciding/identifying the goals, objectives or competencies the institution or program wishes to assess” (Bolen, 2007, p.1). To this end, I reviewed the program syllabus for the SEAGEP international programs targeted for study and items focusing on specific stated syllabus objectives that were directly linked to academic STEM learning and personal growth outcomes were incorporated into the assessment instrument (Appendix F). Objectives pertaining to the study abroad experience, as outlined in the course syllabus were:

- to learn about the history, culture and traditions of the host country;
- to develop an understanding of the differences in STEM education and research cultures between the U.S. and the host country; to investigate one of the four research topics below with an assigned team:
    - Science and Technology
    - Science Communications
    - Technology Transfer
    - Education;

- to network with students, faculty, researchers and government agencies abroad; and
- to present an oral research presentation in the host country.

Following the completion of these four components outlined above, I used the data and information collected to develop a draft assessment instrument containing 53 items. This first draft included five sections: student expectations for academic STEM learning, student expectations for personal growth, program outcomes for academic STEM learning, program outcomes for personal growth, and demographic information. The academic STEM learning and personal growth sections consisted of nine and 11 questions respectively. The program outcomes section consisted of 14 items designed to assess academic STEM learning and 11 questions designed to assess personal growth. The final section included seven items to gather demographic information for each student respondent. Using this first draft of the assessment instrument, I conducted pilot testing on the UF in Chile program as described below.

Pilot Testing of Draft Outcome Assessment Instrument

I pilot tested the outcome assessment instrument in March 2011 with the 11 science and engineering graduate students enrolled in the "UF in Chile – Global Science and Engineering" program. Pilot testing provided an opportunity to determine the clarity, ease-of-use, appropriateness, and feasibility of the overall assessment instrument, as well as the clarity, quality, and usefulness of each individual item. As part of the pilot test process, Chile study abroad participants completed the assessment instrument approximately one week prior to their departure and approximately two weeks after their return to the U.S. Following completion by the students, the pre and post-test scores on each item were analyzed and compared to determine whether the item measured change as a result of their participation in the program. In the process of this analysis, the expectation items were determined to be inappropriate for a pre-post design and were eliminated from this stage of the analysis. The pre and post-trip scores for program outcome items for academic STEM learning and personal growth were reviewed by two experts in survey design and international science education to select and edit the items for inclusion in the assessment instrument. For both the academic STEM learning and personal growth section, six new items were added, based on the eliminated expectation items and student responses to open-ended questions on the original draft instrument.

Expert Review of Pilot Test Data and Draft Outcome Assessment Instrument

Three experts, one in evaluation and assessment methodology and survey design, one in science education and one in international education, reviewed the student responses on the pre and post draft assessment used in the pilot study. This feedback provided guidance for modification of the entire instrument and revision of individual items. The following section provides details of how I modified the draft assessment instrument based on comments received during the expert review.

Two negatively worded items: "I think STEM education in other countries is not as advanced as it is in the U.S." and "career opportunities in other countries are not interesting to me" were determined to be confusing to participants based on the variability of responses on the pre- and post-trip assessments. The diversity of responses provided on these items clearly indicated that some students misinterpreted the phrasing of these items and answered them as if they were written in the affirmative instead of the negative. Due to the fact that these negatively worded items clearly confused some participants, these items were excluded from the analysis of reliability and validity and have been deleted from the final version of the assessment instrument.

Additionally, six items were identified as difficult to answer due to their vagueness and lack of a clear "desired" response. Examples of these items included: "Science policy is the same around the world" and "I believe that people from other countries view the U.S. positively." These items were also excluded from the validity and reliability analysis and have been deleted from the final version of the assessment instrument. The items that were excluded from the validity and reliability analysis and from the final version of the assessment instrument based on expert review are presented in Table 4-2.

Thus, out of an original set of 37 items, I excluded six academic STEM learning and two personal growth outcome items from the validity and reliability analysis. In addition, one item originally coded as an academic outcome item was reviewed and recoded as a personal outcome item. I determined that this item, "I feel confident about practicing my discipline in a different country" related to the students' perceptions of their ability to work in another country, and was thus more appropriate in the career-perceptions sub-construct.

Validation and Testing Phase

The final version of the study abroad outcome assessment instrument consisted of 14 academic STEM learning items and 15 personal growth items (Table 4-3). Thirty-three science and engineering graduate students completing SEAGEP study abroad programs in China, South Africa and Brazil participated in the validation and testing phase for the revised assessment instrument. In addition, a comparison group of 32 science and engineering graduate students who did not complete these study abroad experiences also participated. Thus, a total of 65 students served as the study sample for this phase of the study. Students participating in study abroad experiences completed the pre-trip version of the assessment instrument approximately one week prior to their departure and they completed the post-trip version approximately two weeks after their return to the U.S. The comparison group students only completed the assessment once, during the 2011 fall semester. The following sections of this paper provide details of the validity and reliability analyses of the academic STEM learning and personal growth outcomes assessment instrument.

Reliability Analysis of the Assessment Instrument

Internal consistency reliability of the assessment instrument was measured using Cronbach's Alpha coefficient. The data sources for these analyses were the pre-trip assessment instrument responses for the study abroad participant group and the one-time responses from the comparison group. This provided a total of 65 completed assessments for Cronbach's Alpha calculations. Internal reliability analysis gives an idea of the extent to which items in the same scale are related to each other. The Cronbach's alpha reliability coefficient measures internal consistency of an instrument and is based on average inter-item correlations. For purposes of this study, all reliability coefficient values above 0.7 were considered acceptable. Internal reliability was determined for the two constructs (academic STEM learning and personal growth) and for the each associated sub-scale.

As indicated in Table 4-4, internal consistency reliability for both the academic STEM learning and personal growth outcome scales was high (Cronbach's alpha = .849 and .884 respectively). Internal consistency reliabilities for the sub-scales were somewhat lower, ranging from .620 to .860. The reliability for four of the six sub-constructs were above .70 and were thus considered acceptable. However, the reliability for the professional self-efficacy in science and engineering and the global science communication were .695 and .620 respectively.

Determining Validity of the Assessment Instrument

I used a two-part-process involving a blend of expert advice and qualitative methods to assess the validity of the study abroad assessment instrument. Validity was assessed in terms of both content and construct validity.

Content validity

Content validity, which assesses the extent to which the system covers the full range of meaning for the measured concept in a particular context, was the first type of validation completed. Activities designed to establish content validity included:

- Review of the assessment instrument by experts in the fields of science education and international education and study abroad
- Review of peer-reviewed literature to ensure that the concepts and items included in the assessment instrument were consistent with targeted outcomes for study abroad programs and the fields of science and engineering in general.

An iterative process, involving item development, review by experts, pilot testing, additional expert review and item revisions/deletions/additions and implementation helped to ensure the appropriate assessment of targeted concepts. During this process, several items initially included in the instrument were modified, re-ordered or removed.

Construct validity

Construct validity is the extent to which a scale measures or assesses the concepts it was designed to measure. In this study, construct validity of the assessment instrument was established using three different data sources:

- a review of the literature describing similar outcome measures used in evaluations of the impact of study abroad programs on participants

- statistical analysis of pre and post test data
- an examination of the alignment between the content of a selection of students' reflective writing assignments and the on the academic STEM learning and personal growth outcome construct scores on their completed post-trip assessment instruments.

Literature review. As described above in the data collection section for research question one, development of individual items and grouping of items into constructs and sub-constructs was based on a review of the literature regarding targeted academic learning and personal growth outcomes assessed using similar survey-type instruments in evaluations of other study abroad programs.

Statistical analysis of pre and post-test data. Parametric testing of completed outcome assessments for the 33 study abroad participants' pre- and post-trip academic STEM learning and personal growth outcomes on the China, Brazil, and South Africa programs were used to determine if the constructs and sub-constructs measured change in the concepts as designed. Inferential statistics, in the form of paired t-tests, determined the significance of changes in pre-trip and post-trip scores. In all cases, a 95% confidence level was used (α=0.05) to determine if changes in students' perceptions were significant.

For the academic STEM learning and personal growth constructs, there were significant differences in scores between both the pre-trip and post-trip assessments. For the overall academic STEM learning construct the results were $t\ (32)= 2.954$, $p\ =0.006$ and for the overall personal growth construct results were $t\ (32)= 3.958$, $p\ =0.000$. There were also significant differences between pre-trip and post-trip scores for four of the six sub-constructs: socio-cultural role of science and engineering sub-construct [$t\ (32)= 4.079$, $p\ =0.000$]; personal confidence [$t\ (32)= 2.357$, $p\ =0.025$]; career perceptions [$t(32)= 3.233$, $p =0.003$]; and global awareness [$t(32)= 3.996$, $p = 0.000$]. There was not a significant difference in the pre-post scores the pre-trip and post-trip assessments for the professional self-efficacy in science and engineering [$t(32)= 1.343$, $p =0.189$] or global science communication [$t(32)= 1.954$, $p = 0.059$] sub-constructs, both of which had low levels of reliability.

These significant differences between the pre- and post-test scores on the two primary constructs and four of the six sub-constructs suggest that the assessment tool is capable of measuring changes in the students' academic STEM learning and personal growth as a result of participation in study abroad programs.

Analysis of reflective writing and assessment instrument response alignment. Finally, in terms of construct validity, I reviewed a selected sample of the students' writing assignments in which they were prompted to reflect upon their experiences and discuss their own perceptions regarding what they learned and how they grew as a result of participation in the study abroad program. Six writing assignments were selected for review: three for students who had the highest scores on the academic STEM learning and personal growth and three for students who scored the lowest on the post-trip assessment. The writing assignments were coded using a priori codes that aligned with the concepts and sub-scales assessed by the instrument. These coded segments were reviewed and compared with the students' scores on the academic STEM learning and personal growth quantitative assessments. For reporting purposes, samples of student statements included below are coded according to the trip and individual, with the three highest scoring being Brazil 1, China 1 and China 2, and the three lowest being South Africa 1, South Africa 2, and Brazil 2.

All six students whose reflective writing assignments were reviewed mentioned both academic STEM learning and personal growth outcomes in their reflective writing assignments. The following selected statements validate that the student responses on the assessment instrument accurately reflected the academic STEM learning and personal growth reported by these students in their own reflective writing.

(High) Brazil 1: The experience of meeting a new country, a new culture, new friends, and new learning experiences is something that will mark your life forever, it definitely has marked my life in ways I will never forget.

(High) China 1: I have had the chance to experience the culture, and see some research projects that are being undertake.

(Low) S. Africa 1: If I were to select criteria to evaluate my learning process on this trip, they would be: educational experience, cultural experience and social interaction.

All six students' writing samples mentioned the impact of their respective trips in terms of learning about science and engineering research in other countries, and several expressed surprise at how advanced research facilities were in the host countries. For example,

(High) China 1: I believe that the facilities and people necessary for doing serious research are present.

(Low) S. Africa 2: I am now informed about the type of research conducted in the Republic of South Africa and the capacity to conduct research at several institutions.

(High) China 2: Biomedical engineering, specifically bone and tissue engineering, is quite big in China.

Three students also made observations about the nature of education in the host countries

(High) China 1: One of my secondary interests is engineering education, a field that is rapidly growing in the United States but is non-existent in China according to Dr. Zhang. I believe some great collaboration and exchange of ideas could be found there.

(Low) S. Africa 2: I was also able to speak with other graduate students …. about science and the educational system.

(Low) Brazil 2: After visiting several educational institutions that include, University of Sao Paulo, Institute of Pesquisas Ecologicas (IPE), and University of Campinas, there was a disproportionate amount of African Brazilian students attending these schools.

Three of the students mentioned the challenges and rewards associated with science communication. For example,

(High) Brazil 1: I had the opportunity to interact with other students from different academic areas, where we learned we shared similar interests despite our varied backgrounds.

(Low) S. Africa 2: They were some of the only people I met during my trip that understood what I study without me having to explain it.

(Low) Brazil 2: The greatest challenge of my study abroad trip to Brazil was fully interacting with all students who participated.

Four students indicated that their study abroad programs offered opportunities to network with and learn from other scientists and engineers, which potentially informed their future career decisions.

(High) China 1: I feel that overall, the trip was a great experience and I hope it might lead to some future collaboration.

(Low) S. Africa 1: We had excellent opportunities to make connections.

(High) Brazil 1: I feel that I gained knowledge I would not otherwise ever learned about, and therefore I became more mature as a young scientist.

(Low) S. Africa 2: I now have a better sense of what type of research I want to pursue in the future and can now add the Republic of South Africa to my list places I would like to conduct a postdoc.

In terms of global awareness, all the students' mentioned the value of the cultural activities on the study abroad program. For example, (High) Brazil 1: Brings you an effective cultural experience, and one that opens your eyes to see the world with a broadened perspective.

(Low) S. Africa 2: The people of the Republic of South Africa were very welcoming and kindly answered our questions and ignored our ignorance about their country.

(High) China 2: I wanted something to challenge my thoughts, my ideas, and my worldview. And on this day of May 15th 2011, I can say with no reservations, that my worldview has changed.

Despite the fact that some areas of focus in their reflective writing assignments were consistent across the sample of high and low “scorers” on the outcome assessment instrument, there were notable differences in the reflections of high and low scorers in other areas. These results suggest that the outcome assessment instrument and its sub-constructs do accurately capture differences in students’ self-perceived learning resulting from participation in study abroad experiences and provide evidence for the validity of the instrument. For example, the three students with the highest scores on the post-trip assessment instrument all discussed their trips in positive terms and indicated that it had met their academic STEM learning and personal growth expectations, as illustrated in the following reflective writing excerpts:

(High) Brazil 1: After this experience, I accomplished a big part of what I desired.

(High) China 1: After spending these days in Beijing and arriving in Shanghai, the expectations that I had coming into this trip were certainly met.

(High) China 2: The new friendships I formed with both the Chinese students and my SEAGEP colleagues is something that I will always cherish.

Conversely, the three students with lower scores on the post-trip outcome assessment included more negative comments about their study abroad experience in their reflective writing assignments. Two of these students indicated that the trip did not live up to their expectations and they perceived to have learned little or nothing on their programs.

(Low) S. Africa 1: My educational expectations were not met.

(Low) S. Africa 2: I am not really sure what I was supposed to learn on this trip, so I am unable to come up with a way to evaluate what I learned. Honestly I am not sure that I learned anything.

Interestingly, both these students participated in the South Africa program and had the two lowest post-trip scores of the entire 33-student sample on the post trip assessment. The student with the next lowest score participated in the Brazil program, and although he had some criticisms about the program, he indicated that the trip did meet his overall expectations.

Discussion

The importance of college level study abroad experiences is recognized in the international education literature as a way to prepare students for the global workforce who have the appropriate disciplinary, communication and cultural skills. With the mounting emphasis on global competency in the science and engineering fields, and with the increasing emphasis on study abroad experiences for students in these disciplines, the need for both effective and appropriate instruments for documenting the impacts of these programs on participants is also growing. Thus, the key focus of this study was to develop a valid and reliable academic STEM learning and personal growth outcome assessment instrument specifically for use with graduate students completing science and engineering-related study abroad programs. The following sections summarize the specific types of study abroad-related academic STEM learning and personal growth outcomes that can be measured using the outcome assessment instrument I developed.

Academic STEM learning outcomes. This section of the assessment instrument focuses on students' perceptions of the dominant approach to science and engineering used in other countries and the value they personally attach to scientific knowledge generated outside the United States. It also explores students' perceptions of science communication and the socio-cultural role of science and engineering in other countries. If students are to become globally competent scientists and engineers, it is important that they understand the nature of science and engineering as it is practiced in other countries, the modes of scientific communication used in other countries, and the role these disciplines play in other societies and cultural contexts. Such understanding can help students develop collaborative professional relationships with scientists and engineers overseas and help them work effectively with others to address science-based issues of global significance. For study abroad to be an effective method for the development of a more complete and accurate understanding of science and engineering outside the U.S., it is essential to have appropriate instruments for assessing the impact of study abroad experiences on students' understanding of these topics.

Personal growth outcomes. This construct explores the impact of the study abroad experience on students' career aspirations and levels of self-confidence in a global context. This scale also measures students' global awareness. It assesses changes in students' perceptions of their own academic preparation and competence to perform as global scientists and/or engineers and their levels of interest in a globally focused career. This section of the assessment instrument also investigates students' levels of self-confidence in relation to traveling and living in other countries and cultures and their general knowledge about international issues and current events. Such personal growth outcomes are of crucial importance in determining a student's level of interest and openness to pursue opportunities to live and work in other countries, or at least on multi-national and multi-cultural teams.

Beyond the determination of the appropriate outcomes for assessment, the foundation of any measurement instrument is the determination of its validity and reliability. This study examined questions of content and construct validity and examined questions of internal consistency reliability.

Validity

There was agreement between the experts in all aspects of the content validity of using the evaluation instrument in science and engineering study abroad contexts. In general, the experts thought that the instrument did address all of the appropriate targeted outcomes for science and engineering-related study abroad programs. Reviews of the draft assessment instrument by individual experts did identify inconsistencies among some items, particularly those using negative wording or those without a clearly defined most desirable response. Based on this input, I modified and/or excluded these items from subsequent analyses of test reliability and validity.

One of the recommendations for improvement of future versions of this assessment instrument is the addition of items that capture students' perceptions of how science and engineering research is conducted in the host countries and the extent of funding and equipment for this research, especially compared to the U.S. In addition, the assessment instrument could be modified to meet the needs of particular study abroad programs with the addition of items that relate to specific objectives of a particular program or course.

With regard to construct validity, the assessment instrument aligned well with the most commonly cited outcomes of study abroad experiences in the published literature on study abroad assessment. These outcomes include the development of both academic, or cognitive, and personal, or affective, constructs. Specifically, the assessment instrument developed in this study documents the impact of study abroad experiences on several different aspects of a student's career development, personal confidence, global awareness and communication.

Statistical analyses of the differences in students' scores on the pre-trip and post-trip assessments, together with an analysis of some students' reflective writing assignments, suggest that this instrument is measuring appropriate constructs for science and engineering-related study abroad programs. Those students with higher post trip scores on the assessment instrument generally recorded the more positive comments in their reflective assignments and indicated that the trip met with their overall expectations. Conversely, students with lower scores on the post trip assessment all had strong criticisms of their study abroad programs, indicating that the study abroad experience did not live up to their expectations.

Reliability

The Cronbach's alpha reliability coefficients calculated for the assessment instrument indicated good internal consistency for both scales and all sub-scales. These relatively high internal consistency results indicate that the assessment instrument can be used to reliably assesses the academic STEM learning and personal growth outcomes of science and engineering graduate students participating in study abroad experiences. One potential area for future improvement would be the addition of items to some of the smaller sub-scales. For example, the sub-scale for global awareness is currently comprised of three items with a Cronbach’s alpha of 0.860. However, it could benefit from the addition of other items to assess the impact of study abroad participation on students’ levels of global awareness, as was revealed in their reflective writing assignments.

In conclusion, the results of the analyses indicate that it possible to assess self-reported changes in academic STEM learning and personal growth using a Likert-type electronic outcome assessment instrument. This type of assessment may provide valuable outcomes data for a variety of science and engineering-related study abroad programs at both the graduate and undergraduate levels and therefore merits further research.

Table 4-1. Gender, ethnicity and academic discipline of study participants

Participants	Discipline	Ethnicity	Sex
Chile	8 Engineering	5 Black/African/African American	3 Male
n=11	3 Life & Physical Science	6 Hispanic/Latino/Spanish	8 Female
China	12 Engineering	8 Black/African/African American	8 Male
n=15	3 Life & Physical Science	7 Hispanic/Latino/Spanish	7 Female
South Africa	3 Engineering	4 Black/African/African American	2 Male
n=9	6 Life & Physical Science	4 Hispanic/Latino/Spanish	7 Female
		1 American Indian or Alaskan Native	
Brazil	4 Engineering	5 Black/African/African American	6 Male
n=9	5 Life & Physical Science	4 Hispanic/Latino/Spanish	3 Female
Total Study	27 Engineering	22 Black/African/African American	19 Male
Abroad	17 Life & Physical Science	21 Hispanic/Latino/Spanish	25 Female
n=44		1 American Indian or Alaskan Native	
Comparison	11 Engineering	15 Hispanic/Latino/Spanish	14 Male
Group	21 Life & Physical Science	17 Black/African/African American	18 Female
n=32			

Table 4-2. List of survey items excluded from validation and reliability testing phase based on expert review

Construct	Items
Academic Learning	I think STEM education in other countries is not as advanced as it is in the U.S.
	I think that technology transfer in science/engineering occurs differently in other countries compared to the U.S.
	Science policy is the same around the world
	I think research in science/engineering is more advanced in the U.S. than in other countries
	I think commercial opportunities in science/engineering in other countries are similar to those in the U.S.
	I think that science/engineering research in other countries is similar to the U.S.
Personal Growth	Career opportunities in other countries are not interesting to me
	I believe that people from other countries view the U.S. positively

Table 4-3. Academic STEM learning and personal growth assessment instrument items by subscale

Academic STEM learning Outcomes Scales	
Professional self-efficacy in science and engineering	I believe that I can learn new knowledge from scientists/engineers in other countries
	I am aware of scientific/engineering research opportunities in other countries
	I value research conducted by scientists/engineers in other countries
	I believe that I can learn new skills from scientists/engineers in other countries
Global Science Communication	I think science/engineering are communicated using similar methods in other countries
	I believe that English is the most important language in the communication of science/engineering
	I am comfortable giving an academic presentation in an international setting
	I think it is important for scientists/engineers to speak more than one language
	I am comfortable discussing my research with people from other countries
Socio-Cultural Role of Science/ Engineering	It is important to understand the perspectives of people from other countries have regarding science/engineering
	I feel I can apply my research in global settings
	My discipline has an important role to play in solving global problems
	I have a clear understanding about the role of science and engineering in other countries
	I have a clear understanding about the role of science/engineering in other countries

Table 4-3. Continued

Personal Growth Outcomes Scales	
Career-related perceptions	I feel prepared to work on a multinational research project
	I am interested in working on a multinational project
	I am interested in working as a scientist/engineer in another country
	I feel confident about practicing my discipline in a different country
	I am competent to work as a scientist/engineer in other countries
	I aspire to work in another country
Personal Confidence	I am prepared to live in another country
	I am confident that I can take care of myself in a new situation
	I have the ability to make a difference in the world
	I am confident that I can deal efficiently with unexpected events
	I am confident in my abilities as a scientist/engineer
	I am a self-sufficient person
General Global Awareness	I am knowledgeable about international issues
	I am familiar with current events in China/South Africa/Brazil
	I am familiar with current events in other countries

Table 4-4. Cronbach's alpha reliability coefficients for academic STEM learning and personal growth outcome scales and sub-scales (n=65)

Scale	Sub-scale	Items	Cronbach's alpha
Academic Learning Outcomes		1,2,3,5,6,7,8,9,11,12, 13,15,17,18	.849
	Professional self-efficacy in science and engineering	1, 2, 5, 18	.695
	Global Science Communication	3,6,7,9,17	.620
	Socio-Cultural role of Science & Engineering	8,11,12,13,15	.723
Personal Growth Outcomes		19,22,23,24,25,27,28,29, 30,31,32,33,34,35,37	.884
	Personal confidence	24,27,29,30,33,34	.802
	Career Perceptions	19,23,25,28,31,37,	.826
	Global Awareness	22,32,35	.860

CHAPTER 5
AN ASSESSMENT OF ACADEMIC LEARNING, PERSONAL GROWTH AND INTERCULTURAL DEVELOPMENT OUTCOMES OF UNDERREPRESENTED LIFE AND PHYSICAL SCIENCE AND ENGINEERING GRADUATE STUDENTS PARTICIPATING IN A SHORT-TERM STUDY ABROAD PROGRAM

According to the National Association of International Educators (NAFSA, 2003), "an educational opportunity outside the United States can be among the most valuable tools for preparing a student to participate effectively in an increasingly interconnected, international community that demands cross-cultural skills and knowledge" (p. 4). A record number of U.S. college students studied abroad in 2009/2010. However, of the 270,604 U.S. college students studying abroad during the 2009/2010 academic year, only 20,953, or less than 10% were life or physical science, students and only 10,554 were engineering students (IIE, 2011). The Commission on the Abraham Lincoln Study Abroad Fellowship Program Report (2005) declared that students majoring in the sciences and engineering are among the most underrepresented groups on study abroad programs. Similarly, the Council on International Educational Exchange (CIEE), a non-profit, non-governmental organization that promotes international education, recognized that science and engineering college students are not only underrepresented on study abroad programs, but also that unique barriers limit opportunities for study abroad participation for students in these disciplines (CIEE, 2003).

A second traditionally underrepresented group in study abroad programs is minority students. In 2009-2010, only 7.9% of college-level study abroad students were Asian, Native Hawaiian or other Pacific Islander, 6.4% were Hispanic or Latino/a, 4.7% were Black or African-American, and 0.5% were American Indian or Alaska Native (IIE, 2011). The Commission on the Abraham Lincoln Study Abroad Fellowship Program

Report (2005) also declared that “minority students, including African-American and Hispanic-American students, are significantly underrepresented” and that “American colleges and universities must make new efforts not only to raise the number of students abroad but also to increase the diversity of these students” (p. 17).

According to the CIEE, lack of appropriate programs is not the only barrier to study abroad for science and engineering students. Another major obstacle is the lack of recognition of the value of study abroad experiences in the science and engineering disciplines by students, their families, and faculty in science and engineering colleges and departments. The CIEE argues that study abroad professionals and faculty advocates must demonstrate the intrinsic value of study abroad as a significant aspect of the education of tomorrow’s scientists (CIEE, 2003). Similarly, the Institute on International Education (IIE) report titled Promoting Study Abroad in Science and Technology Fields calls on researchers to identify the impacts of international collaborations on science and engineering students (IIE, 2009). Finally, the majority of existing college level study abroad programs are at the undergraduate level, with few opportunities for participation by graduate students. In 2009/2010, only 36,802 of the 270,604 study abroad participants were graduate students, and of those, only 1,624 were pursuing doctoral degrees (IIE, 2011).

In 2011, the University of Florida South East Alliance for Graduate Education and the Professoriate (SEAGEP) developed and implemented a series of four short-term study abroad experiences for underrepresented graduate students in the science and engineering disciplines. The National Science Foundation (NSF), which supports the goal of developing a globally engaged scientific workforce, provided funding for this program. This program provided an opportunity to investigate the impacts of participation in international experiences on the academic STEM learning, personal growth, and intercultural development of underrepresented science and engineering graduate students.

Purpose of Study and Research Questions

Documenting the academic STEM learning, personal growth and intercultural development of science and engineering graduate students who engage in study abroad programs is clearly of considerable importance. In addition, measuring and documenting the actual outcomes resulting from participation in study abroad experiences completed by underrepresented graduate students in science and engineering disciplines addresses a significant gap in the current literature. Researching the impacts of study abroad participation on underrepresented science and engineering graduate students can also provide both higher education institutions and national agencies, such as the NSF, with a clearer understanding of the benefits associated with these programs for specific, underrepresented groups. It is my belief that this knowledge can be used to develop models for new and improved study abroad experiences specifically targeting college students in the science and engineering disciplines.

The purpose of this study was twofold. First, I examined the self-reported academic STEM learning, personal growth, and intercultural development outcomes of underrepresented science and engineering graduate students who participated in UF SEAGEP study abroad programs. Secondly, I examined how the learning outcomes of SEAGEP study abroad students differed from those of comparable minority science and engineering graduate students who did not participate in an international program.

Theoretical Framework

The development of a theoretical framework guiding research in the area of study abroad experiences has been quite limited, and most work in the area has been practitioner-based (Hoffa, 1993; King & Baxter Magolda, 2005). However, given the interdisciplinary nature of study abroad experiences, one can build on other existing theories of academic learning and personal development. The theoretical framework used in this study builds on related theories and concepts in several areas of educational research, developmental learning, psychology, experiential learning, and intercultural development.

Currently, study abroad researchers and practitioners use three prominent theoretical frameworks: positivism, relativism and experiential-constructivism (Vande Berg, Paige & Hemming Lou, 2012). Positivism, which served as the foundational theoretical framework for study abroad, is now waning in popularity as research has demonstrated that mere exposure to different places, peoples and cultures does not necessarily lead to learning for all students. Relativism, based on the early work of psychologists such as Dewey and Piaget, is still popular as a theoretical framework for study abroad. In this approach, the educator structures the experience, supports the student learning process, and operates on the premise that immersion and interaction will facilitate learning. Most recently, and of relevance to the current study, the experiential-constructivism theoretical framework based on Kolb's experiential learning theory has emerged as a popular framework guiding study abroad efforts. Kolb (1979) developed a cycle of learning consisting of four phases: concrete experience, reflective observation, abstract conceptualization and active experimentation, which then cycles back to concrete experience. When using this framework for study abroad experiences, the educator works directly with students to facilitate their learning, providing frequent feedback and actively involving students in the learning process. In the context of the current study, I perceive academic STEM learning and personal growth as both experiential and transformative in nature. During study abroad, students encounter real-world examples of the ideas and knowledge during the study abroad program that they first came across in the classroom and/or laboratory. At the same time students on study abroad programs face situations that are much more complex than, and even contradict and challenge, their classroom-generated understandings and pre-existing beliefs. The role of the faculty is crucial to provide support as the student navigates these new experiences.

Transformative learning is another approach in the constructivist school of thought that, in many ways, is complementary to the experiential learning theory outlined above. Transformative learning involves a “change in the frame of reference or the structures of assumption through which students understand their experiences” (Mezirow, 1997, p.5). Transformative learning occurs in response to a disorientating experience, creating dissonance in what students are hearing, seeing and feeling, which then causes them to re-examine their existing knowledge and assumptions. According to Brewer and Cunningham, “study abroad has tremendous potential for transformative learning” (2009, p. 10). In this theoretical framework, students move from a situation of disorientation and disequilibrium through a period of questioning assumptions to a stage characterized by integration of new and old assumptions. The resulting outcome of this process is a change in frame of reference or worldview.

While the theoretical frameworks of constructivism and experiential learning are of vital importance when researching study abroad programs, learning can only occur if students are developmentally ready to process their experiences productively (Brewer & Cunningham, 2009). In terms of human development theory, several approaches offer potential frameworks for studying the impact of study abroad participation on psychosocial and interpersonal development (Pascarella & Ternezini, 2005). Of particular interest is the theory of intercultural development, which is perhaps the best-known and most widely applied theoretical framework of personal growth used in study abroad research. This model is based on the premise that improving students' understanding of cultural differences is vital to their general education (Mahoney & Schamber, 2004).

In summary, successful study aboard programs should include a focus on the development of new academic knowledge and skills as well as the exchange of information and ideas across cultures. These kinds of experiences involve aspects of both experiential and transformative learning and personal growth, including intercultural communication. Thus, the comprehensive theoretical framework used in this study was based on the experiential-constructivist approach while incorporating aspects of other cognitive and personal development theories.

Literature Review

According to Van Hoof and Verbeeten (2005), the most common benefit of studying abroad is "the student's exposure to different social and cultural environments" (p. 43). They claim that study abroad experiences help students understand the world in which they live while also helping them understand how they fit into that world. In addition, study abroad advocates often cite the contribution of international experiences to the development of job skills that are increasingly required for employees to think and act using a global perspective (IIE, 2009).

Student Learning Outcomes for Study Abroad

Many colleges and universities promote study abroad programs as opportunities for students to experience another country, acquire new knowledge and skills needed to become productive and successful members of the global community, broaden their worldview, and increase their intercultural awareness to promote cross-cultural understanding (Anderson et al., 2006; Black & Duhon, 2006). Underlying these claims is the need for a college education to prepare students for a future as inter-culturally competent global citizens, with the skills and knowledge required to work in an increasingly globalized world. Indeed, researchers frequently cite the phenomenon of globalization as being the driving force for the growing interest and participation in study abroad (Lewin, 2009).

Research on study abroad indicates that there are numerous potential benefits for participants across cognitive, affective, and interpersonal dimensions (Carlson, 1990; McKeown, 2006; Pascarella and Terenzini, 2005). Study abroad researchers have also found that study abroad participation can be particularly influential in improving international awareness, intercultural competency, and foreign language skills (Anderson et al., 2006; Black & Duhon, 2006; Lewin, 2009; Savicki, 2008).

Academic learning outcomes

In terms of academic learning, there is evidence that study abroad can enhance the development of disciplinary knowledge and skills (Hadis, 2005; Immelman & Schneier, 1998; McKeown, 2006). For example, most professionals working in study abroad and international education today embrace the notion that study abroad can enable students “to learn things and learn in ways that aren’t possible on the home campus” (Vande Berg, 2007, p.392). A large-scale study conducted by the Institute for the International Education of Students (IES) reported long-term, positive impacts of study abroad on students’ personal, professional, and academic development, influencing issues such as career path, worldview, and self-confidence of alumni (Dwyer & Peters, 2004). Meanwhile, others have documented gains in foreign language learning and cultural knowledge as well as an increased interest in interdisciplinary studies resulting from participation study abroad experiences (Lewis & Niesenbaum, 2005).

Personal growth outcomes

Many colleges and universities promote study abroad programs as opportunities for students to broaden their worldview and increase their intercultural awareness (Anderson et al., 2006). In a study at Oregon State University 97% of study abroad participants reported that their experience was worth the cost with the largest benefits being broadening their cultural perspective, enriching their personal life and enriching their academic experience (King & Young, 1994). Moreover, several studies have indicated that study abroad provides students opportunities to examine their own national identity and associated traits and their role in the global context (Dolby, 2004).

Intercultural development outcomes

Other studies have documented gains in the development of cultural knowledge, cultural sensitivity, and interpersonal maturity of study abroad participants (Engel & Engel, 2004; Kitsantas, 2004; McCabe, 1994). For example, Chieffo and Griffiths (2004) found significant changes in intercultural awareness, functional knowledge, global interdependence, and personal growth and development for students who participated in short term study abroad programs. They concluded that short-term study abroad programs have a “significant self-perceived impact on student’s intellectual and personal lives” (p. 174). An assessment of the intercultural sensitivity of 23 undergraduate business students who participated in a four-week, faculty-led study abroad program in Europe also found that short-term programs can have a positive impact on the overall development of cross-cultural sensitivity (Anderson et al., 2006). These researchers concluded, “by increasing students’ intercultural sensitivity, it is reasonable to expect that they will also be better prepared to address different cultures” (Anderson et al., 2006, p. 467).

Science and Engineering Student Participation in Study Abroad

As discussed earlier in this paper, participation in study abroad by students in the science and engineering disciplines is relatively low when compared to the social sciences, business and the humanities. Yet, study abroad offers one potential mechanism for students in these disciplines to acquire globally relevant skills required for future careers that specifically focus on addressing critical science-based issues of national and international importance (Grandin, 2006; Guerrero et al., 2007; Haddad, 1997).

However, numerous obstacles exist for science and engineering students interested in completing an international experience as part of their college education. These include fitting the study abroad opportunity into a generally crowded and rigid curriculum and a lack of motivation and support on behalf of some faculty and administrators who believe that scientific concepts are culturally neutral and best studied in U.S. institutions (Shih, 2009; Van Eyck, Van Toll, Wattiaux & Ferrick, 2012). Graduate level science and engineering students interested in study abroad experiences face additional obstacles such as mentors who are reluctant to allow graduate students to leave the lab and a lack of funding for such experiences.

Student Learning Outcomes for Science and Engineering Students

Despite the availability of research evidence documenting the general positive impacts of study abroad experiences on students, very few studies have been conducted to investigate the academic, personal or intercultural learning outcomes for students in science and engineering disciplines. However, below I review those few papers that have investigated these outcomes for science and engineering students.

Academic learning outcomes

A wide-ranging literature search located a few studies focusing on the academic learning outcomes of science and engineering students participating in international programs. Bender, Wright and Lopatto (2009) investigated students' self-reported changes associated with three undergraduate science experiences: a domestic undergraduate biology research program (UBRP), a semester at sea program (SAS), and a biomedical research abroad program (BRAVO). Results indicated that students in the BRAVO and SAS programs were highly motivated by the international scope of their programs and reported comparable or greater gains on certain academic constructs than domestic program participants. These constructs included becoming part of a learning community, skill in oral presentations, skill in science writing and skill in interpretation of results (Bender et al., 2009, p. 311).

However, a more recent study by Lumkes, Hallett and Vallade (2012) which examined the impact of a study abroad course on agriculture and environment globalization in China, reported a lack of evidence of academic outcomes resulting from the international experience. This research study found that the study abroad experience contributed minimally to students' knowledge of Chinese agriculture and environmental issues and their understanding of the general nature of the global economy. However, the study abroad experience profoundly altered students' cultural self-awareness and outlook on global political issues. The most tangible learning outcomes reported were not in the academic realms of globalization, agriculture or the environment, but rather focused more on the cultural and personal development of the students.

Personal outcomes

In addition to the findings of increased self-awareness and global awareness by Lumkes et al. (2012) mentioned above, a few other studies of science and engineering-related study abroad experiences have investigated these personal outcomes. An early assessment of a study abroad program in engineering at Kettering University reported increases in students' confidence (Nasr, Berry, Taylor, Webster, Echempati & Chandran, 2002), and Guerrero et al. (2007) reported that U.S. computer science and engineering students participating in an international research experience developed "a broader and better perspective on education and culture in Latin American countries" (p. 10). Bender et al. (2009) also found that students on a biomedical research abroad program experienced significant personal growth, indicated by increases in their levels of self-confidence and increased awareness of global issues.

Intercultural development outcomes

The intercultural development inventory (IDI), which is based on Milton Bennett's Developmental Model of Intercultural Sensitivity (DMIS; Bennett, 1993), is used frequently in research regarding general study abroad experiences. This assessment measures an individual's orientation toward cultural difference and level of intercultural competence/sensitivity across a developmental continuum for individuals, groups and organizations (Figure 5-1). The first three stages, denial of difference, defense of difference and minimization of difference are identified as ethnocentric stages. In these stages, the individual values his/her own culture more highly than other cultures. The latter three stages, acceptance of difference, adaptation to difference, and integration of difference are ethnorelative, with other cultures viewed in an increasingly positive and non-threatening light. The IDI measures an individual's stage on this continuum and can track progression from denial and defense, through minimization, adaptation, and integration with another culture. However, the IDI has not often been used to assess intercultural development resulting from participation in science and engineering-related study abroad experiences. This is despite the acknowledgment that intercultural competence is an important skill for scientists and engineers (Beckman et al. 2007; Guest et al., 2006).

Intercultural competence gains were investigated by Bender et al., (2009) and they reported that students on an international biomedical program exhibited greater increases compared with students on domestic biology or semester at sea programs. In their study, students demonstrated enhanced global awareness and, as participants in an immersion experience, they reported greater understanding of their host country cultures, with a tendency to form stronger relationships with individuals in that country. Similarly, Pedersen (2010) reported that students on a semester-long psychology course in England experienced significant changes in their intercultural development, as measured by the IDI.

Minority Student Participation in Study Abroad

Even as overall college level study abroad participation has increased, American students studying abroad remain disproportionately White in comparison to the racial composition of college-level students overall (Dessoff, 2006; IIE, 2011; Shih; 2009). Despite substantial efforts to increase the participation of ethnic minority students in study abroad, the gap between ethnic minority and majority students participating in these programs is actually widening (Dessoff, 2006; Salisbury, Paulsen, & Pascarella, 2010; Shih, 2009). Many reasons have been cited to explain the low levels of study abroad participation by African American, Hispanic/Latino(a), Asian American, Native American and other minority groups. Marjorie Ganz, Director of the Study Abroad and International Exchange Program at Spelman College, offered one of the most widely accepted explanations for this phenomenon when she cited barriers she refers to as the four Fs: family, faculty, finances and fear (Pickard & Ganz, 2005). Others have expounded upon these ideas and cited additional obstacles and constraints, including a lack of culturally-relevant study abroad programs and minority student misconceptions about the value of study abroad (Brux & Fry, 2010).

Although recent research has shed some light on the factors influencing minority student decisions to study abroad (Goldstein & Kim, 2006; Salisbury et al., 2010), a detailed understanding of the impact of participation in study abroad experiences on minority students remains elusive. As Dessoff (2006) states, “we need to present study abroad as normal, generally beneficial, and certainly worth the extra effort and cost” to increase levels of minority student participation (p. 24).

Student Learning Outcomes for Minority Students Participating in Study Abroad

Few studies have investigated the impacts of study abroad experiences on minority students, perhaps because their levels of participation in these programs are so low. However, several reports suggest numerous potential benefits for minority students, including positive impacts on employment readiness, the expansion of job opportunities; increases in income potential and development of new career-relevant skills (Ikeda, 2006; Picard, Bernardino & Ehigiator, 2009). Advocates also claim that, after completing study abroad experiences, minority students get better grades and improve their chances of acceptance to graduate, medical and law school (Martinez, 2011). However, these assertions are generally unsubstantiated by empirical research. While not an explicit objective of this study, the findings for the SEAGEP science and engineering graduate students may provide data to enhance our understanding of the benefits of study abroad participation for ethnic minorities.

Study Design

This study was conducted at the University of Florida (UF), in conjunction with the National Science Foundation-funded South East Alliance for Graduate Education and the Professoriate (SEAGEP). This program is a collaboration between three universities: UF, Clemson University, and the University of South Carolina (USC), and provides a comprehensive professional development program designed to increase minority representation among science technology, engineering and mathematics (STEM) faculty. During 2011, SEAGEP implemented a series of new international initiatives for their graduate students to address the need for global experience at the graduate level. These comprehensive international experiences were designed to provide students with opportunities to develop global competencies that would give them a competitive edge in their preparation for, and pursuit of, academic careers. Three specific SEAGAP "Science and Engineering in the Global Context" study abroad programs were investigated in this study: UF in China (May, 2011); UF in South Africa (June, 2011); and UF in Brazil (July, 2011).

A specific science and/or engineering topic formed the basis of each program with related visits to science and engineering educational and research facilities, private sector facilities and manufacturing sites, government agencies, and museums as well as organized cultural activities. Each program was approximately 12 days in length and visited several cities and/or provinces in the host country. The UF in China program focused on manufacturing and transportation engineering in the cities of Beijing, Tianjin and Shanghai. The UF in South Africa program focused on natural resources and water conservation and included visits to Johannesburg, Pretoria, rural areas of Limpopo province as well as a visit to Kruger National Park. The UF in Brazil program focused on biofuels, agriculture and natural resources and included time in three cities: Sao Paulo, Campinas, and Piracicaba as well as an overnight stay at a rural ecological research institute near Nazare Paulista and a day trip to Jureia Natural Park on the Atlantic coast. While traveling on all three trips, students had opportunities to meet with researchers, faculty and students at host institutions, talk with government representatives and participate in group presentations and discussions about various aspects of the trip.

A particular challenge for assessment of study abroad experiences is the inherent belief that students will increase in maturity during their participation. As a result, it was necessary to implement a research design that provided control for issues of internal validity. To minimize these validity threats, a pre-trip and post-trip design, with a comparison group of non-study abroad participants was used. This two-part design facilitated the documentation of academic STEM learning, personal growth, and intercultural development outcomes of students participating in the SEAGEP study abroad programs (Part 1), and the investigation of how these targeted outcomes differed between equivalent groups of students who did and did not participate in a study abroad program (Part 2).

Study Sample

Part 1 – SEAGEP Program Participants

The original study sample consisted of 35 SEAGEP-affiliated graduate students enrolled in study abroad programs in 2011, with 15 visiting China and 10 visiting South Africa and Brazil respectively. All of these the students were pursuing doctoral degrees in science or engineering and all met NSF criteria for classification as underrepresented minorities in these disciplines. Some students did not complete both pre and post-trip assessments, thus the final study sample consisted of 33 students with complete data for the academic STEM learning and personal growth assessment instrument and 31 students for the IDI. The final study sample included 16 male and 17 female students, with 18 from engineering, and 15 from the life and physical science disciplines. There were 17 Black/African/African American students, 15 Hispanic/Latino/Spanish students, and 1 American Indian or Alaskan Native.

Part 2 – Comparison Group Participant

To address the second purpose of the study, an additional 32 underrepresented science and engineering graduate students served as a comparison group. SEAGEP participants assisted with recruitment of the comparison group by identifying counterparts in their respective disciplines with similar demographics (ethnicity and gender). This selective recruitment approach ensured that the comparison group matched the study abroad program group as closely as possible (Table 5-1). Thirty-two comparison group participants completed the academic STEM learning and personal growth assessment and 30 completed the IDI. The comparison group included 14 male and 18 female students, with 11 from engineering, and 21 from the life and physical science disciplines. There were 17 Black/African/African American students and 15 Hispanic/Latino/Spanish students.

Data Collection Instruments

Two quantitative instruments were administered electronically to measure academic STEM learning, personal growth and intercultural development of student participants before and after completion of a study abroad experience. The first instrument, developed specifically for this study, assessed students' self-reported perceptions of their own academic STEM learning and personal growth outcomes. The second assessment instrument, used to measure intercultural development was the commercially available Intercultural Development Inventory (IDI). Both assessment instruments are described in more detail below.

Study abroad participants completed both pre-trip assessments immediately following the pre-departure orientation for each program approximately two weeks prior to departure. Students completed the same two post-trip assessments approximately two weeks after their return to the U.S. However, in some cases, post-trip assessments were not completed until up to four weeks after program completion, as not all students returned immediately to the U.S. Students in the comparison group completed the same two assessments during the fall of 2011.

Academic STEM learning and personal growth assessment instrument

As mentioned in Chapter 2 and in the literature review above, very few studies have assessed academic and personal outcomes of science and engineering students participating in study abroad programs. Thus, a new assessment instrument for these targeted outcomes was developed as part of this study. The three-part assessment instrument includes 29 statements with a 5-point Likert-type response scale and 9 demographic items. The first 14 items focus on academic STEM learning outcomes with three sub-constructs: professional self-efficacy (4 items), global science communication (5 items), and the socio-cultural role of science/engineering (5 items). The second section contains 15 items focusing personal growth outcomes with three additional constructs: career-related perceptions (6 items), personal confidence (6 items), and general global awareness (3 items). The third section contains nine demographic and personal background questions including name, age, sex, race, nationality, previous general travel experience, previous travel experiences to the specific study abroad site country, languages spoken, and levels of fluency. Details regarding the development and validation of this assessment instrument are provided in Chapter 4.

Intercultural development inventory

The Intercultural Development Inventory (IDI) was selected to assess the students' orientation toward cultural difference and commonality. The IDI consists of 16 demographic information items and 50 Likert-type items and has been shown to be a statistically reliable and valid measure of intercultural sensitivity in many contexts. The IDI includes items based on actual statements made by people from many cultures throughout the world. The wording and content of the items reflect a range of viewpoints toward cultural differences. For example, one item asks respondents to indicate their level of agreement with the statement, “I have observed many instances of misunderstanding due to cultural differences in gesturing or eye contact.” Additional details regarding the IDI, including reliability and validity information, are available on the IDI website (http://idiinventory.com/) and in several associated publications (Hammer, Bennett & Wiseman, 2003 Hammer, 2011).

The IDI provides several different assessments of an individual’s intercultural development in relation to the DMIS continuum (Figure 5-1). For the purposes of this study, each participant’s developmental orientation score on the IDI was used. This score indicates an individual’s primary orientation towards cultural differences and commonalities along the continuum and is the perspective that an individual is most likely to use in situations where cultural differences and commonalities need to be bridged.

Data Analysis

Part 1 – SEAGEP Program Participant Outcomes

Descriptive statistics including means, standard errors and standard deviations were calculated for the pre-trip and post-trip assessment scores for each academic, personal and intercultural outcome construct and sub-construct (Table 5-2). In addition, means and standard deviations were calculated separately for engineering students and life and physical science students (Table 5-3) and separately for groups completing each of the three different trips (Table 5-4).

Inferential statistics in the form of paired t-tests were used to determine the significance of changes in pre-trip and post-trip scores for each targeted outcome. In all cases a 95% confidence level was used (α=0.05) to determine significance. One-way within subjects ANOVAs were used to compare the potential effect of the students’ discipline (science or engineering) and the students' participation in a particular trip (China, South Africa or Brazil) on academic STEM learning, personal growth and intercultural development.

Part 2 – Comparison Group Outcomes

In addition to descriptive statistics (means, standard errors and standard deviations) for each of the academic STEM learning, personal growth and intercultural development outcome constructs and sub-constructs, independent-samples t-tests were used to compare the post-trip outcome assessment scores of the study abroad participant group with outcome assessment scores of the comparison group. In all cases a 95% confidence level was used (α=0.05) to determine significance.

Results

The results for the statistical analyses are broken down into two parts. First, I examine the differences between the pre- and post-trip assessment scores of the SEAGEP program participants. These analyses also include an examination of the effect of students' discipline and participation in the three different study abroad programs. The second part of the analyses examines the differences between assessment scores of students in the SEAGEP participant group versus the comparison group.

Part 1 – SEAGEP Program Participant Outcomes

Descriptive statistics for the pre-trip and post-trip assessment scores of the entire study abroad group are presented in Table 5-2. Table 5-3 includes descriptive statistics for the assessment scores broken down into separate engineering and life and physical science groups and Table 5-4 summarizes descriptive statistics for assessment scores of students completing each of the three different trips. Inferential statistical analysis results are presented in Table 5-5.

Academic STEM learning outcomes

For the study abroad group, mean scores on the overall academic STEM learning construct increased from 63.76 (*SD* = 8.02) on the pre-trip assessment to 67.21 (*SD* = 5.81) on the post-trip assessment. A paired-samples t-test compared the academic STEM learning construct and sub-construct scores on the pre-trip and post-trip assessments. There was a significant difference in the scores for the pre-trip and post-trip assessments for the overall academic STEM learning construct; t (32) = 2.954, p =0.006. Similarly, mean scores increased between pre-trip and post-trip assessments for all three academic STEM learning sub-constructs (professional self-efficacy in science and engineering, global science communication, and socio-cultural role of science and engineering pre-trip). These differences in scores for the pre-trip and post-trip assessments were significant for the socio-cultural role of science and engineering sub-construct; t (32) = 4.079, p =0.000. However, there was not a significant difference in the pre-trip and post-trip scores for the professional self-efficacy in science and engineering [t(32) = 1.343, p =0.189] or global science communication [t(32) = 1.954, p = 0.059] sub-constructs.

When broken down into life and physical science and engineering sub groups, there was no significant difference between gain scores for the academic STEM learning construct at the p<.05 level [F(1, 31) = 2.590, p = 0.118]. Nor were there significant differences between gain scores for students from the different disciplines on two of the academic sub-constructs at the p<.05 level [professional self-efficacy in science and engineering; F(1, 31) = 1.045, p = 0.315: socio-cultural role of science and engineering; *F*(1, 31) = 0.258, *p* = 0.615]. However, there was a significant difference between the gain scores of the two discipline groups on the science communication sub-construct [*F*(1, 31) = 4.457, *p* = 0.043]. There was no significant difference between gain scores for the overall academic STEM learning construct for groups visiting each study abroad site [*F*(2, 30) = 1.313, *p* = 0.284]. Similarly, there were no significant differences between the changes in pre- and post-trip scores on the academic STEM learning sub-constructs for the groups on the three study abroad programs [professional self-efficacy in science and engineering; *F*(2, 30) = 1.218, p = 0.310: science communication; *F*(1, 31) = 1.389, *p* = 0.265: and socio-cultural role of science and engineering; *F*(2, 30) = 0.281, *p* = 0.757].

Personal growth outcomes

Mean scores on the overall personal growth construct increased significantly from 59.09 (*SD* = 7.53) on the pre-trip assessment to 63.61 (*SD* = 7.14) on the post-trip assessment (*t* (32)= 3.958, *p* =0. 000). All three personal growth sub-construct mean scores also significantly increased between the pre-trip and post-trip assessments (personal confidence [*t* (32)= 2.357, *p* =0.025], career perceptions [*t*(32)= 3.233, *p* =0.003], and global awareness [*t*(32)= 3.996, *p* = 0.000]).

There was not a significant difference between the gain scores for the pre- and post-trip scores of the life and physical science students compared to engineering students on the overall personal growth construct at the *p*<.05 level [*F*(1, 31) = 0.998, *p* = 0.326]. Nor were there significant differences in gain scores in three personal growth sub-constructs for students from the life and physical sciences compared to engineering [career perceptions; *F*(1, 31) = 1.651, *p* = 0.208: personal confidence; *F*(1, 31) = 0.288, *p* = 0.596: and global awareness; *F*(1, 31) = 0.100, *p* = 0.754]. In addition, there was no significant difference between the gain scores on the personal construct scores at the $p<.05$ level for the students that participated in the different trips. The gain scores in the pre- and post-trip assessments for the overall personal growth construct [$F(2, 30) = 0.328$, $p = 0.723$] and for the three personal growth sub-constructs [career perceptions; $F(2, 30) = 0.351$, $p = 0.707$: personal confidence; $F(1, 31) = 1.012$, $p = 0.376$: and global awareness; $F(1, 31) = 1.614$, $p = 0.216$] were not significant.

Intercultural development outcomes

Mean scores on the IDI did not change significantly pre-trip to post-trip ($t(30)= 0.590$, $p =0.559$) indicating that this instrument did not detect changes in participants' levels of intercultural development.

When broken down into life and physical science and engineering sub groups, there was also no significant difference between gain scores for the academic STEM learning construct at the $p<.05$ level [$F(1, 29) = 3.545$, $p = 0.070$. With respect to the three different trips, IDI mean scores increased for the group that went to China (pre-trip $M = 87.57$, $SD = 13.01$and post-trip $M = 92.29$, $SD = 14.49$). However, the IDI scores decreased for those who went to Brazil (pre-trip $M = 84.75$, $SD = 15.64$ and post-trip $M = 82.43$, $SD = 10.58$) and South Africa (pre-trip $M = 94.00$, $SD = 13.47$ and post-trip $M = 86.20$, $SD = 14.34$). There was a significant difference between gain scores across the three different trips [$F(2, 28) = 3.746$, $p = 0.036$]. Post-hoc analyses using Bonferroni pairwise comparisons indicated that there was a significant difference in gain scores between the group that went to China and the South Africa group. However, there were no significant differences in gain scores between the China and Brazil groups, nor between the South Africa and Brazil groups.

Part 2 – Comparison Group Outcomes

Descriptive statistics for the scores of the comparison group are presented in Table 5-2. Independent t-test results for comparisons between the study abroad and the non-study abroad groups are presented in Table 5-6. Independent t-test results indicated no significant differences between most of the academic STEM learning, personal growth and intercultural development responses of the comparison group and the study abroad participants prior to their enrollment in the program. The one exception was a significant difference between students' career perceptions, with those enrolled in the international programs (M = 24.15, SD = 3.35) reporting more positive perceptions of global career concepts than the comparison group (M = 21.47, SD = 5.05); $t(63)$= 2.518, p = 0.015.

Academic STEM learning outcomes

Independent t-test analyses yielded significant differences in academic STEM learning constructs when study-abroad group post-test scores were compared to those of the comparison group. Significantly higher scores in all three sub-construct assessments were also found when these two groups were compared (Table 5-6).

Personal growth outcomes

When independent t-test analyses between the study abroad group's post-test scores and the comparison group's scores were conducted for the personal growth construct, differences between these two groups were significant and scores for the study abroad group were significantly higher than those of the comparison group. Scores on the career perceptions and personal confidence sub-constructs were also significantly higher for the study abroad group. However, global awareness sub-construct scores for these two groups were not significantly different from each other.

Intercultural development outcomes

Independent t-test comparisons between IDI scores of students in the study abroad and comparison groups indicate no significant differences in levels of intercultural development of students who completed study abroad experiences and those who did not.

Discussion

Research Question 1

What are the self-reported academic STEM learning, personal growth and intercultural development outcomes of underrepresented life and physical science and engineering graduate students who participate in science and engineering-related study abroad experiences?

Results of this research study suggest that students completing science and engineering-related study abroad experiences do significantly increase their self-reported levels of academic STEM learning and personal growth as a result of participation in a study abroad experience. However, results of this study also suggest that science and engineering-related study abroad experiences may not significantly influence students' levels of intercultural development. In addition, results of this study indicate that study abroad experiences have significant positive impacts on all three personal growth sub-constructs while changes in academic STEM learning sub-constructs resulting from study abroad participation are more variable.

Academic STEM learning outcomes

In terms of academic STEM learning outcomes, students' perceptions regarding the socio-cultural role of science and engineering were significantly higher after completion of a study abroad experience while their perceptions of professional self-efficacy in science and engineering and global science communication did not significantly increase as a result of participation in a study abroad experience. While an individual item analysis was not conducted, examples of the individual items that comprise each sub-construct can be found in Table 5-7.

An examination of the SEAGEP study abroad program itineraries (Appendix G) and onsite observations conducted during each of the three study abroad programs suggest some possible explanations for these results. For example, as part of each study abroad program, students visited science and engineering projects focused on the advancement of society and bringing benefit to the local community. Visits to a water management project and an organic farming cooperative in South Africa, conversations with students and faculty at key research laboratories in China and visits to an ecological institute in Brazil all overtly emphasized the socio-cultural role of science and engineering in the host countries. Thus, it is not surprising that gains for this sub-construct were significant.

Conversely, changes in the professional self-efficacy in science and engineering and global science communication sub-constructs were not significant. While these sub-constructs were found to be less reliable than the other academic STEM learning sub-construct, students' learning may also have been impacted by logistical constraints. For example, the visits to both South Africa and Brazil occurred during semester breaks at the host institutions, which limited the opportunities for interaction with local faculty and students. These logistical constraints also prevented students from making presentations to audiences in their host countries during two of the study abroad programs may have hindered student growth in global science communication. Finally, because all three study abroad experiences were interdisciplinary, it was not possible for students from many specializations to make connections with faculty expertise in each of their respective areas of focus. This limitation may have hindered student growth in both professional self-efficacy in science and engineering and global science communication.

Personal growth outcomes

The most powerful positive impacts resulting from completion of study abroad experiences in this study occurred in the area of personal growth outcomes. Overall, student scores for all three sub-scales in the personal growth construct (personal confidence, career perceptions, and general global awareness) significantly increased as a result of participation in a study abroad experience. The individual items for each sub-scale are presented in Table 5-7. These results suggest that students completing science and engineering-related study abroad programs experience the same types of personal growth gains reported for students completing study abroad experiences in other disciplines. For example, several studies have reported the positive impact of study abroad experiences on students' levels of self-confidence (Anderson et al., 2006; Bender et al., 2009; Dwyer & Peters, 2004). Other studies have demonstrated positive impacts on career aspirations (Fass & Fraser, 2009; Sachdev, 1997) and on students' levels of global awareness (Chieffo & Griffiths, 2004; Dolby, 2004; Lambert, 1993; McCabe, 1994).

Intercultural development outcomes

The lack of growth in levels of intercultural development resulting from participation in study abroad experiences in this study is not surprising. Intercultural development or competence is not an explicit objective of the SEAGEP study abroad program, but it is often cited as a desired outcome for study abroad programs in general. Results of this study indicate that mere completion of a study abroad experience does not guarantee that changes in the individual's level of intercultural development will occur. In particular, this short-term study tour program format, during which students stayed in hotels and typically participated in group academic and social activities, did not provide many opportunities for interaction with the host culture.

These findings substantiate Vande Berg's assertion that simply sending students abroad for academic study is not enough to achieve the larger goal of creating effective global citizens (Vande Berg, 2007). Other researchers have also documented the need for specific and intentional interventions in order to facilitate intercultural development during study abroad experiences. For example, in a study of 50 students on a year-long study abroad program in England, Pedersen (2010) found that the use of an intercultural pedagogy and students' previous travel experience both had significant impacts on whether or not a student moved along the developmental model of intercultural sensitivity (DMIS) as measured by the IDI. In particular, Pedersen determined that the use of intentional intercultural pedagogy is particularly important for students with limited international travel experience prior to completion of a study abroad program. This finding may also be applicable to the current study, which lacked a specific intercultural pedagogy and in which a third (33%) of participants had limited (two times or less) foreign travel experience. It is also important to note that the IDI has not been used previously to measure the intercultural development of science and engineering graduate students and may not be valid for use in this context. Therefore, further research is needed in order to understand why science and engineering-related study abroad programs do not seem to improve levels of intercultural development.

Comparison of outcomes by discipline

Comparisons between engineering and life and physical science students completing study abroad experiences yielded no significant differences between pre-trip or post-trip scores for any of the three major categories of targeted outcomes (academic STEM learning, personal growth, or intercultural development). These results indicate that: 1. engineering, and life and physical science graduate students had similar levels of academic STEM learning, personal growth, and intercultural development before completing the study abroad trips and 2. engineering and life and physical science students experienced similar increases (or lack of increase) in academic STEM learning, personal growth, and intercultural development as a result of participation in the SEAGEP study abroad programs.

Interestingly, there was a significant difference between science and engineering students on a single sub-construct, that of global science communication. In this aspect, life and physical science students exhibited a significantly greater gain score (M = 1.8667, SD = 2.47) as a result of the program compared to engineering students (M = 0.0556, SD = 2.44). These results may reflect the different backgrounds of the students and their previous experiences, rather than any impact of the study abroad program on perceptions of global science communication. However, additional research is needed to further investigate this phenomenon.

Comparison of outcomes by trip

There were also no significant differences found between the academic STEM learning and personal growth post-trip scores of students participating in the three different trips. However, IDI post-trip scores were significantly different for students completing the three different trips. Closer examination of the mean post-trip IDI scores for each country visited indicate that students on the China trip experienced significant positive increases in their levels of intercultural development while students on the South Africa and Brazil programs did not experience significant gains in their levels of intercultural development.

Again, a review of the three program itineraries, together with onsite observations conducted during implementation of the three study abroad programs, provide tentative explanations for these results. During the China program, students stayed in two different locations and spent most of their program time in Beijing. As a result, they had ample time for more independent explorations of the city during their free time, during which they had multiple opportunities to interact with local Chinese citizens and directly experience a very different culture. In addition, this trip occurred while local universities were still in session and students were able to spend time, both during the day and in the evenings, with their Chinese science and engineering graduate student counterparts. These numerous opportunities to interact with people from another culture appear to have played a major role in the increase of intercultural development of students during the China study abroad program.

During the South Africa and Brazil programs however, students visited and stayed in multiple locations for short durations, which limited their opportunities for non-structured individual exploration and interaction with local people and cultures. These trips also occurred during semester breaks at the local universities, which precluded opportunities for SEAGAP students to directly interact with their South African and Brazilian counterparts as envisaged in the program syllabus. Finally, security and safety concerns in several locations visited during the South Africa and Brazil trips, such as

Johannesburg and Sao Paulo, significantly restricted opportunities for students to explore the area during their free time, thus limiting the options for cultural interaction.

Overall, however, the results of this study suggest that participation in science and engineering-related study abroad programs do have significant positive impacts on many areas of academic STEM learning, personal growth, and potentially intercultural development of participants. Previous research has clearly demonstrated the value of study abroad as a pathway to internationalization for college-level students in general and the results of this study support those same conclusions in science and engineering contexts (Anderson et al. 2006, Bender et al., 2009; Lumkes et al., 2012; Pedersen, 2010). However, this study was unique in that it also investigated the impact of study abroad participation on student outcomes that are specific to science and engineering disciplines (e.g., socio-cultural role and global science communication).

These results suggest that assessment instruments used to evaluate the impact of study abroad experiences on science and engineering-specific student outcomes need to include more discipline-related items and constructs in order to fully understand the impact of these experiences on science and engineering students. It would be useful to include items to investigate how students' perceptions of their disciplinary knowledge, understanding of technical concepts or specific skills were impacted by participation in the study abroad experience. For example, an item that asks a student to rate his/her current level of disciplinary knowledge or confidence in their laboratory skills would enable faculty and study abroad administrators to use these findings to design activities to promote student learning in their discipline, in addition to enhancing students' general academic learning and personal growth.

Research Question 2

Do perceived academic STEM learning, personal growth and intercultural development outcomes of study abroad experiences differ for life and physical science and engineering graduate students who participate in study abroad experiences compared to those who do not?

The results of Part 2 of this study suggest that, prior to program participation, the SEAGEP study abroad participants were representative of the broader population of under-represented science and engineering graduate students in most areas. However, one area in which students enrolled in the study abroad programs significantly differed from the comparison group prior to departure was that of career perceptions. Students enrolled in the study abroad program had higher pre-trip perceptions of international career opportunities and exhibited more interest in living and working in another country as compared to students in the non-study abroad group. This is not unexpected, given the fact that students participating in SEAGEP study abroad programs were self-selected and thus were already more likely to have a pre-existing interest in globally-focused science or engineering careers. As Gray, Murdock and Stebbins (2002) noted, self-selection is a common challenge when assessing study abroad students, as they "already may be different from those who do not select those activities" (p. 50).

After completing the study abroad programs, participants' academic STEM learning and personal growth outcomes were significantly higher than those of the comparison group suggesting that program participation did have a significant positive impact in both of these areas. However, for two constructs (intercultural development and general global awareness), study abroad participant post-test scores were not significantly different from those of the comparison group. As I have previously noted, intercultural development was not an explicit objective of the SEAGEP study abroad program, and, as such, there were no specific program activities or assignments to enhance students learning in this area. Furthermore, previous research has suggested intentional pedagogy focused on intercultural competency outcomes must be included in a study abroad syllabus to ensure student development (Pedersen, 2010). Similarly, global awareness was not a stated objective for student learning on the SEAGEP study abroad program, although students were expected to learn about the history, culture and traditions of the host country. In the academic STEM learning and personal growth assessment instrument, the general global awareness sub-construct consisted of only three items, of which only one asked about the students' knowledge of the host country. These results suggest that more direct attention needs to be devoted to addressing and assessing those aspects of student growth in future science and engineering-related study abroad programs.

Study Implications

This study's results document the positive impacts of study abroad experiences on science and engineering students and support the argument for development of more international programs in these disciplines. However, the lack of significant improvement in some targeted participant outcomes highlight some areas of focus that need to be addressed when conceptualizing and implementing future science and engineering-related study abroad programs and when designing assessment measures. Specifically:

- To increase the professional self-efficacy in science and engineering of graduate students who participate in science and engineering-related study abroad programs, opportunities should be provided to visit leading research facilities and meet with key faculty in the fields of study of the program participants. Graduate students have very specific research interests and it is important to provide networking opportunities within their disciplines and fields of study, as well as in an interdisciplinary context. Such networking activities and research visits can provide program participants with the chance to observe the on-going research and caliber of facilities in the host country and enable them to make research-specific connections.

- Attention must be paid to the scheduling of programs to ensure multiple opportunities for students to meet and interact with their graduate student peers at host institutions. These interactions may not only impact participants' perceptions of professional self-efficacy in science and engineering through discussions with their counterparts, but may also provide opportunities for participants to make research presentations to host audiences with science and/or engineering knowledge;

- To further enhance opportunities for global science communication during study abroad experiences, students should conduct presentations of their own research in their host countries and engage in faculty led scientific discussions with graduate students and researchers to enhance their understanding of issues related to science communication across cultures;

- The results of the current study suggest that study abroad students experienced significant increases in their perception of the socio-cultural role of science and engineering. These results are indicative of the multiple opportunities students had to learn about the impact of research on the local communities in the host culture. Often graduate students work in relative isolation, conducting field and/or laboratory research without the opportunity to explore or even understand the broader impacts of their work. These study abroad activities can provide the chance to observe the impact of science and engineering in a real-world context and can motivate students to pursue and persist with research that will benefit communities and ecosystems on a global scale.

- The significant positive impacts of the study abroad experience on the personal growth construct, including career perceptions, personal confidence and global awareness suggest that the combination of cultural and professional activities provided appropriate learning experiences. In particular, on each program students were provide information about various post-graduate and job opportunities and were encouraged to develop contacts for future career exploration. In addition, the program included a variety of cultural activities during which students learned about the history, geography, and politics of the host nation. Finally, as has been documented by study abroad programs, participation in international travel provided students with the opportunity to build their personal confidence.

- Finally, concerning students' intercultural development, there should be more time for individual exploration and personal experience during the program. This, together with group and individual reflection exercises has been found to enhance study abroad participants' intercultural development (Pederson, 2010). In addition, study abroad faculty should be trained in intercultural pedagogy and course syllabi should include intentional interventions designed to promote intercultural development (Lederman, 2007; Pedersen, 2010)

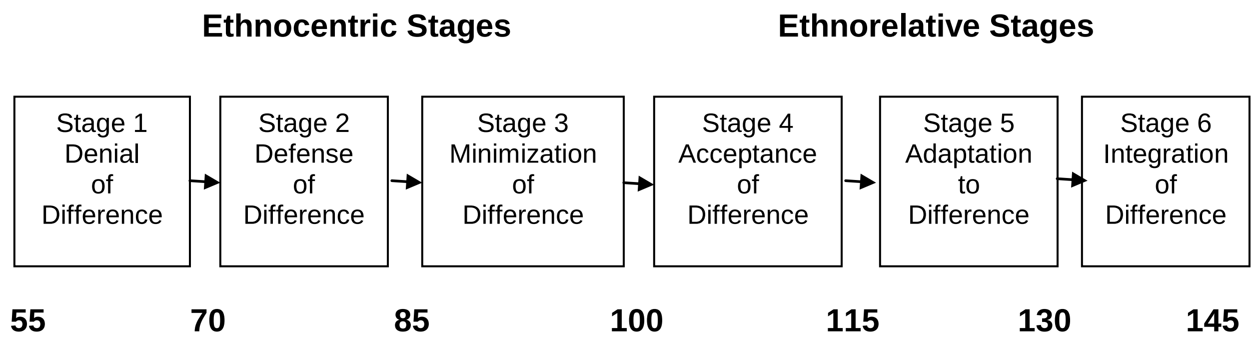

Figure 5-1. Developmental Model of Intercultural Sensitivity and IDI Assessment Scale [Adapted from Hammer, M. R., Bennett, M. J., & Wiseman, R. 2003. Measuring intercultural sensitivity: The Intercultural Development Inventory. International Journal of Intercultural Relations, 27, 421-443.]

Table 5-1. Demographics of student participants of the SEAGEP international program and the comparison group of under-represented science and engineering graduate students

Participants	Discipline	Ethnicity	Sex
China	12 Engineering	8 Black/African/African American	8 Male
	3 Life & Physical Science	7 Hispanic/Latino/Spanish	7 Female
South Africa	3 Engineering	4 Black/African/African American	2 Male
	6 Life & Physical Science	4 Hispanic/Latino/Spanish	7 Female
		1 American Indian or Alaskan Native	
Brazil	3 Engineering	5 Black/African/African American	6 Male
	6 Life & Physical Science	4 Hispanic/Latino/Spanish	3 Female
Total Study Abroad	18 Engineering	17 Black/African/African American	16 Male
	15 Life & Physical Science	15 Hispanic/Latino/Spanish	17 Female
		1 American Indian or Alaskan Native	
Comparison Group	11 Engineering	15 Hispanic/Latino/Spanish	14 Male
	21 Life & Physical Science	17 Black/African/African American	18 Female

Table 5-2. Overall means, standard errors and standard deviations of academic, personal and intercultural development scores for the study abroad participant group and the comparison group

Construct	Sub-construct	Assessment	Number of participants (n)	Mean	Standard Deviation	Standard Error
Academic Outcomes		Pre-trip	33	63.76	8.02	1.40
		Post-trip	33	67.21	5.81	1.01
		Comparison	32	62.53	7.68	1.36
	Professional self-efficacy in science and engineering	Pre-trip	33	17.73	2.39	0.42
		Post-trip	33	18.27	1.35	0.24
		Comparison	32	17.13	2.43	0.43
	Global Science Communication	Pre-trip	33	19.97	3.22	0.56
		Post-trip	33	20.85	2.45	0.43
		Comparison	32	19.53	2.77	0.49
	Socio-Cultural role of Science & Engineering	Pre-trip	33	19.33	2.93	0.51
		Post-trip	33	21.09	2.66	0.46
		Comparison	32	19.47	3.11	0.55

Table 5-2. Continued

Construct	Sub-construct	Assessment	Number of participants (n)	Mean	Standard Deviation	Standard Error
Personal Outcomes		Pre-trip	33	59.09	7.53	1.31
		Post-trip	33	63.61	7.14	1.24
		Comparison	32	56.66	10.07	1.78
	Personal confidence	Pre-trip	33	25.42	3.94	0.69
		Post-trip	33	26.94	2.59	0.45
		Comparison	32	25.03	3.38	0.60
	Career Perceptions	Pre-trip	33	24.15	3.35	0.58
		Post-trip	33	25.91	3.49	0.61
		Comparison	32	21.47	5.05	0.89
	Global Awareness	Pre-trip	33	9.52	2.32	0.40
		Post-trip	33	10.76	2.77	0.48
		Comparison	32	10.16	3.13	0.55
Intercultural Development		Pre-trip	31	89.42	13.75	2.47
		Post-trip	31	88.10	13.85	2.49
		Comparison	30	87.27	14.52	2.65

Table 5-3. Means and standard deviations of academic, personal and intercultural development scores for engineering and life and physical science students who participated in the study abroad participant program

Construct	Sub-construct	Discipline	Number of participants (n)	Assessment	Mean	Standard Deviation
Academic Outcomes		Engineering	18	Pre-trip	64.67	7.98
				Post-trip	66.44	5.10
		Life & Physical Science	15	Pre-trip	62.67	8.22
				Post-trip	68.13	6.63
	Professional self-efficacy in science and engineering	Engineering	18	Pre-trip	17.94	2.34
				Post-trip	18.11	1.13
		Life & Physical Science	15	Pre-trip	17.47	2.50
				Post-trip	18.47	1.60
	Global Science Communication	Engineering	18	Pre-trip	20.11	3.07
				Post-trip	20.17	2.64
		Life & Physical Science	15	Pre-trip	19.80	3.49
				Post-trip	21.67	1.99
	Socio-Cultural role of Science & Engineering	Engineering	18	Pre-trip	19.72	3.01
				Post-trip	21.28	2.02
		Life & Physical Science	15	Pre-trip	18.87	2.88
				Post-trip	20.87	3.34

Table 5-3. Continued

Construct	Sub-construct	Discipline	Number of participants (n)	Assessment	Mean	Standard Deviation
Personal Outcomes		Engineering	18	Pre-trip	58.28	6.67
				Post-trip	63.83	6.34
		Life & Physical Science	15	Pre-trip	60.07	8.59
				Post-trip	63.33	8.23
	Personal confidence	Engineering	18	Pre-trip	25.39	4.07
				Post-trip	27.22	2.32
		Life & Physical Science	15	Pre-trip	25.47	3.91
				Post-trip	26.60	2.92
	Career Perceptions	Engineering	18	Pre-trip	23.72	3.01
				Post-trip	26.11	3.71
		Life & Physical Science	15	Pre-trip	24.67	3.75
				Post-trip	25.67	3.33
	Global Awareness	Engineering	18	Pre-trip	9.17	2.15
				Post-trip	10.50	2.23
		Life & Physical Science	15	Pre-trip	9.93	2.52
				Post-trip	11.07	3.37
Intercultural Development		Engineering	18	Pre-trip	87.50	12.66
				Post-trip	90.76	15.07
		Life & Physical Science	15	Pre-trip	90.64	15.61
				Post-trip	84.86	11.95

Table 5-4. Means and standard deviations of academic, personal and intercultural development scores for students completing each study abroad program

Construct	Sub-construct	Country	Number of participants (n)	Assessment	Mean	Standard Deviation
Academic Outcomes		Brazil	9	Pre-trip	65.56	7.45
				Post-trip	68.56	5.27
		China	15	Pre-trip	65.57	8.22
				Post-trip	67.36	6.31
		South Africa	9	Pre-trip	59.60	7.38
				Post-trip	65.80	5.83
	Professional self-efficacy in science and engineering	Brazil	9	Pre-trip	18.56	2.01
				Post-trip	18.67	1.50
		China	15	Pre-trip	17.93	2.09
				Post-trip	18.07	1.27
		South Africa	9	Pre-trip	16.70	2.91
				Post-trip	18.20	1.40
	Global Science Communication	Brazil	9	Pre-trip	19.78	2.77
				Post-trip	20.89	1.54
		China	15	Pre-trip	20.57	3.47
				Post-trip	20.64	3.30
		South Africa	9	Pre-trip	19.30	3.41
				Post-trip	21.10	1.86
	Socio-Cultural role of Science & Engineering	Brazil	9	Pre-trip	20.44	2.60
				Post-trip	21.78	2.28
		China	15	Pre-trip	20.00	3.01
				Post-trip	21.71	2.27
		South Africa	9	Pre-trip	17.40	2.32
				Post-trip	19.60	3.10

Table 5-4. Continued

Construct	Sub-construct	Country	Number of participants (n)	Assessment	Mean	Standard Deviation
Personal Outcomes		Brazil	9	Pre-trip	60.11	6.45
				Post-trip	63.67	7.48
		China	15	Pre-trip	60.79	7.60
				Post-trip	64.93	6.96
		South Africa	9	Pre-trip	55.80	7.98
				Post-trip	61.70	7.41
	Personal confidence	Brazil	9	Pre-trip	25.67	3.32
				Post-trip	26.11	2.93
		China	15	Pre-trip	26.57	4.26
				Post-trip	27.86	2.32
		South Africa	9	Pre-trip	23.60	3.66
				Post-trip	26.40	2.46
	Career Perceptions	Brazil	9	Pre-trip	25.00	3.20
				Post-trip	26.00	3.64
		China	15	Pre-trip	24.50	3.25
				Post-trip	26.57	3.76
		South Africa	9	Pre-trip	22.90	3.57
				Post-trip	24.90	3.07
	Global Awareness	Brazil	9	Pre-trip	9.44	1.33
				Post-trip	11.56	2.40
		China	15	Pre-trip	9.71	2.79
				Post-trip	10.50	2.93
		South Africa	9	Pre-trip	9.30	2.50
				Post-trip	10.40	2.99
Intercultural Development		Brazil	7	Pre-trip	84.75	15.64
				Post-trip	82.43	10.58
		China	15	Pre-trip	87.57	13.01
				Post-trip	92.29	14.49
		South Africa	9	Pre-trip	94.00	13.47
				Post-trip	86.20	14.34

Table 5-5. Paired t-test comparisons of pre and post-trip academic, personal and intercultural development scores for the study abroad participant group (alpha = 0.05)

Construct	Sub-construct	Number of participants (n)	Mean	Standard Deviation	t Value	Significance (p)
Academic Outcomes		33	3.45	6.72	2.954	.006
	Professional self-efficacy in science and engineering	33	0.55	2.33	1.343	.189
	Global Science Communication	33	0.88	2.58	1.954	.059
	Socio-Cultural role of Science & Engineering	33	1.76	2.48	4.079	.000
Personal Outcomes		33	4.52	6.55	3.958	.000
	Personal confidence	33	1.52	3.69	2.357	.025
	Career Perceptions	33	1.76	3.12	3.233	.003
	Global Awareness	33	1.24	1.79	3.996	.000
Intercultural Development		31	1.32	12.48	0.590	.559

Table 5-6. Independent t-tests of academic, personal and intercultural development scores for the study abroad participant group and comparison group (alpha = 0.05)

Construct	Sub-construct	Pre-trip & Comparison Group			Post-trip & Comparison Group		
		Degrees of Freedom	t-value	p-value	Degrees of Freedom	t-value	p-value
Academic Outcomes		63	0.629	0.532	63	2.775	.007
	Professional self-efficacy in science and engineering	63	1.007	0.318	63	2.341	.023
	Global Science Communication	63	0.588	0.559	63	2.032	.046
	Socio-Cultural Role of Science & Engineering	63	0.181	0.857	63	2.261	.027
Personal Outcomes		63	1.106	0.273	63	3.218	.002
	Personal confidence	63	0.431	0.668	63	2.560	.013
	Career Perceptions	63	2.518	0.015	63	4.112	.000
	Global Awareness	63	0.940	0.351	63	0.820	.415
Intercultural Development		60	0.446	0.657	60	0.228	.820

Table 5-7. Academic STEM learning and personal growth assessment instrument items by subscale

Academic STEM learning Outcomes Scales	
Professional self-efficacy in science and engineering	I believe that I can learn new knowledge from scientists/engineers in other countries
	I am aware of scientific/engineering research opportunities in other countries
	I value research conducted by scientists/engineers in other countries
	I believe that I can learn new skills from scientists/engineers in other countries
Global Science Communication	I think science/engineering are communicated using similar methods in other countries
	I believe that English is the most important language in the communication of science/engineering
	I am comfortable giving an academic presentation in an international setting
	I think it is important for scientists/engineers to speak more than one language
	I am comfortable discussing my research with people from other countries
Socio-Cultural Role of Science/ Engineering	It is important to understand the perspectives of people from other countries have regarding science/engineering
	I feel I can apply my research in global settings
	My discipline has an important role to play in solving global problems
	I have a clear understanding about the role of science and engineering in other countries
	I have a clear understanding about the role of science/engineering in other countries

Table 5-7. Continued

Personal Growth Outcomes Scales	
Career-related perceptions	I feel prepared to work on a multinational research project
	I am interested in working on a multinational project
	I am interested in working as a scientist/engineer in another country
	I feel confident about practicing my discipline in a different country
	I am competent to work as a scientist/engineer in other countries
	I aspire to work in another country
Personal Confidence	I am prepared to live in another country
	I am confident that I can take care of myself in a new situation
	I have the ability to make a difference in the world
	I am confident that I can deal efficiently with unexpected events
	I am confident in my abilities as a scientist/engineer
	I am a self-sufficient person
General Global Awareness	I am knowledgeable about international issues
	I am familiar with current events in China/South Africa/Brazil
	I am familiar with current events in other countries

CHAPTER 6
BEST PRACTICES FOR GRADUATE LEVEL STUDY ABROAD IN THE SCIENCE AND ENGINEERING DISCIPLINES

Traditionally, study abroad opportunities have focused on undergraduate students in the social sciences, business and humanities disciplines. The Institute for International Education (IIE, 2011) reports that, during the 2009-2010 academic year, 85.4% of U.S. college students who participated in a study abroad program were undergraduates. In addition, 22.3% were social sciences majors, 20.8% were business and management majors and 12.1% were humanities majors. Only 7.5% of study abroad students during the 2009-2010 academic year were physical or life science majors and 3.9% were engineering majors. Further, only 13.6 % were graduate students, with 8.1% masters' students, 2.5% graduate students in professional programs, such as law and medicine, and 0.6% doctoral students.

However, the IIE data also indicate that there has been a slow but steady increase in both the number of graduate students and the number of science and engineering majors participating in study abroad programs over the last decade. This reflects the fact that many institutions of higher education are currently trying to address these historic imbalances, offering more study abroad opportunities for graduate students and students in traditionally underrepresented disciplines such as science and engineering (Gearon, 2011). These increases in graduate student and science and engineering major participation, together with a growing recognition of the importance of an international experience for all students, provided the underlying rationale for this study.

Purpose of the Study and Research Question

There is clearly an increasing need to document the impact of international study abroad experiences on college students, particularly those at the graduate level and those majoring in science and engineering disciplines. The recent report from a National Science Foundation (NSF)-funded workshop entitled *International Experiences in STEM Graduate Education and Beyond: From Anecdotal to Empirical Evidence* highlighted this need. This workshop, which convened a group of experts on international education, identified priority areas for future research on graduate-level international experiences (Blumenfield & Nerad, 2012). These priorities include: (a) an examination of the impact of international collaboration on participants' abilities as scientists or engineers; (b) identification of the most effective study abroad program structures and characteristics, including length, timing and location of programs; and (c) the assessment and documentation of participant learning outcomes following completion of an international experience.

According to Nerad and Blumenfield (2012), while there is an increasing level of acceptance of, and participation in, study abroad programs by graduate students, little comprehensive evaluative research has been conducted to assess the efficacy of these programs and determine what types and models of international experience are most effective for this population of students. Furthermore, they acknowledge that the lack of evaluative data regarding the effectiveness of study abroad programs is especially problematic in the science and engineering fields, which have traditionally faced many obstacles regarding international opportunities for students. Kirk (2008) agrees with these concerns, stating that while "anecdotal evidence suggests students and researchers who participate in international collaborative activities" develop the "knowledge, skills and behaviors of a globally competent scientist or engineer," empirical evidence regarding these impacts and outcomes is still lacking (p. 3).

Previous research (Chapter 5) has suggested that a short-term study abroad experience can significantly impact academic STEM learning, personal growth and intercultural development outcomes for graduate students in the science and engineering disciplines. However, the existing literature does not clearly indicate which specific components of science and engineering-related study abroad program enhance and/or limit student gains in each of these three areas of targeted outcomes.

The purpose of this study was to determine which specific components of graduate-level study abroad programs designed specifically for science and engineering students enhance and/or limit participants' academic STEM learning, personal growth and intercultural development outcomes. This study sought to answer the following specific research question: What are the essential components of a successful graduate-level study abroad program in the science and engineering disciplines?

In this paper, I present the results of a qualitative study of three short-term study abroad programs designed for science and engineering graduate students. Using this rich set of contextual evidence, my goal is to provide college and university faculty and administrators in the science and engineering disciplines with specific recommendations to guide the development, implementation and evaluation of successful study abroad programs for graduate students.

Literature Review

Modern study abroad at U.S. institutions of higher education dates back to the early part of the twentieth century, and currently, more than 270,000 college students study abroad each year (Baskin, 1965; IIE, 2011). As the numbers of students and the numbers of programs have increased, various guidelines and best practices recommendations have evolved to guide the development, implementation and evaluation of these programs. Recently, several study abroad organizations have taken the next step with the development of formalized standards and benchmarks for study abroad practice. While these guidelines and standards primarily focus on undergraduate study abroad programs and do not focus specifically on science and engineering-related international experiences, a review of these documents provides a useful context for this research study.

General Standards for College-Level Study Abroad Programs

In recent years, two different organizations have developed standards and guidelines for college level study abroad programs: the Institute for International Education of Students Abroad (IES Abroad) and the Forum on Education Abroad (Forum). The IES Abroad is one of the oldest and largest study abroad providers, representing a consortium of 195 U.S. colleges and universities and enrolling almost 6,000 students annually. The Forum on Education Abroad is a non-profit organization recognized by the U.S. Department of Justice and the Federal Trade Commission as the standards development organization for the field of education abroad. The Forum currently has more than 550 members, including U.S. colleges and universities, overseas institutions, consortia, agencies and third-party provider organizations.

In 1999, IES Abroad assembled a group of leaders in both international and U.S. higher education to address the growing need for more effective program development and assessment in international education. This research and analysis effort produced the first version of the IES standards document called *ISE Abroad Model Assessment Practice (MAP) for Study Abroad Programs*, in 1999. These initial IES Abroad standards served as the foundation for subsequent development of the Forum's *Standards of Good Practice for Education Abroad* in 2007. Joan Gillespie, associate vice president for academic affairs and assessment at the Institute for International Education advocates applying both sets of standards, those of the Forum and those of IES MAP, to college level study abroad programs (Gillespie, 2009). She argues that, “both sets of standards are explicit in describing the framework for planning and operating a program abroad and the types of policies and procedures that are required to support the framework” (Gillespie, 2009, p. 16).

The IES Abroad Model Assessment Practice for Study Abroad Programs

These study abroad standards focus on three categories: (a) the student learning environment, including pre-departure preparation, coursework, internships and field study; (b) resources for student learning, including administrative and staff qualifications, student qualifications, facilities, housing, health, and safety and risk management; and (c) the field of assessment of student learning and development abroad. These categories are intended to serve as the framework for design, development and evaluation of all college level study abroad programs.

The Forum on Education Abroad Standards of Good Practice for Education Abroad

The fourth edition of the Forum’s *Standards of Good Practice for Education Abroad* (2011) lists nine specific standards to guide the design, implementation and assessment of college level study abroad programs. These standards include five institutional and four programmatic level program requirements. At the institutional level, the standards stipulate that:

1. an institution’s mission statement must include education abroad as a component
2. the institution must provide adequate financial and personnel resources for funding and staffing these programs

3. the institution should have a clearly defined academic framework to govern study abroad institution-wide

4. the institution must ensure that programs have adequate health, safety, security and risk management procedures in place

5. the institution must operate ethically and with integrity

Programmatic guidelines require each study abroad program to:

6. identify specific student learning objectives for study abroad

7. use fair and transparent participant selection procedures

8. use appropriate codes of conduct

9. provide adequate preparation for students through pre and post-trip advising and support activities (Forum on Education Abroad, 2011).

With the recent growth in short-term study abroad programs (eight weeks or less) and the increasing numbers of students participating in these short-term programs, the Forum recently developed the more specific *Standards for Short-Term Education Abroad Programs* (2009). These standards were formulated using the existing framework of the nine *Standards for Good Practice for Education Abroad* and extracting elements from them that apply most directly to short-term programs. There are still nine standards in this 2009 document, but more specific guidance is provided to ensure that, despite their brevity, these short-term programs still maximize student learning opportunities.

National Society for Experiential Education Standards for Practice

Finally, as I consider study abroad as an experiential learning activity, it is appropriate to include a review of the *National Society for Experiential Education's (NSEE) Standards for Practice* (1998). These eight standards mandate that experiential education programs, such as study abroad, ensure that:

1. all parties understand the intention, purpose, goals and objectives of the activity

2. all participants receive adequate preparation and planning to support their learning,
3. all programs are authentic and provide experiences in a real world context
4. all programs have opportunities for reflection to transform the experience into a learning experience
5. all programs provide adequate orientation and training
6. all programs include monitoring and continuous improvement
7. learning outcomes for all participants are assessed
8. all parties to the experience are included in the recognition of progress and accomplishments (NSEE, 1998).

Best Practices in College-Level Study Abroad

Despite the existence of standards and the large number of students participating in college level study abroad programs each year, only a limited number of articles and research studies have investigated and documented the actual use of best practices in the design and implementation of these programs (Sachau, Brasher & Fee, 2010). Yet, faculty members and program directors agree that when working with a short time frame for study abroad, preparation is tantamount to success, both for students and for the faculty members leading thee group (Donnelly-Smith, 2009). The following sections summarize key findings from existing articles and research studies regarding best practices for study abroad programs.

Program guidelines

The guidelines for study abroad programming can be divided into three distinct, but equally important, components: (a) program design and development; (b) program implementation; and (c) program evaluation.

Program design and development. A review of the available literature has revealed that there are four primary areas of consideration when designing and developing a study abroad program:

a. curriculum design and content
b. logistics (including timing, cost etc.)
c. personnel
d. participant preparation.

Curriculum Design and Content*.* A key recommendation in the design of study abroad program curricula is well-defined objectives and learning goals. For example, Vande Berg (2007) contends that the design of study abroad programs must begin with the identification of learning goals for student participants and should only proceed with the identification of courses, activities and strategies for the program once these learning goals are clearly defined. Similarly, Sachau, et al. (2010), state that the first step in organizing a trip is to develop educational goals, which they divide into three categories of increasing knowledge, shaping attitudes, and building confidence.

Beyond the initial identification of program goals and objectives, several researchers and organizations have advocated the integration of study abroad programs with the home curriculum (Association of Departments of Foreign Languages, 2008; Donnelly-Smith, 2003; Parkinson, 2007; Stanitski & Fuellhart, 2003; Wainwright, Ram, Teodorescu & Tottenham 2009). At the same time, study abroad should be more than a U.S.-style course that just happens to occur in another country. To this end, Henthorne, Miller and Hudson (2001) promote the inclusion of guest lecturers from host institution(s). They argue that local lecturers can provide a unique perspective, but warn that study abroad organizers must select guest speakers carefully and communicate with them prior to the program to ensure that their presentations adequately address intended curriculum requirements.

Koernig (2007) also emphasizes the importance of balancing the study abroad curriculum and suggests that the ideal time allocation is 40% academic activities (university and company visits), 40% structured cultural activities, and 20% free time for student free-choice learning and exploration. He advocates involving the students in the planning of cultural activities, requiring them to submit a short list of sites they would like to visit during pre-trip meetings. He also suggests leaving open time slots in the schedule to adjust the itinerary based on student feedback during actual implementation of the program. Koernig's recommendations are based on personal experience planning, organizing and conducting short-term study abroad programs and on data collected for program evaluations.

Conversely, Sachau et al., (2010) suggest that faculty leaders should pack the travel tour itinerary with scheduled activities and give students very little opportunity to modify the daily schedule once the trip starts. However, they do agree with Koenig that soliciting student input during the pre-trip planning phase and building in one or two days for unstructured, independent student exploration are important considerations. Sachau et al., (2010) based these recommendations on an examination of three different short-term study abroad programs: the summer semester abroad, the study tour, and the service-learning trip.

Logistics. The key recommendation in relation to program logistics is to begin planning early. Most researchers suggest starting planning at least one year prior to departure (Sachau et al., 2010; Tritz & Martin, 1997). The Association of Departments of Foreign Languages (ADFL) not only advocates early planning on behalf of faculty and/or administrations, but also emphasizes the importance of including all stakeholders, including participants, in the planning process (ADFL, 2008). Henthorne et al., (2001) and Stanitski and Fuellhart (2003) both stress the need to assess he level of student interest in international study as a critical preliminary planning activity.

Koenig (2007) advises that major logistical considerations for planning a study abroad program includes location, cost, travel arrangements, program activities, and program duration. Locations or destinations of study abroad programs have received attention in several best practices publications. For example, Sachau, et al., (2010) suggest that the trip leader should establish a home base location for the program, securing accommodations and arranging other logistics well in advance. They argue that a program will be more successful if the location is selected to fit the both the course theme and the program leader's area of expertise. Considerations of the cost of a study abroad program are also crucial to success. The size of the study abroad group, rates for transportation and accommodations, and faculty and staff salaries must all be considered when developing the budget for any program (Koenig, 2007; Sachau et al., 2010).

Personnel. "Developing, planning, and executing a study abroad tour is a difficult and time-consuming venture for faculty" (Koenig, 2007, p. 210). Thus, when developing a study abroad program, the selection of a faculty leader who is passionate and knowledgeable about the type of program is extremely important (AFDL, 2008). Henthorne et al., (2001) claim that "the individual chosen to fulfill this role should possess a genuine enthusiasm for and belief in this type of experiential learning" (p. 56).

Additionally, Donnelly-Smith (2009) promotes the selection of faculty leaders who are inter-culturally competent, able to adapt to working in different locations and cultures, and comfortable and competent with experiential teaching. Lutterman-Aguilar and Gingerich (2002) say that faculty and staff who are trained in experiential education and intercultural education must facilitate programs. In terms of faculty preparation, Henthorne, et al., (2001) emphasize the importance of an initial planning visit to the study abroad site to provide faculty leaders with a basic working knowledge of the study area and allow them to make contact with local hosts and lecturers and begin to formulate the itinerary and arrange specific site visits.

Participant preparation. According to McGowan (2007), “preparation aids students with cross-cultural adjustments and makes experiencing another culture more enjoyable resulting in a more rewarding study abroad program” (p. 65). Tritz and Martin (1997) and Roberts and Jones (2009) both emphasize the importance of identifying students’ preconceptions and pre-existing knowledge as part of their study abroad program preparation. They argue that determining students’ previous knowledge allows faculty trip leaders to directly address misconceptions and help participants build a solid base for the new knowledge they will gain through their experience. Participant preparation should also include traveler tips and address practical concerns in order to reduce student anxiety about issues ranging from appropriate clothing to food options. According to McGowan (2007), students tend to worry about their study abroad experience and trip leaders should “make sure students have sufficient details about the experience and its potential application to reduce anxiety and stress while at the same time increasing excitement and focus” (Roberts & Jones, 2009, p. 406).

With regard to facilitating cross-cultural adjustments, some studies have demonstrated the importance of pre-departure orientations with a specific cultural focus, while others have contradicted those findings. For example, Fuller (2007) used the Intercultural Development Inventory (IDI) to conduct a pre-trip and post-trip assessment of the impact of study abroad experiences of variable lengths on a sample of 18 graduate-level theology students. He found that the study abroad experiences had no significant impacts on students' intercultural communication skills (Fuller, 2007). Fuller (2007) suggests that a lack of appropriate preparation was partially responsible for these findings and argues for "substantial cross-cultural immersion" and "pre-immersion orientation" to facilitate students' intercultural engagement during study abroad experiences (p. 328).

The Georgetown Consortium Study (Vande Berg, Connor-Linton & Paige, 2009) determined that pre-departure orientations with a strong cultural component were significantly correlated with students' levels of satisfaction and intercultural learning. Vande Berg et al. (2009) therefore recommend that intercultural learning be included in pre-departure orientations. However, these conclusions contradict Shaheen's (2004) research on the impact of pre-departure preparation on student intercultural development during study abroad programs. She investigated students' intercultural development using the IDI in a pre- and post-trip format and found that a pre-departure orientation did not significantly increase students' intercultural development. She concluded that two different conditions increased the likelihood that students would have a significant increase in intercultural sensitivity. Those were: 1) having parents who have had overseas experiences and 2) being non-minority students (racial and ethnic minorities as well as international students).

Another important component of pre-departure preparation is establishing contact between study abroad participants and host institutions' students using email, social media and other forms of electronic communication (Sachau et al., 2010). They argue that this pre-trip communication helps students begin building relationships and sharing information prior to the program and can also be used to maintain relationships after the trip.

The detailed pre-departure orientation activities outlined above usually cannot be achieved in a single session, and thus several researchers advocate a series of pre-departure briefings beginning several months before the trip (Sachau et al., 2010; Stanitski & Fuellhart, 2003). Koernig (2007) also recommends that pre-trip meetings/sessions be supplemented with frequent communication via email, phone and in person to ensure that students are comfortable with all trip plans and logistics and to maximize rapport among participants before departure.

Program implementation. There are many different models for implementation of study abroad programs, including U.S. faculty-led programs, enrollment in host institution courses, cohort programs, and home-stay programs. (Engle & Engle, 2003; Vande Berg, 2010). Despite this variety in format, some best practices recommendations are applicable to the implementation of all study abroad programs.

Intercultural learning. Donnelly-Smith (2009) recommends extensive integration of program participants within the local community, the inclusion of lecturers from the host country, and opportunities for ongoing reflection for both individual students and the group as a whole. Koernig (2007) recommends that integration into the local community is best facilitated early in the program and suggests that the first day of a study abroad experience should include a walking tour of the local area and an opportunity to use local transportation, if available. He contends that these activities help students acclimate to their new environment and gain confidence getting around on their own. Henthorne, et al. (2001) promote the use of “student research projects” (p. 62) as a highly effective method of initiating interaction between students and the local population and allowing them the opportunity to gain further insight into the culture they are visiting. However, they caution that these research projects should be useful and meaningful for the student and should be aligned with the overall goals of the program.

During the actual study abroad experience, McGowan (2007) notes that students value their interactions with students from the host university and encouraged students to make friends with host country students and spend time with them. Likewise, Koernig (2007) advocates organizing a student exchange with a class from a local university to provide study abroad participants with an opportunity to interact with their peers from the host country and learn about the culture of the country from native residents.

Sachau, et al. (2010) suggested several ways to enhance students’ intercultural learning on a study abroad program, including homestays, visits to small communities, internships, and structured interactions with host country students. These researchers also suggested group activities to help introduce different cultural aspects of the host country. For example, a group dinner early in the program can help alleviate concerns about ordering and trying new and different foods. Koernig (2007) also suggested a group dinner early in the program as an introductory activity to facilitate group bonding and introduce hosts or discuss the upcoming itinerary. Maximizing contact with the host culture and mentoring to “guide, inform, and stimulate the experiential learning process” is also advocated by Engel and Engle (2004, p. 232) as the most effective means of developing a student’s intercultural competence.

Academic STEM learning*.* In relation to the academic component of the program, Stanitski et al. (2003) noted that the academic nature of the program should be emphasized to students and that all program activities (including cultural excursions, and social events) should be closely tied to the study abroad curriculum. Similarly, Koernig (2007) suggests arranging visits to host country industries and businesses to help students better understand the differences between practices in the host country compared to the U.S. However, he acknowledges that careful planning of these visits is necessary to avoid long, boring presentations. He notes that feedback from previous study abroad program evaluations indicates that students prefer opportunities to walk around the facilities and hear from local presenters as they tour. Sachau et al. (2010) recommend visiting only one academic-related site and one cultural site in a given day and suggest that more than this results in information overload for students. Sachau et al. (2010) also suggest that organizers avoid the traditional lecture in favor of site visits and note the need to include free time for independent travel/exploration. “Independent student travel can be an important part of the student growth process” (Sachau et al., 2010, p. 652).

Donnelly-Smith (2009) and Stanitski et al. (2003) emphasize the importance of post-trip meetings, debriefing sessions and re-entry support for returning students and suggest a follow-up course or capstone experience to maximize student learning associated with short-term programs. Finally, several researchers emphasize the importance of reflection as a necessary component of an international experience (Koenig, 2007; Roberts & Jones 2009). Sachau et al. (2010) recommend using reflective journaling to encourage students to think about their learning experiences, as most, if not all of these occur outside the classroom setting.

Program evaluation. Program evaluation should be a key component of any study abroad program and should focus on both program implementation and program impact. In addition, due to the experiential nature of study abroad experiences, Lutterman-Aguilar and Gingerich (2002), note that this pedagogical approach requires both ongoing formative, as well as post-trip summative, evaluation to ensure that learners are accomplishing intended objectives and to allow for continuous improvement of study abroad program quality.

Areas of study abroad program implementation commonly evaluated include aspects of program logistics, faculty leader quality, and pre and post-trip support activities (Stanitski et al., 2003). To evaluate student learning outcomes, IES Abroad advocates the use of both qualitative and quantitative assessments, combining measures and tests designed by faculty leading the program with other standardized measures of content knowledge and alternative performance-based assessment measures, such as student assignments and presentations (Gillespie, 2009). In fact, the *IES MAP* discussed previously, provides a set of detailed criteria for evaluating study abroad programs (Gillespie, Braskamp & Braskamp, 1999). Meanwhile, based on their extensive experience leading different types of study abroad programs, Sachau et al.,

(2010) recommend that assessment of learning objectives for a short-term study abroad or study tour is best accomplished through student journal assignments.

Best Practices for Science and Engineering Study Abroad Programs

With few existing study abroad programs in science and engineering, and with limited numbers of students from these disciplines participating in an international experience, it is not surprising that the literature contains few articles addressing best practices for these specific types of programs. However, Parkinson (2007) has conducted a survey of engineering study abroad programs to identify: (a) what types of programs are offered; (b) what are the challenges associated with these programs; and (c) what constitutes a set of best practices regarding these programs. He reviewed 25 different engineering study abroad programs and conducted interviews with program directors.

Based on these investigations, Parkinson (2007) notes some of the challenges associated with study abroad in engineering and provides some guidelines for conducting programs in this discipline. He notes that engineering programs are already demanding and long and students will not participate if the study abroad experience conflicts with the existing curriculum or delay their graduation. To overcome these obstacles, he suggests that departments of engineering offer a series of integrated study abroad programs with a variety of formats that allow students to fit study abroad in their existing program of study. He also notes that there are often difficulties with transfer credits in engineering, especially in relation to programs that are hosted by foreign institutions not accredited by the Accreditation Board for Engineering and Technology (ABET). Parkinson suggests that colleges and universities be more proactive to ensure that credits will transfer seamlessly.

According to Parkinson (2007), engineering colleges also struggle to engage faculty in study abroad as it is time consuming and does not often align with their research interests. He contends that colleges and universities must commit to the long-term future of such programs by rewarding faculty who are willing to participate in study abroad program development and implementation. Finally, Parkinson (2007) notes that engineering students often have little travel experience or foreign language skills and he recommends specific pre-trip preparation in four areas:

a. cultural issues, such as cultural diversity and communication across cultures
b. country issues, such as a country or region's history, economy and politics
c. study abroad issues, such as handling money, safety and health
d. globalization issues, such as trade policy, outsourcing, and intellectual property.

Wainwright, Ram, Teodorescu and Tottenham (2009) discuss study abroad in the sciences, noting that, as with engineering programs, there are a variety of formats for these activities. Although they do not directly advocate a list of best practices, they do review some of the obstacles for study abroad in the science disciplines and offer suggestions for overcoming these barriers. In particular, they note that the crowded curriculum can be a significant impediment for science students wishing to study abroad. Wainwright et al. (2009) recommend the use of summer and short-term programs that do not conflict with the existing curriculum and course schedule.

Alternatively, they acknowledge that significant efforts must be made to integrate longer, semester programs with the home campus curriculum. They also note the importance of collaborating with host institutions that have strong reputations in the science disciplines to ensure that students are exposed to high quality instruction and research opportunities. Another obstacle to study abroad in the sciences is the lack of science faculty support for these programs (Wainwright et al., 2009). This can be addressed with more meetings, seminars and information sessions to educate science faculty about the benefits of study abroad programs for students and with targeted strategies to engage students with discipline-specific opportunities.

This summary of the current literature demonstrates that research regarding standards and best practices for college level study abroad is primarily applicable to undergraduate study abroad programs. In addition, the majority of best practices documents and articles currently available in the literature are not based on systematic empirical research, but rather reflect recommendations based on anecdotal evidence or personal experiences/observations. Currently, little research evidence exists regarding the best methods for design, development, implementation and evaluation of graduate-level science and engineering-related study abroad programs. Using available literature regarding best practices and general guidelines for study abroad as a foundation, the current study was completed in an attempt to provide more useful empirical evidence regarding most effective strategies for the design, implementation, and evaluation of graduate level study abroad programs in the science and engineering disciplines.

Study Design

This study was conducted at the University of Florida (UF), in conjunction with the National Science Foundation (NSF)-funded South East Alliance for Graduate Education and the Professoriate (SEAGEP). During 2011, SEAGEP implemented a series of new international initiatives for their graduate students to address the need for global experience at the graduate level. These comprehensive international experiences were designed to provide students with opportunities to develop global competencies that would give them a competitive edge in their preparation for, and pursuit of academic careers. Three specific SEAGAP “Science and Engineering in the Global Context” study abroad programs were investigated in this study: UF in China (May, 2011); UF in South Africa (June, 2011); and UF in Brazil (July, 2011). Specific details regarding the structure and content of each of these international experiences is provided in Chapter 5 of this dissertation and in Appendix G.

Study Sample

Thirty-five SEAGEP affiliated science and engineering doctoral students enrolled in the study abroad programs in 2011, with 15 visiting China and 10 visiting South Africa and Brazil respectively. All of these the students were pursuing doctoral degrees in science or engineering and all met NSF criteria for classification as underrepresented minorities in these disciplines (Appendix H).

Initially, all students agreed to participate in the research study and gave permission for us to analyze their course assignments and to observe them during the program implementation. However, three students, two on the Brazil program and one on the South Africa program, did not submit their reflective writing assignments and thus the final study sample consisted of 32 students with complete reflection data. The final study group was comprised of 14 male and 18 female students, with 18 from engineering, and 14 from the life and physical science disciplines. There were 17 Black/African/African American students, 14 Hispanic/Latino/Spanish students, and 1 American Indian or Alaskan Native.

Data Collection

As mentioned in Chapter 2, the over-arching theoretical perspective used in this study was experiential-constructivism, defined as a theory of learning where humans construct meaning from current knowledge structures and experiences. According to Crotty (2003), constructivism “is the view that all knowledge, and therefore all meaningful reality as such, is contingent upon human practices being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context" (p. 42). Constructivist inquiry starts with the experience and asks how participants construct meaning of the event. However, previous studies have indicated that there is often a lack of connection between stated goals for study abroad programs and the actual educational experience as perceived by program participants (Skelly, 2009). Thus, I decided it would be important to observe and document the actual implementation of study abroad programs to determine which components of the programs enhanced and/or limited the students' ability to make meaning out of these experiences.

The program observation component of this study provided an opportunity to examine three alternate deliveries of the same science and engineering study abroad program syllabus by several different faculty members in different settings (China, South Africa, and Brazil). Program observations were completed during four different types of activities in each study abroad course: the pre-departure orientation, a research facility visit, a commercial facility visit, and a cultural activity. Each observation session lasted between one and two hours and, on each occasion, detailed field notes were recorded. As much as possible, I adopted an observational stance during these sessions and refrained from interacting with students, faculty or guest speakers during these periods (See Appendix E Observation Protocol).

As an additional qualitative data source, I collected students' post-trip reflective writing assignments after the conclusion of each program. These writing assignments were a required component of the study abroad syllabus for each program and specifically focused on student reflections regarding how their experiences during the program contributed to their personal learning and growth.

Data Analysis

Students' post-trip reflective writing assignments and field notes of program observations served as the primary data sources for examining how actual implementation of the study abroad programs enhanced and/or limited students' academic STEM learning, personal growth and intercultural development outcomes. These data sources were analyzed using the qualitative general content analysis approach. According to Bogdan and Biklen (1992), the "rough materials researchers collect from the world they are studying…are the particulars that form the basis of analysis" (p. 106). As part of the general content analysis process, a priori coding was used to condense, summarize, and organize the raw text data and establish links between the research study objectives and findings emerging from the raw data.

I initially familiarized myself with the material by reading the field notes of each set of program observations and each student's reflective writing assignment twice, making preliminary notes during this process. Text segments containing meaning units were identified and coded using a pre-existing, or a priori, set of codes. These pre-determined codes were derived from previous research regarding factors influencing the effectiveness of study abroad programs (Chapters 4 and 5) and also reflected specific research and study abroad course objectives unique to this particular study. Specific outcome-related constructs examined in this research study included:

- Academic STEM learning
    - Professional self-efficacy in science and engineering
    - Global science communication
    - Socio-cultural role of science/engineering

- Personal Growth
    - Career-related perceptions
    - General global awareness
- Intercultural Development
    - Knowledge and understanding of other cultures.

Content analyses specifically focused on determining which specific study abroad program components and experiences facilitated or hindered student gains in each of the outcomes of interest. Results of these analyses were then used to generate a list of recommended best practices for the design and implementation of science and engineering-related study abroad programs.

Findings

The findings for academic STEM learning, personal growth, and intercultural development are each presented separately and include both the findings from program observations and students' reflective writing assignments. The academic STEM learning section contains findings for the three sub-constructs of professional self-efficacy in science and engineering, global science communication and the socio-cultural role of science and communication. Findings for the two personal growth sub-constructs, career-related perceptions and general global awareness, are presented next. Finally, I present findings for intercultural development, focused on students' knowledge and understanding of other cultures.

In each section, I first make an "assertion" based on my analysis of the data from the program observations and the students' reflective writing assignments. I then provide sample evidence from both field notes and reflective writing assignments to support these assertions and my conclusions with respect to each construct and sub-construct.

Academic STEM learning Outcomes

Three sub-constructs of academic STEM learning were specifically examined in this study: 1. Professional self-efficacy in science and engineering, 2. Perceptions of science communication in a global context, and 3. Perceptions regarding the sociocultural role of science and engineering in other countries. The professional self-efficacy sub-construct focuses on students' perceptions of the approaches to science and engineering used in other countries and the value that they attach to scientific knowledge generated outside the United States. In the next sections, I present results of the analysis of the observations and students' reflective writing for each of these three academic STEM learning sub-constructs.

Professional self-efficacy in science and engineering

Two of the stated objectives of the graduate-level study abroad programs examined in this study included helping students develop an understanding of the differences in science and engineering education and research cultures between the U.S. and the host country and helping students network with students, faculty, researchers and government agencies abroad. To accomplish these objectives, the itinerary of each study abroad program included multiple visits to institutions of higher education, research facilities and government agencies (Appendix G). It is therefore not surprising that all of the students completing all three programs made concrete connections to the concept of professional self-efficacy in science and engineering.

The students' comments in their reflective assignments and the field notes for the program observations on professional self-efficacy in science and engineering were further analyzed and three themes emerged from the data: itinerary and site visits; level of research and technology in the host country and networking and opportunities for future research collaboration. The results for each of these themes are presented in the following sections.

Itinerary and site visits. Overall, the majority of students (25 out of 32) indicated that they enjoyed the opportunity to visit many different institutions, organizations and companies during their study abroad programs and discussed how these meetings and visits enhanced their knowledge and understanding of scientific research and development activities in their host countries. For example, in South Africa, where the visits included several universities and government research facilities, students' reflective writing assignments focused on the diversity of on-going projects and indicated that they were impressed by the openness of the researchers:

SA 2: I am now informed about the type of research conducted in RSA (Republic of South Africa) and the capacity to conduct research at several institutions.

SA 6: I did get to meet individuals at the Council on Scientific and Industrial Research (CSIR), the University of Pretoria, the Limpopo Department of Agriculture, and Tshwane University of Technology who are involved in applied scientific research…..the scholars involved in research were extremely eager to share their work.

Similarly five of the eight students who went to Brazil had positive perceptions of the program itinerary and the visits to the various research and production facilities. In particular, one student commented, "although I read the itinerary several times before we departed, it wasn't until the end of our study in Brazil that I realized how inclusive our investigation of bioethanol had been" (*B 7*). Other Brazil participants also noted the value of the various site visits in their reflective writing assignments:

B 1: A good aspect of the places we visited was the opportunity to learn about the different points of view.

B 5: I found putting on a hard hat and moving around the facility from the sugar cane grinding area to the control room to be a very memorable experience.

Twelve of the 15 students on the China program also remarked on the opportunities to learn about science and engineering in different locations. For example, the visits to two major cities elicited reflective writing comments such as: “the leading cities of Shanghai and Beijing offer excellent opportunities for business people and students” (*C 3*) and “in both Beijing and Shanghai, I have witnessed some of the most brilliant engineering I have ever seen” (*C 8*). Overall the research opportunities in China impressed the students, as illustrated by the following reflective writing assignment comment:

C 1: Before this experience, I would not have thought China would have had so large a potential in research.

One challenging aspect of all three study abroad programs appeared to be the scheduling of visits, with one student commenting that, “we were so focused on making meetings and sticking to a schedule that we did not have time to actually converse with the presenters and learn more about what they had presented” (*SA 1*). Program observations also suggested a lack of time for discussion and informal interaction during all of the programs, with students frequently complaining about the pace of the program. In fact, during the Brazil site visits, I observed that some students completely tuned out from the presentation and one even fell asleep. This program itinerary was particularly busy, with multiple daily meetings, and I observed that students’ interest waned most frequently during the last meeting of the day. It is important to note that a staff member, rather than a faculty member, had the primary responsibility of developing the program itineraries and negotiating the program logistics. For the China and South Africa programs, the staff member worked closely with UF faculty leaders who had extensive experience in the host countries and had previously led student groups to these destinations. In contrast, the Brazil trip was organized by a commercial study abroad provider, with some limited input by a UF faculty trip leader who had previously lived and worked in Brazil, but who did not have study abroad experience.

Level of research and technology. In their reflective assignments, the majority of students (14 of 24) who visited South Africa and China mentioned how impressed they were with the on-going research and associated facilities that they encountered during their visits. Several even mentioned that they were surprised to see such high quality equipment and extensive resources in these countries. In South Africa, the visits to two governmental agencies, the Innovation HUB and the CSIR in Pretoria particularly impressed three students:

SA 3: The other experience that was a surprise was the level of scientific research that is being conducted in South Africa.

SA 6: I was extremely impressed by the work, facilities, and culture of the Council for Scientific and Industrial Research.

SA 9: In terms of the technology in South Africa, it exceeded my expectations. After visiting the Innovation HUB, the CSIR, the University of Pretoria and Tshwane University of Technology (TUT), I was impressed with the technology used.

In China, the itinerary enabled students to visit more laboratories and research facilities at several of the nation’s leading universities. The students’ comments reflected their level of impression at these institutions:

C 6: My second most memorable event was seeing all the instrumentation and resources available at the universities. Being in the energy efficient College of Engineering building of Tsinghau University opened my eyes to how advanced the universities are and the great strides China are making to be a more green country.

C 8: I was impressed by the world-class facilities in art design and agricultural and environmental engineering.

C 11: I observed some of the Ph.D. level labs and research at the Beijing University of Science and Technology. We were able to visit one of the National Key labs in Materials Science and Engineering. Basically, we were all pretty blown away by some of the materials they were working on and some of the great facilities they were using.

C 12: The universities in China are nothing like what I expected they would be; they are massive, filled to capacity with students and contain some very impressive facilities.

These comments were supported by program observations, during which I noted that students exhibited great interest in the facilities and equipment at each site visited in both China and South Africa. They often made comments to each other and to the U.S. faculty about how the facilities were much more advanced than they expected. As we left the Beijing University of Science and Technology, one student commented aloud that he was, “very impressed by the equipment that we saw in the departments this morning.” He noted that, “they were better equipped than our labs at U.F. and some of the instruments are very expensive.”

Interestingly, during the program in Brazil all students discussed the fact that the bioethanol industry technology was much more advanced than in the U.S. However, in their reflective writing assignments, only one student in this group commented on the high level of research, saying, “I didn’t quite know what to expect about the different kinds of research going on there but I was blown away by the depth, diversity, and funding available for its numerous programs and fields of study” (*B 8*). This lack of reflective focus on the level of scientific research and technology in Brazil may have been influenced by negative impressions students developed as a result of visits to several universities whose labs and other scientific research facilities were poorly maintained and contained out-of-date and aging scientific equipment.

Networking and opportunities for future research collaboration. An explicit objective of these study abroad programs was facilitation of opportunities for students to network with students, faculty, researchers and government agencies abroad. Results of my analyses indicate that networking opportunities varied considerably between the three study abroad programs. While networking opportunities were not a major outcome identified by students completing the Brazil trip, the majority of students on the programs to China (8 of 15) and South Africa (5 of 9) mentioned how much they valued opportunities they had to network with counterparts and make connections for future collaborations. In their reflective writing assignments nine out of 24 students even mentioned their desire to return to the host country in an academic or professional capacity:

SA 1: We had excellent opportunities to make connections. I do have intentions to revisit South Africa and make stronger professional connections.

SA 6: During this trip, there were a plethora of opportunities to establish both professional and personal networks.

C 5: I am especially thankful for the opportunities presented to us to build connections with some of the Chinese students. If an opportunity to study abroad in China for a whole summer presented itself I would like to take advantage of it.

C 6: I have also managed to make friends and establish contacts throughout the process

C 8: Interacting with students from the Tsinghau University, Beijing University, and China Agricultural University was by far the best part of the trip in my opinion

Following the university visits in Beijing, program participants also engaged the local host faculty member in a long conversation about opportunities to return to China to study or conduct research in a university exchange capacity. One student commented, “I feel that the experiences of this trip will help my international professional collaborations as I advance through coastal engineering….I wish to return in a summer exchange student program” (*C 15*).

However, five students (three on the South Africa program and two on the China program) made negative comments in relation to the networking opportunities they experienced during these programs. The first related to a significant deviation in the itinerary in South Africa, where the last minute cancellation of a presentation at Kruger National Park was noted by two participants in their reflective writing assignments:

SA 4: The inability of Kruger scientists to meet us hampered the ecological aspect of the course.

SA 8: Since the main topic of this trip was ecology/conservation I was expecting to interact more with professors, students and researchers of these areas, or related ones. Unfortunately, our interaction was mainly with researchers from agricultural, social sciences and other areas like engineering, which is not a bad thing but just different from the expectations generated under the announced topics of ecology/conservation.

On the China program, one student was disappointed not to meet researchers in her own discipline and commented, “Unfortunately, I did not meet any professors who were doing any research in my field” (*C 2*).

During the Brazil program, I observed that there were significantly fewer opportunities for participants to meet with students and faculty at the host institutions and the lack of comments about networking in their reflective writing assignments reflected this observation. Conversely, members of this study abroad group seemed to bond very well with each other and the participants appreciated the disciplinary diversity of their group and the opportunities they had to learn from each other. One student commented, “The people on this trip really enabled me to appreciate different perspectives from different disciplines…..I believe our focus on learning about alternative fuels opened our minds to learning from other unique perspectives" (*B 3*).

The timing of each study abroad program impacted the opportunities students had to interact with local faculty, researchers and student counterparts during the university visits. I observed that students made the most connections and developed the greatest networking opportunities during the visit to China when the universities were in session and participants were able to observe and discuss on-going research projects with host country faculty and students. Conversely the program to Brazil occurred during the semester break and study abroad participants had very limited opportunities to visit laboratories or meet with host country faculty and students. The program to South Africa actually occurred during the examination period for most universities, but there were some opportunities to meet directly with host country faculty and students. For example, the South Africa study abroad participants toured several laboratories and attended research presentations at Tswhane University of Technology (TUT) in Pretoria. In addition, during a field trip to a research site, they were able to informally interact with host country graduate students.

Global science communication

The second major sub-construct related to the academic STEM learning outcome was students' perceptions of science communication in a global context. To engage students in global science communication, the faculty members who designed the study abroad program included an objective in the syllabus requiring students to deliver an oral research presentation to a host audience. Regrettably, due to scheduling issues with the local universities this component was eliminated from both the South Africa and Brazil programs. This change in itinerary was unfortunate, as one student on the China program reflected, "a valuable part of this trip was presenting in front of more than 100 students and faculty…..it was an experience that I would like to repeat" (*C 3*).

On the Brazil and South Africa programs, faculty members leading these trips supplemented group discussions of research topics, but these did not involve audience members from the host country. However, even these group discussions seemed to have positive impacts on students' perceptions of global science communication:

B 3: I especially enjoyed the group discussions in which I was able to work with a microbiologist and a bird zoologist to discuss Brazil's education system.

B 4: We had several group discussions among ourselves both during and after presentations, and even in our time off over dinner and drinks. That was cool.

SA 9: A set of criteria I would choose to best describe my learning process is the group discussions. They helped me get a better understanding of the readings. It also helped see other's point of view of the same experiences shared and see where they're coming from.

Overall, students on all three trips made both positive and negative comments about their attempts to communicate about scientific topics while in each country. On a positive note, two students discussed how science and engineering offer the opportunity to communicate across cultures:

SA 9: I met a master student at TUT that was working in the same area as me (groundwater treatment). Despite our cultural differences, we were able to communicate through science, which became one of the memorable experiences in South Africa.

B 6: The most memorable or valuable aspect I gained from the trip was how science and innovation is a universal language.

However, half of the students on the Brazil program indicated that communication with host scientists and engineers was one of the most difficult and frustrating aspects of the program. For example, a student from the Brazil program commented that "communication was more difficult than I anticipated" (*B 8*) and another said, "the biggest challenge during the trip was my inability to speak Portuguese” (*B 7*). He continued, “I found my inability to follow conversations or communicate effectively to be very frustrating” (*B 7*). Similarly, in China, students struggled with the language barrier, with one commenting, “regarding the language, it was one of the most difficult barriers” (*C 13*). Encouragingly, three students indicated that their study abroad experience inspired them to learn another language or reach out to students in the U.S. who do not speak English as a first language. One student was overheard saying, “I have to get my languages going” and another commented, “it would be advantageous to learn more Portuguese” (*B 3*). Finally, another student commented, “now, knowing the language barriers, I will try to engage more (with) the Chinese students at my laboratory” (*C 13*).

During the programs to Brazil and China, translators were present for all scheduled activities. On both programs, a host country faculty member with technical expertise in science and/or engineering was also available to provide translations during the academic presentations. This was particularly important, as some of the general translators did not have the ability to translate technical scientific terminology. However, on some occasions, when the groups on the China and Brazil programs split to tour laboratories, or during informal interactions with local students, language differences did appear to create a significant communication barrier. This was particularly evident in China, although many of the local students and faculty did speak some English. On the Brazil program, I observed that Spanish-speaking participants were able to communicate on some level with their Portuguese-speaking counterparts. In all cases, even on the South Africa program where the language barrier was not a major impediment, I noted that students were much more reticent to speak to their hosts at the beginning of the program. However, as each program progressed, students were much more willing to engage the hosts with questions and comments on the science and engineering research projects they observed.

Socio-cultural role of science and engineering

The third major sub-construct related to the academic STEM learning outcome was students' perceptions of the socio-cultural role of science and engineering in a global context. Some interesting differences emerged in the reflective writing samples of students visiting each of the three different countries. The majority of students (7 of 9) visiting South Africa made comments about the sense of responsibility they felt to conduct science and engineering research that benefits the general community. For example, one student commented on how "the research they conducted there was very applicable to their own unique problems and they emphasized accessing the need of the people to realize what is and isn't relevant research" (*SA 5*). Another said that, "the best part of our actual interactions was that we were able to learn a lot of what applied science is taking place in South Africa" (*SA 8*). One student rhetorically asked himself "professionally, do my publications ten years down the road indicate that I am interested in developing solutions for poor around the world?" (*SA 7*).

The program in Brazil, which was focused on bioethanol production, prompted reflective comments regarding the environmental aspects of science and engineering. For example, one student noted, "we learned about their perseverance to create a green energy, capable of transforming their economy and at the same time serving as an example to the world" (*B 5*). However, overall, students on the Brazil program made relatively few comments about the socio-cultural role of science and engineering (only three out of seven students).

Given the Communist government in China, it was not surprising that students paid attention to the influence of politics on the social and cultural role of science and engineering. Students appeared to be most aware of this during the university visits, and one commented, “I was expecting the Chinese to be indoctrinated by the Communist Party (CP), but was not expecting it in the University level” (*C 4*). Similarly, another student observed, “many Chinese research projects are applied and aimed directly at the development of the country”(*C 11*). He surmised that their research motivation correlated with “patriotic pride.”

Personal Growth Outcomes

The two specific types of personal growth outcomes examined in this study focused on career-related perceptions and general global awareness. The sub-construct of career-related perceptions focused on the impact of the study abroad experience on participants’ career aspirations and their levels of interest in globally-focused careers.

Career-related perceptions

Thirty percent of students on the three study abroad programs commented on the impact of the experience on their interest in working outside the United States in their reflective writing assignments. These comments indicate that their interest in work opportunities in other countries increased as a result of their participation in the programs. For example, three students mentioned their increased interest in a post-doctoral opportunity in the country they visited:

SA 2: I can now add RSA to my list of places I would like to conduct a postdoc.

SA 6: So with a collaborative research environment and the opportunity to have an impact on the education community, CSIR is on my radar for possible post-doctorate employment opportunities.

B 6: I am considering doing a post-doc abroad rather than in the United States.

Observations of students asking host institution representatives about the opportunities to return as an international post-doctoral student supported these findings. During site visits to the CSIR in South Africa, FAPESP (the scientific research agency in Sao Paulo) and the Beijing University of Science and Technology, students heard detailed information about how to access post-doctoral opportunities.

Meanwhile, in their reflective writing, eight students indicated their intentions to explore future research opportunities, suggesting a longer-term impact of the study abroad experience on their career perceptions. One student on the China program commented:

C 9: I plan to talk to Dr. Zhang this evening about possible opportunities of returning China to do research. I feel that opportunities such as these will make me a more well-rounded and cultural individual.

Likewise, three students on the Brazil program and two on the South Africa program noted impacts on their research interests, with a South African participant saying, “I now have a better sense of what type of research I want to pursue in the future” (*SA 2*) and a Brazilian participant commenting, “This experience opened the door to the infinite international possibilities to develop my career” (*B 5*).

Finally, however, it was noted that the majority of students did not comment on the impact of their participation in the programs on their career-related perceptions. This may have been due to the fact that the reflective writing assignments were completed immediately after the end of each program, leaving students with little time to contemplate these impacts. It could also reflect the fact that student participants were at different stages in their degree programs, with some approaching graduation and actively pursuing post-graduate opportunities and others in their first year of doctoral study.

General global awareness

The second sub-construct of personal growth outcomes was general global awareness. In their reflective writing assignments, students only made brief mention of the impact of the study abroad experience on their levels of general global awareness. Two indicated that the program reinforced previously held perceptions about the countries they visited. For example, one student commented, “I did know that South Africa was a developed nation” (*SA 7*) and another said, “I was not surprised by the rate of development in Beijing” (*C 8*). However, others commented on how the programs contradicted their pre-trip perceptions of the country they visited. For instance, one student commented “The Republic of South Africa (RSA) was and was not what I expected…there are many more middle class households than I expected, and a substantial amount of infrastructure exists” (*SA 2*).

Three students suggested that the study abroad experience made them realize the need for more global awareness among American scientists and engineers. One was overheard to say, “I think it’s really important for Americans, especially engineers, to be more globally aware” (C7) and another wrote:

C 6: Being in China for almost two weeks has raised my awareness of the fact that life is progressing beyond the borders of the United States of America.

One student who attended the program China commented, “I wanted something to challenge my thoughts, my ideas, and my worldview. And on this day of May 15th 2011, I can say with no reservations, that my worldview has changed” (*C 2*).

The findings for this sub-construct suggest that the study abroad programs did not impact most participants' level of global awareness. One possible explanation for these results is the fact that the students received very little pre-departure information about their destination. Another possible explanation is that, as a result of their participation in this program, students realized how little they actual know about other countries and world affairs in general.

Intercultural Development

This section summarizes field note observations and reflective writing evidence regarding how the study abroad experience affected students' knowledge and understanding of other cultures.

Knowledge and understanding of other cultures

The majority of students' comments in their reflective writing assignments were devoted to observations and perceptions of the different cultures they encountered in the host country. Once again, some interesting differences emerged between the different program groups, but there were also some commonalities. For example, in all three programs, students commented on the similarity between the host culture and their home culture. In Brazil, one student observed, "Brazil is just like the United States" (*B 3*) and another said, "Brazil is like America" (*B 8*). A student on the China program commented, "a large swath of the population (mostly the younger generation) are becoming increasingly westernized" (*C 12*). This student seemed to consider westernization as a positive attribute. However, two students who visited South Africa and China seemed to be more disappointed by the cultural similarities they encountered:

SA 1: I was a bit disheartened to see that a lot of the places that we explored were very much like places in the United States.

C 4: However, it is not necessarily good in all ways because Shanghai looks like a melting pot of western cultures and it has lost its Chinese heritage...my biggest disappointment in China is how westernized everything is.

Another similarity between the students' perceptions on the three programs related to the hospitality of the people they encountered. Students frequently mentioned the warm welcome and kindness they encountered. Six of the nine South African program participants commented on the warmth and friendliness of the people they met. One student commented, "the people of RSA were very welcoming and kindly answered our questions" (*SA 2*) and "everyone we interacted with went out of their way to make us feel comfortable and no one we met felt like a stranger" (*SA 5*). A third student on the South Africa program said, "I was extremely surprised to find that all the people with whom we interacted, and even the strangers on the road were very kind to us" (*SA 8*). Also in Brazil, one student was "pleasantly surprised by the Brazilian people" and felt "the people of Brazil were very warm and welcoming" (*B 3*). Another student was "in awe of how hospitable all the guest speakers were and how they appeared to be honored to speak to us" (*B 6*).

In China, the program participants interacted most frequently with local students and this was reflected in their reflective writing assignments. One student reported a "memorable moment of mine is my encounters with Hao and Jackson. These two are new friends of mine and I would never have met them if I did not attend this trip" (*C 7*). Another student was surprised by the Chinese students' "openness and friendliness" and how they "fraternized with us outside the allotted time at the university with only sincere intentions of making strong friendship bonds" (*C 10*).

Differences between students' cultural reflections across the three different trips were primarily associated with the living conditions they observed and the food they tried. Seven of the 15 students on the program to China commented on the bathroom facilities and "weird" food (*C 13*). Overall, students found these to be some of the greatest cultural challenges during the trip to China.

Meanwhile, some of the greatest cultural challenges in South Africa were connected to the concept of group travel. One student commented that she felt "very sheltered during most of the course" (*SA 2*) as a result of traveling in a group and another felt she did not have adequate opportunities to encounter the "real" South Africa (*SA 1*). Another challenge for students visiting South Africa was navigating the political history of apartheid. Some pre-trip conceptions of "tension between races" (*SA 2*) were overturned and students particularly appreciated the cultural program to educate them about these issues. One student commented "one of the most memorable moments of the course was to visit the SOWETO Township….it made me more culturally aware and sensitive throughout the course" (*SA 4*).

The students on the Brazil program made the fewest comments about their perceptions of the host culture (only 6 out of 9). Three students did mention the challenge of navigating in a culture when they could not speak the language, but two noted their knowledge of Spanish helped them communicate. However, the majority (five of eight) of students' cultural reflections on the Brazil program were positive. For example "the experience of meeting a new country, a new culture, new friends, and new learning experiences is something that will mark your life forever, it definitely has market my life in ways I will never forget" (B 1).

One overriding observation during the implementation of all three programs was the general lack of cultural information and orientation provided. At the pre-departure sessions, less than 10% of this orientation time was devoted to cultural learning and the pre-trip readings primarily focused on issues of science and engineering, rather than culture. In addition, with the exception of the South Africa program, there was no opportunity provided for students to discuss their cultural observations and learning during the programs.

Here again, program observations highlighted the critical impact of faculty leading the different programs. On the South Africa program, one faculty member with a background in counseling psychology organized two group discussion and reflection sessions to help students process some of their cultural experiences. This activity was not a part of the syllabus for the program and occurred on an ad hoc basis. However, the other programs to China and Brazil, led by faculty who were less experienced in both international and intercultural education, did not include any structured group discussions focused on cultural experiences. Furthermore, two of the three faculty members on the South Africa program had previously visited this country as leaders of student groups. One of those faculty members had multiple years of experience working in South Africa, and living, and working in several other countries on the continent. Observations of these two South Africa trip faculty members indicated that they frequently discussed the cultural aspects of the program, including the impact of culture on science and engineering enterprises, with students. By contrast, only one of the two faculty members on the China program had previously visited this country, and only then for a short trip. Similarly, only one of the two faculty members on the Brazil program had in-country experience, but he had not led a study abroad program before.

Despite the lack of previous cultural experience of the China and Brazil faculty trip leaders, the Chinese director of the U.F. Beijing Center, who accompanied the students throughout the China program, enhanced cultural learning and provided mentoring for the group that the regular science and engineering faculty member leaders were not equipped to provide. In Brazil, the study abroad program was organized by a private agency which had not previously hosted science or engineering students. Overall, faculty members leading the Brazil trip were less attentive to both the academic and cultural learning outcomes than faculty working with the China and South Africa programs.

Summary of Findings

This research study sought to determine which components of a graduate-level science and engineering-related study abroad program enhanced and/or limited the students' academic STEM learning, personal growth and intercultural development outcomes.

Academic STEM learning outcomes

Evidence from program implementation field notes and participants' reflective writing assignments indicate that several components of the study abroad program enhanced students' academic STEM learning outcomes. These included the opportunity to visit a wide variety of science and engineering facilities and opportunities to directly interact with counterparts in the host country. Students' perceptions of professional self-efficacy in science and engineering, global science communication and the socio-cultural role of science and engineering were affected by both the formal component of the program, with presentations and laboratory tours, as well as the informal program, when they had opportunities to network with other students, faculty and business representatives. One factor that appeared to limit opportunities for academic STEM learning during these programs was the rigid and full itinerary for each program, most notably in Brazil and South Africa, when little to no time was allotted for informal interactions or meetings with a greater diversity of researchers.

For some students, the lack of informal, unstructured opportunities for interaction with host country scientists and engineers was compounded by the lack of opportunities to meet researchers, educators and business representatives in their particular fields of study. Other aspects of the programs that limited opportunities for enhancing students' academic STEM learning outcomes were changes in activities in the planned itinerary that eliminated opportunities for participants to make their own scientific presentations to a host country audience and the cancellation of meetings with key science and engineering personnel at some locations.

Personal growth outcomes

Personal growth outcomes were enhanced by the multiple opportunities students had to learn about career opportunities in science and engineering in each country visited. Students were particularly animated by these interactions and indicated that this aspect of the trip had the greatest potential for long-term repercussions and benefits. Conversely, the programs seemed to have limited impacts on students' levels of global awareness. This may have been due to the limited information about the host country presented during the pre-departure orientation, or it could reflect the fact that, as students encountered new countries and cultures, they realized the limitations of their global knowledge.

Intercultural development outcomes

Students made many positive comments about the cultural components of the study abroad programs. They particularly enjoyed the opportunities to meet local people during the programs and learn about their lifestyles, history, politics and other aspects of their culture. The hosts' hospitality toward student participants clearly enhanced their experiences and provided them with opportunities to reflect on their own culture. Two components that limited students' intercultural development outcomes during these programs were the lack of cultural preparation provided before trip departure and the lack of opportunities for reflection related to cultural learning during the programs.

Finally, the selection of faculty to lead science and engineering-related study abroad programs appears to have a significant impact on both the academic STEM learning and intercultural development of participants. Both student writing reflections and program implementation observations suggest that programs led by faculty with more international and intercultural educational experience are more effective.

Discussion

The results of this study were used to develop an initial set of guidelines and best practices for the design, implementation and evaluation of science and engineering-related study abroad programs for graduate students. Suggested guidelines and best practices emerging from this study are presented for each of the three targeted participant outcomes: academic STEM learning, personal growth and intercultural development.

Academic STEM learning

According to students' reflective writing comments and program observations, the opportunity to visit a wide variety of science and engineering facilities and interact with counterparts in the host country enhanced participants' academic STEM learning outcomes. Each of the three study abroad programs examined in this study was organized around an overriding theme specific of the host country; but, regardless of the theme of each trip, all three trips included visits to institutions of higher education, government research facilities and private sector operations in their planned itineraries. When implemented, the particular structure of each program varied according to the theme and site visit locations chosen. For example, the China program included two full days and an additional half day at three different university campuses, whereas the South Africa program only included two three-hour visits to two different university campuses. In addition, the Brazil program focused more on private sector operations, with four company visits, whereas the programs to South Africa and China each included only two commercial site visits.

Despite these variations in the duration, variety, and types of sites visited in each program, the diversity of sites visited appears to be a significant factor influencing students' academic STEM learning. As student participants clearly indicated, exposure to a variety of different points of view during the study abroad experience helped them understand the complexities of science and/or engineering research and practice in a global context.

Students also valued the opportunities provided to meet and talk with researchers, faculty members, students and industry representatives in the host country. However, rigorous daily program schedules appear to be detrimental and students in this study felt that there was not enough time to participate in substantive discussions with the individuals they met during the site visits. This was particularly true for the South Africa and Brazil trips which included a lot of in-country travel and often scheduled three different site visits during a single day. As Koenig (2007) suggests, the number of academic site visits each day should not exceed two and organizers should avoid long lecture formats. Unfortunately, staff, with limited faculty input, primarily organized each of the programs in this study and staff members did not apply these guidelines when developing the itineraries. This resulted in excessively long days, during which students became overloaded with information and had little opportunity to engage in reflection, discussion or informal interactions with their hosts.

Another concern emerging from this study that may be unique to graduate-level study abroad experiences is the students' desire to meet researchers in their own specific disciplines and areas of study. The programs in this study were designed for an interdisciplinary group of science and engineering graduate students, and as a result of the diversity of their research interests, it was not possible to arrange meetings that addressed each individual student's area of expertise adequately. Perhaps, if students had been more involved in the planning process for the programs, and if there had been some flexibility built into the schedules, it would have been possible to arrange individual meetings, particularly during the campus visits. As Henthorne et al., (2001) and Stanitski and Fuellhart (2003) noted, it is important to take students' interests into account during the planning process; and for graduate-level students, the opportunities to meet researchers in relevant disciplines is of paramount importance.

Finally, while this science and engineering study abroad program did have a set of student learning objectives outlined in the syllabus, they were not clearly defined, nor did they integrate with the home curriculum, as advocated by Donnelly-Smith (2009), Vande Berg (2007), and Sachua et al. (2010). For graduate-level programs, integration of study abroad program objectives with the home curriculum may be less crucial than the need for inclusion of experiences that match students' particular research interests in the study abroad curriculum. However, clearly-stated course goals and objectives are necessary in order to verify the impact of any study abroad experience. In this particular case, planning for the study abroad programs was constrained by the funding timeline which only allowed three months to develop and design all three programs and recruit participants.

Personal Growth

As outlined in the syllabi, each study abroad program included opportunities to learn about career prospects, including post-doctoral and research positions in each host country. In addition, all three of the pre-departure orientations included information on Fulbright options for funding international post-doctoral and research positions. In this way, students received multiple sources of information regarding the potential for international science and engineering careers and it was not surprising that the study abroad experience enhanced their personal growth in this aspect.

Obviously, one limiting factor for such opportunities is access to funding. However, both host country personnel and program faculty provided students with information about agencies and organizations that provide financial support for international research and post-doctoral positions, and students were encouraged to apply for these funds. Thus, participation in these study abroad programs enhanced students' awareness of potential research and post-doctoral positions available overseas and increased their interest in pursuing these opportunities as part of their future career paths.

There are many obstacles limiting the participation of science and engineering graduate students in international experiences, particularly those that demand long time commitments (Van Eyck, Van Toll, Wattiaux, & Ferrick, 2012). However, the findings from this research study suggest that short-term programs that include opportunities for participants to interact with researchers, faculty and students at host institutions and provide participants with detailed information about potential international research and post-doctoral positions are an effective way to expose students to international career prospects. Thus, study abroad programs designed for graduate students should include a strong career component, with opportunities to explore international opportunities and build networks with counterparts in other countries.

One objective listed on the syllabi for each study abroad program was for students to learn about the history, politics, geography, culture and traditions of the host country. Before departure, students in all three study abroad programs had to prepare a country report to familiarize themselves with the history, geography, government and politics and other facts of interest for their destination. However, no opportunities were provided either before or during each trip for students to participate in organized discussions about the host countries or share the information they learned when completing their individual country report assignments.

Furthermore, aside from a short component of 30 minutes or less during each pre-departure orientation, students did not receive any advance information about the host countries from program faculty or country experts. Results of this study indicate that students did gain knowledge about cultural aspects of their host countries during the study abroad programs, but students did not mention or seem to recognize the effects of program participation on their levels of general global awareness.

Intercultural Development

The review of students' reflective writing assignments and program observations indicate that students had multiple opportunities to participate in cultural activities and learn about the host culture as part of each study abroad experience. Koenig (2007) suggested that a study abroad itinerary should allocate 40% of total time to organized cultural activities and that 20% of time should be allotted for students to explore the host country individually.

Following these guidelines, each of the programs in this study contained both organized co-curricular activities and personal time for participants to explore independently and, in their reflective writing assignments, students made many positive comments regarding the cultural components of the program. They particularly enjoyed the opportunities to meet local people and learn about their lifestyles, history, politics and other aspects of their cultures. However, the time dedicated to cultural activities and individual exploration varied between the three programs, with the program to China offering both the most organized cultural activities and the most free exploration time for the students. The fact that this program visited only three primary locations, Beijing, Tianjin, and Shanghai, and that the group stayed in just two locations, facilitated the inclusion of adequate cultural excursions and free time for students.

Conversely, the programs to South Africa and Brazil had fewer organized cultural excursions and less free time and the students moved between four or five sites and accommodations during the program. Participants in the South Africa and Brazil programs noted the lack of interaction, both organized and informal, with people from their host countries and they made fewer comments about cultural activities in their reflective writing assignments. Furthermore, as mentioned previously, inadequate pre-departure orientations regarding host country cultures may have limited students' intercultural development during these programs. According to several researchers (McGowan, 2007; Roberts & Jones, 2009; Sachau et al., 2010), pre-departure orientation sessions regarding host country culture are a critical component of the study abroad experience.

Finally, a key component promoting intercultural development on study abroad programs is the inclusion of opportunities for reflection on cultural interactions (Donnelly-Smith, 2009; Koenig, 2007; NSEE, 1998; Roberts & Jones, 2009). In this study, only one study abroad program, the South Africa program, included any opportunity for such group discussion and reflection. This occurred on an ad hoc basis, primarily as the result of the intervention of one faculty member leader with a background in psychology and counseling. On the China and Brazil programs, no structured cultural interaction reflection activities occurred. In fact, intercultural development was not included as an explicit objective in the syllabi of any of the programs and even the reflective writing assignments outlined in the syllabus only directed students to focus on how the study abroad experience affected their academic STEM learning. These inadequate opportunities for reflection regarding cultural development during the program limited students' intercultural development.

Summary of Recommended Best Practices for Graduate Level Science and Engineering Study Abroad Programs

Based on the results of this study, the following best practices recommendations have emerged. These recommendations are grouped into three major categories:

program development, program implementation, and program evaluation. The program development category includes recommendations for the development of the curriculum, logistics planning, student preparation and selection of program personnel. The program implementation category includes recommendations about the curriculum delivery, on-going logistics and cultural activities. Finally, the program evaluation category provides recommendations for overall evaluation.

Program Development

Curriculum

- Seek support at the institutional, college and departmental levels for graduate study abroad programs in the science and engineering disciplines. Conduct meetings, seminars and workshops to educate faculty in these disciplines about the benefits of study abroad for their graduate students and solicit faculty member input in the program design phase.

- Involve all stakeholders (students, parents, host country representatives, study abroad administrators and program evaluators) early in the study abroad planning process.

- Establish clear educational goals and objectives for the study abroad program in the areas of academic STEM learning, personal growth, and intercultural development. As part of this process, consult with faculty and students in the target disciplines to ensure that the course is appropriately integrated into the existing graduate program curriculum and ensure that the credits earned will apply to the students' degree programs.

- Engage home campus faculty to assist with the development of a curriculum and itinerary that adequately address discipline-specific educational goals and learning objectives.

Logistics

- Determine an international destination that is appropriate for the selected program's subject area topic and ensure there is sufficient student interest to meet minimum course enrollment numbers.

- Determine the appropriate duration and timing of the program, taking the graduate students' other commitments to research and teaching and the university schedules and public holidays in the host country into account.

- Develop a program that is affordable for graduate students and ensure that any study abroad-related grants and scholarships provided do not negatively impact their existing financial aid, fellowships, assistantships and other funding.

Student preparation

- Conduct multiple pre-departure orientations, or even a minimal credit pre-departure seminar course, to provide participants with information about logistics, health and safety issues, course content, country-specific details, intercultural development training, and potential funding sources for international career opportunities, such as Fulbright and post-doctoral positions.

- Develop a balanced program that includes academic sessions, cultural activities and sufficient time for students to engage in both reflection and independent exploration.

- Work with graduate students to set up meetings and/or short research experiences in country that are relevant to their specific disciplines and are content matched with their research topics.

- Coordinate with host faculty to ensure that all site visits are engaging and relevant to the study abroad course theme and research focus.

- Facilitate contact between graduate students and their international counterparts, faculty and researchers in the host country prior to departure on the study abroad program.

Personnel

- Recruit faculty who have prior successful experience leading study abroad programs, who have expertise in the specific content disciplines relevant to the study abroad course topic and who are inter-culturally competent.

- Recruit faculty who are familiar with the chosen country destination and both the everyday and technical language used in the host country.

- Include early career and/or junior faculty to ensure continued engagement in study abroad by science and engineering disciplines.

Program Implementation

Curriculum

- Schedule a varied itinerary that provides students with opportunities to explore the diversity of science and/or engineering institutions related to the program topic.

- Include host lecturers and guest speakers when possible,

- Arrange visits to key laboratories and leading universities to enable students to see the top facilities in the host country.
- Arrange post-trip de-briefings and presentations to build on and reinforce the experience after returning to the home campus.
- Ensure that students deliver engage in discussion and with local students, faculty and researchers.

Logistics

- Limit scheduled activities to a maximum of one academic and one cultural visit in a day.
- Build in flexibility in the itinerary and ensure time for informal networking,
- Include time for independent exploration of the local culture and individual meetings with local researchers and students.
- Use public transportation as much as possible and avoid the bubble effect of using coaches and moving around as a cohort.
- Avoid multiple sites and lots of internal travel.
- Provide translators who are fluent in technical scientific language.
- Promptly communicate all schedule changes with students and solicit input on alternate options.

Cultural

- Arrange group dinners at the beginning and end to introduce participants to the host country's culture and food and celebrate the completion of the program. Otherwise, let students organize their own meals in the evening or arrange small group dinners with various local faculty and students.
- Set up on-site research or service-learning projects with teams consisting of U.S. and local students.
- Include opportunities for individual and group reflection during the trip, preferably with a trained intercultural facilitator.
- Include organized interactions with host country students.
- Include home stays and internships if possible.

Program Evaluation

- Develop a comprehensive evaluation protocol and use qualitative and quantitative assessments to measure both short and long-term outcomes,
- Use reflective journaling or writing assignments to evaluate students' intercultural development and other learning outcomes.
- Ensure that findings are utilized improve programs.

CHAPTER 7
CONCLUSIONS

The purpose of this study was to investigate the academic STEM learning, personal growth and intercultural development outcomes for underrepresented life and physical science and engineering graduate students who participated in science and engineering-related study abroad programs. To achieve this purpose, it was necessary to develop a new instrument for assessing academic STEM learning and personal growth outcomes for the target population. This assessment instrument, together with the commercially available Intercultural Development Inventory (IDI), was used to measure pre and post-trip outcomes of 33 science and engineering graduate students who participated in three short-term study abroad programs between May and August 2011. In addition, a comparison group of 32 life and physical science and engineering graduate students who did not participate in South Eastern Alliance for Graduate Education and the Professoriate (SEAGEP) study abroad programs, completed the same two outcomes assessment instruments. Results (pre-trip and post-trip scores) of the study abroad group were compared with those of the non-study abroad group. Finally, I analyzed my own field notes of onsite study abroad program implementation observations as well as students' post-trip reflective writing assignments in order to determine which specific components of the study abroad programs helped or hindered student growth in the three targeted outcome areas: academic STEM learning, personal growth, and intercultural competence.

This chapter provides a summary of the research study, including the overarching theoretical framework, specific research questions and methodology. This is followed by a review of key quantitative and qualitative study results and a discussion synthesizing the study's major findings. I next discuss implications of this study's findings for the design and implementation of science and engineering-related study abroad for science and summarize study-related limitations. Finally, I present recommendations for future research based on the new questions and issues emerging from this study.

Theoretical Framework

The lack of an existing theoretical foundation for college-level study abroad programs made it necessary to develop a new integrated framework to guide this study. The resulting integrated theoretical framework developed for this study is based on existing theories and concepts in related areas of educational research, developmental learning, cognitive and educational psychology, experiential learning and intercultural development.

The experiential-constructivist theoretical foundation for this study assumes that students use their experiences during and after study abroad programs to construct meaning about academic, personal and intercultural concepts. In fact, the syllabi for the specific SEAGEP study abroad programs examined in this study inadvertently followed Kolb's experiential learning cycle, with opportunities for students to have concrete experiences, observe real-world situations and undertake reflection activities. In addition, the integrated theoretical framework guiding this study includes aspects of transformative learning, implying that exposure to new experiences during study abroad programs can alter students' frames of reference for academic STEM learning, personal growth and intercultural development. Indeed, the SEAGEP study abroad programs examined provided multiple opportunities for science and engineering students to encounter real-world conditions and circumstances that appeared to contradict pre-trip knowledge and beliefs developed during previous classroom and laboratory learning experiences. These new conditions and circumstances encountered during the study abroad experience caused students to re-examine and question their existing knowledge and assumptions, thereby creating numerous transformative learning opportunities.

Finally, the integrated theoretical framework used in this study also addressed specific aspects of personal growth and intercultural development. Despite the fact that changes in individual identity development, including personal confidence and interpersonal competence, have previously been reported for study abroad participants, these outcomes were not explicitly included as objectives for the SEAGEP programs (Chickering & Braskamp, 2009; Deardorff, 2005; Jenkins & Skelly, 2004). However, I theorized that these would also be important outcomes for participants of science and engineering-related study abroad programs and therefore included assessment of personal growth and intercultural development as components of this research study.

In the following sections, I summarize the study's three research questions and associated methodologies and results. A total of 76 science and engineering graduate students participated in this research study, with 33 participating in the three SEAGEP study abroad programs examined and 32 non-study abroad science and engineering graduate students forming the comparison group. All study participants were pursuing doctoral degrees in science or engineering and all were members of an ethnic minority group as defined by the National Science Foundation (NSF) Alliances for Graduate Education and the Professoriate (AGEP) program.

Research Question 1

How can researchers and practitioners effectively assess the academic STEM learning and personal growth outcomes of life and physical science and

engineering graduate students who participate in science and engineering-related study abroad programs?

This research study involved the development of a new assessment instrument to measure academic STEM learning and personal growth outcomes for students completing science and engineering-related study abroad programs. Initial development of this assessment instrument involved a focus group of six SEAGEP students, a comprehensive literature review of existing study abroad assessment studies and consultation with three experts in international education, science education and assessment and evaluation. The draft instrument developed as a result of these preliminary activities was pilot-tested with 11 SEAGEP students completing a study abroad program in Chile in March 2011. After revising the assessment instrument based on pilot test results, the pre-trip assessments completed by students participating in the China, South Africa and Brazil SEAGEP trips as well as students in the comparison group were analyzed to determine the reliability and validity of the revised academic STEM learning and personal growth assessment tool. In total, 65 students participated in the reliability and validity-testing phase of this study.

The final version of the assessment instrument consisted of 29 Likert-style items, with 14 items assessing the academic STEM learning construct and 15 items addressing the personal growth construct. In addition, nine items were included to gather demographic data for each study participant. Cronbach's alpha statistics were calculated to assess reliability of the instrument and content and construct validity was established based on expert reviews, a literature review, statistical analysis of pre-trip and post-trip data and analysis of the alignment between assessment tool scores and the content of students' post-trip reflective writing assignments.

Results indicate that the academic STEM learning and personal growth assessment instrument developed as part of this study is largely valid and reliable. Two academic STEM learning sub-constructs (professional self-efficacy for science and engineering, and global science communication), were less robust in terms of their validity and reliability, and further development for these scales is needed. However, overall these results demonstrate that it is possible to use a Likert-type electronic assessment instrument to measure and document self-reported changes in academic STEM learning and personal growth of graduate students who complete science and engineering-related study abroad programs.

Research Question 2

What are the self-reported academic STEM learning, personal growth and intercultural development outcomes for graduate science and engineering students who complete science and engineering-related study abroad programs?

This research question involved two sub-questions:

a. What are the self-reported academic STEM learning, personal growth and intercultural development outcomes for underrepresented graduate students in life and physical science and engineering who participate in science and engineering-related study abroad experiences?

b. Do the perceived academic STEM learning, personal growth and intercultural development outcomes differ for underrepresented life and physical science and engineering graduate students who participate in study abroad experiences compared to those who do not?

Thirty-three students, 15 visiting China, eight visiting Brazil and nine visiting South Africa, completed pre-trip and post-trip assessments of academic STEM learning and personal growth outcomes using the electronic assessment instrument developed for this study. Thirty-one SEAGEP study abroad students (15 to China, seven to Brazil and nine to South Africa) also completed the IDI assessment of intercultural development. Additionally a comparison group of 32 non-study abroad science and engineering graduate students completed the same academic learning and personal growth assessment and 30 completed the IDI. Data analysis included paired t-tests to examine differences between the pre-trip and post-trip assessment instrument scores of students completing the study abroad experiences. In addition, independent t-tests were used to compare assessment instrument responses of the study abroad group and the comparison group of non-study abroad students. Finally, one-way ANOVAs and appropriate follow-up statistical procedures were used to compare the academic learning, personal growth, and intercultural competence outcomes of students completing the three different study abroad programs (China, South Africa and Brazil) and to compare these outcomes for life and physical science and engineering students participating in the study abroad experiences.

Results of these statistical analyses yielded significant differences between the pre-trip and post-trip assessment scores of SEAGEP study abroad students for both the academic STEM learning and personal growth constructs. In addition, there were significant differences between pre-trip and post-trip trip assessment scores for four of the six sub-constructs, including the socio-cultural role of science and engineering, personal confidence, career-related perceptions and general global awareness. Conversely, no significant differences were found between the pre-trip and post-trip IDI scores of SEAGEP study abroad participants.

Independent t-test results indicated no significant differences between the pre-trip and post-trip scores of SEAGEP study abroad with the comparison group scores on either the overall academic STEM learning and personal growth constructs, five of the six sub-constructs, or in intercultural development. However, pre-trip assessment scores for the SEAGEP study abroad group did differ significantly from comparison group scores on the career-related perceptions sub-construct. Results of independent t-tests comparing post-trip assessment scores of the SEAGEP study abroad group with scores of comparison group participants indicated significant differences in academic STEM learning and personal growth constructs and all sub-constructs, except general global awareness. As was the case with the pre-trip assessment scores, no significant difference was found between the post-trip assessment scores of SEAGEP students and scores of the comparison group for the intercultural development construct.

Finally, when scores of life and physical science students were compared with those of engineering students completing the study abroad experiences, no significant differences were found for any academic STEM learning, personal growth or intercultural competence constructs or sub-constructs. In addition, no significant differences were found between the academic STEM learning and personal growth post-trip scores of students participating in the three different trips. However, IDI post-trip scores were significantly different for students completing the three different trips. Closer examination of mean post-trip IDI scores for each country group indicated that the 15 students completing the China program experienced significant positive increases in their levels of intercultural development while students completing the South Africa and Brazil trips did not experience significant gains in intercultural competence.

Overall, results of this study suggest that participation in science and engineering-related study abroad programs does have significant positive effects on many aspects of academic STEM learning and personal growth regardless of the country visited.

However, the impact of these study abroad experiences on intercultural development of participants was not significant, except for the group that went to China.

Furthermore, the results of the independent t-tests between the pre-trip scores for the SEAGEP participant group and the comparison group indicate that SEAGEP study abroad participants were representative of the broader population of underrepresented science and engineering graduate students in most areas. However, one area in which the science and engineering graduate students completing study abroad programs differed on their pre-trip responses from their comparison group counterparts prior to departure was that of career-related perceptions. Students enrolled in the SEAGEP study abroad programs already had significantly higher pre-trip perceptions of international career opportunities and exhibited more interest in living and working in another country as compared to their counterparts in the non-study abroad group. This is not unexpected, given the fact that students participating in SEAGEP study abroad programs were self-selected and thus were already more likely to have a pre-existing interest in globally-focused science or engineering careers.

After completing the study abroad programs, participants' academic STEM learning and personal growth outcome scores were significantly higher than those of the comparison group suggesting that study abroad program participation does have a significant positive impact in both of these areas. However, for two constructs (intercultural development and general global awareness), study abroad participant post-test scores were not significantly different from those of the comparison group. Since intercultural development was not an explicit objective of the SEAGEP study abroad program no specific program activities or assignments were built into the study abroad experience to enhance student growth in this area.

Research Question 3

Which specific components of science and engineering-related study abroad programs enhance and/or limit the impact of these programs on the academic STEM learning, personal growth and intercultural development of participants?

On-site observations and accompanying field notes collected during implementation of the study abroad programs provided the opportunity to investigate connections between the intended study abroad programs, as outlined in course syllabi and actual program implementation. In addition, an analysis of students' post-trip reflective writing assignments provided insight into the participants' personal perceptions of the actual study abroad experience as compared to their pre-trip expectations of the experience.

First, I observed three alternate deliveries of the same science and engineering study abroad program syllabus in different settings (China, South Africa and Brazil). These observations were completed during four different types of activities on each trip and lasted between one and two hours each. These field notes along with students' post-trip reflective writing assignments served as the primary data sources for examining how actual implementation of the study abroad programs enhanced and/or limited students' academic STEM learning, personal growth and intercultural development outcomes. These data sources were both analyzed using qualitative general content analysis.

Findings indicated that study abroad participation enhanced students' academic STEM learning, personal growth and intercultural development. Regarding the academic STEM learning construct, evidence from both observations and reflective writing assignments specifically indicated that students valued opportunities to visit research facilities and private companies and interact with host researchers and students. However, some differences between students' perceptions regarding the three different trip experiences were noted for all three sub-constructs of academic STEM learning, namely: professional self-efficacy in science and engineering, global science communication and socio-cultural role of science and engineering. First, the effect of language barriers on perceived program success varied noticeably across the three programs, with students on the China and Brazil programs noting more challenges than those on the South Africa program. Second, the level of scientific infrastructure observed also differed greatly across the three different programs, with the students visiting South Africa and China being particularly impressed with the facilities they visited, while the students on the Brazil program noting less well-developed science and engineering infrastructure, particularly at the universities. Third, variations in the number and types of opportunities participants had to explore different projects during each study abroad program also affected students' perceptions of the socio-cultural role of science and engineering.

Findings for personal growth outcomes revealed that all three SEAGEP study abroad programs positively affected participants' career-related perceptions, with students expressing increased interest in international research opportunities in their post-trip reflective essays. Conversely, findings for the general global awareness sub-construct suggest that, as implemented, none of the three SEAGEP study abroad programs affected participants' perceptions regarding this sub-construct.

The intercultural development construct generated the largest dataset of participant comments in both program implementation observations and participants' post-trip reflective essays and examination of these data sources elucidated some interesting differences between the three different program deliveries. Comments by Brazil program participants indicated positive perceptions of U.S. influence on the host culture, while South Africa program participants expressed disappointment with their observations of western influence on the host culture.

Other notable differences between students' cultural reflections across the three different trips were associated with perceptions regarding the host country's political situation, race-relations, and general living conditions. One recurring observation emerging during implementation of all three programs was the general lack of cultural information and orientation provided to participants as part of the planned program. In addition, with the exception of the South Africa program, no opportunities were provided for students to discuss their cultural observations and perceptions during the study abroad experience.

Discussion

In previous chapters, I discussed this study's results and findings in relation to the three individual research questions. A comprehensive review of the existing study abroad literature, together with expert consultation, student focus groups and a pilot study of the draft academic STEM learning and personal growth assessment instrument all supported my selection of three over-arching outcome constructs: academic STEM learning, personal growth and intercultural development. The following discussion provides a synthesis of how the results and findings of this study relate to the existing literature regarding these constructs and their associated sub-constructs. Each section also includes a discussion of the data sources used and the results of both quantitative and qualitative analyses of these date sources.

Academic STEM learning Outcomes

Academic learning is frequently cited as a desired outcome for study abroad participants (Bolen, 2007; Ingraham & Peterson, 2004; Sutton, Miller and Rubin, 2007). However, previous study abroad outcomes assessments have primarily focused on student knowledge and skills development in foreign language and social studies (Deardorff, 2006; Engle & Engle, 2003; Mohajeri Norris & Dwyer, 2005). Few studies have investigated academic learning outcomes resulting from science and engineering-focused study abroad experiences and results of these limited studies have been inconclusive. For example, while two studies of undergraduate science students reported gains in academic learning constructs, such as skill in oral presentation, science writing and technical understanding (Bender, Wright & Lopatto, 2009; Nasr, Berry, Taylor, Webster, Echempati & Chandran, 2002), others found no significant gains in knowledge of scientific concepts by science study abroad students (Lumkes, Hallett & Vallade, 2012; Strauss & Terenzini, 2007). This dissertation study attempted to address the lack of adequate measures for assessing academic learning resulting from study abroad experiences with the development of a valid and reliable quantitative instrument for use specifically with college students completing science and engineering-related study abroad programs. This resulting assessment instrument focuses on three sub-constructs of academic learning that are especially applicable to science and engineering-related study abroad contexts: professional self-efficacy in science and engineering, global science communication, socio-cultural role of science and engineering.

Professional self-efficacy in science and engineering

Four items on the assessment instrument address the first sub-construct of academic STEM learning, professional self-efficacy in science and engineering. These items focus on students' perceptions of science and engineering in other countries and the value they personally attach to scientific knowledge generated outside the United States. Results of this study indicate that participation in the SEAGEP study abroad program did not have a significant impact on participants' professional self-efficacy in science and engineering. However, it should be noted that this scale had relatively low reliability according to Cronbach's alpha analysis.

Observations of onsite implementation of the three SEAGEP study abroad programs indicate that the inability to arrange meetings with in-country researchers in each participant's particular scientific discipline may have hindered student growth in the area of professional self-efficacy in science and engineering. Examination of students' post-trip reflective writing assignments, which included a few comments expressing disappointment with some of the trips' academic meetings, provided additional support for this hypothesis.

Furthermore, both reflective writing entries and onsite program observations revealed that the planned rigorous daily program schedules were detrimental to the growth of professional self-efficacy in science and engineering. Students in this study felt that there was not enough time to participate in substantive discussions with the in-country science and engineering professionals they met during the site visits. These findings all indicate that small modifications to the design and implementation of science and engineering-related study abroad programs could promote greater gains in professional self-efficacy in science and engineering of participants.

Further examination of field note and reflective writing data also highlighted aspects of professional self-efficacy in science and engineering that were not directly examined by the four items on the quantitative assessment instrument. For example, students included numerous positive comments about site visits to a wide variety of science and engineering facilities in their reflective writing assignments, but none of the professional self-efficacy items on the assessment instrument focused on this particular topic. Participants clearly indicated that exposure to a variety of different points of view during the study abroad experience helped them understand the complexities of science and/or engineering research in the countries visited. These analyses of student writing assignments indicate that perhaps certain areas of professional self-efficacy in science and engineering did improve as a result of the study abroad experience but these particular areas were not directly measured on the existing assessment instrument. Based on these emerging findings, I recommend the addition of items specifically focusing on the value of the specific site visits and interactions with science and engineering professionals during the site visits could impact participants' professional self-efficacy in science and engineering. Modification of the items on this sub-construct could also serve to strengthen the reliability and validity of the scale for quantitative analysis.

Global science communication

The five items focusing on the second academic STEM learning sub-construct, global science communication, addressed the relevance of speaking a second language, the primacy of English in science and engineering and personal level of comfort discussing research in foreign contexts. As was the case for the professional self-efficacy sub-construct, results of this study indicate that participation in the

SEAGEP study abroad program did not have a significant impact on participants' perceptions of global science communication. An examination of the study abroad program itineraries (Appendix G) and onsite observations conducted during implementation of each of the three study abroad programs suggested some possible explanations for the lack of growth in this area.

First, logistical constraints prevented students from making planned presentations to audiences in host countries during two of the study abroad programs, thus limiting their opportunities to directly practice global science communication skills. Additionally, in their post-trip reflective writing essays, several participants from all three programs included both positive and negative comments regarding their attempts to communicate with host country residents about scientific topics. For example, students appreciated the opportunity to discuss science and engineering concepts across cultures, but several noted that communication with host scientists and engineers was one of the most difficult and frustrating aspects of the program. These conflicting perceptions and experiences may have hindered participants' growth in the area of global science communication competence.

Encouragingly, in their reflective essays, some students indicated that their study abroad experience inspired them to learn another language or reach out to students in the U.S. who do not speak English as a first language. Additionally, while observing program implementation I noted that students became more confident communicating with their hosts as each program progressed and the presence of expert translators facilitated cross-cultural conversations. To increase the effect of study abroad programs on global science communication, future programs should include opportunities for formal presentations by participants. Additionally, an itinerary with more time for informal communication opportunities with in-country scientists and peer graduate students may enhance student growth in the area of global science communication.

Socio-cultural role of science and engineering

The third major sub-construct related to academic STEM learning outcome focuses on the socio-cultural role of science and engineering in a global context. Five items on the instrument relate to this sub-construct. Results of this study found a significant positive difference between participants' pre-trip and post-trip assessment scores on this sub-construct. Analyses of field note data and students' reflective writing assignments corroborated these positive results, but also revealed some interesting differences in student perceptions of the socio-cultural role of science and engineering across the three programs.

In reflective writing samples, most students visiting South Africa made comments about the sense of responsibility they felt to conduct science and engineering research that benefits the larger community. Meanwhile, participants from the Brazil program, which focused on bioethanol production, commented on environmental aspects of science and engineering and students on the China program paid attention to the influence of politics on the social and cultural role of science and engineering. These differences in the focus of students' perceptions regarding the socio-cultural role of science and engineering directly reflect the priorities and focus of each specific SEAGEP study abroad program and the types of site visits arranged in each country. To facilitate the development of a broader perspective regarding the socio-cultural role of science and engineering, future study abroad programs for scientists and engineers should continue to emphasize the application of specific types of research while also providing students with opportunities to explore diverse perspectives related to the program theme.

Personal Growth Outcomes

The second major construct examined in this study was personal growth, which included three sub-constructs: global career perceptions, personal confidence and general global awareness. A review of studies examining the impact of study abroad participation on personal growth outcomes suggests that several of the most frequently assessed parameters include the development of personal identity and personal confidence, the perception and understanding of different cultures and the effect of study abroad experiences on career aspirations (Dolby, 2004. Ingraham & Peterson, 2004; Norris & Gillespie, 2009). Such personal growth outcomes are of crucial importance in determining a student's level of interest in, and openness to, pursuing opportunities to live and work in other countries or at least participate as part of a multi-national and multi-cultural team. The assessment instrument developed for this study included 15 items focusing on the personal growth construct and its three sub-constructs.

Career-related perceptions

The first personal growth sub-construct examines students' perceptions of their ability to perform as scientists and/or engineers in a global context and measures changes in their levels of interest in a globally focused career. Six items on the assessment instrument address this sub-construct and results of this study found a significant positive difference between participants' pre and post-trip career-related perceptions. These results align with positive impacts on career aspirations demonstrated in other study abroad research studies and are supported by the course syllabi, field note data, and reflective writing essays examined in this study (Fass & Fraser, 2009; Sachdev, 1997).

Opportunities to learn about career prospects, including post-doctoral and research positions in each host country, were outlined in the SEAGEP syllabi and pre-departure orientations included information on Fulbright funding. Each country program also included site visits during which students learned about potential research opportunities. Thus, the SEAGEP study abroad programs provided students with multiple sources of information regarding international science and engineering careers and had the intended positive impact on students' career perceptions. Findings from this study suggest that short-term study abroad programs targeting science and engineering students have similar impacts on career-related perceptions as general study abroad programs (Norris & Gillespie, 2009). However, results also indicate that effective science and engineering-related study abroad programs for graduate students should include extensive opportunities for participants to interact with researchers, faculty and students at host institutions and should provide participants with detailed information about potential international research and post-doctoral positions.

Personal confidence

Six items on the assessment instrument addressed the second personal growth sub-construct of students' self-confidence in relation to traveling and living in other countries and cultures. Results of this study found that overall, participation in the SEAGEP study abroad programs led to a significant increase in students' personal confidence scores. These results suggest that students completing science and engineering-related study abroad programs experience the same types of gains in self-confidence reported for students completing study abroad experiences in other disciplines (Anderson et al., 2006; Bender et al., 2009; Dwyer & Peters, 2004).

However, analysis of students' reflective writing essay data revealed only one comment related to the impact of the study abroad experience on personal confidence. This particular student, who participated in the Brazil program, commented, "this experience gave me the opportunity to grow as a person and as a professional" (*B 1*). In addition, program observations did not provide any insight into particular aspects of the study abroad experience that influenced changes in students' personal confidence. This lack of emphasis on personal confidence outcomes in students' trip comments and post-trip reflective writing essays indicates a need for the inclusion of more during-trip reflective activities, including specific writing prompts or focused discussion sessions, to help participants become more aware of the impact of the study abroad experiences on their personal self-confidence.

General global awareness

The final personal growth sub-construct examined students' general knowledge about international issues and current events using three items on the assessment instrument. Results indicated a significant increase in participants' general global awareness following participation in the SEAGEP programs. These results are similar to those reported in previous studies of the impact of study abroad experiences on participants' levels of global awareness (Chieffo & Griffiths, 2004; Dolby, 2004; Lambert, 1993; McCabe, 1994).

Supporting evidence from qualitative data sources such as students' reflective writing essays were limited by the fact that students only made brief mention of the impact of the study abroad experience on their levels of general global awareness.

Despite the inclusion of a specific objective on the SEAGEP study abroad syllabi for students to learn about the history, politics, geography, culture and traditions of the host country, only six of 31 reflective writing assignments included comments related to general global awareness. On-site program observations suggest that these findings might be due to the lack of opportunities provided for students to participate in organized discussions about the host countries or share information they learned when completing their country report assignments. Results of this study indicate that study abroad participants did increase their levels of general global awareness, but additional pre-departure information and in-country discussions might further participant gains for this sub-construct.

Intercultural Development Outcomes

The final construct addressed in this study was intercultural development, which was examined with the 50-item IDI. Previously, some studies using the IDI have documented significant gains in cultural knowledge, cultural sensitivity, and interpersonal maturity resulting from completion of study abroad experiences (Anderson, et al., 2006; Kitsantas, 2004; Paige, Cohen and Shively, 2004). However, in this study, no significant differences between SEAGEP participants' pre-trip and post-trip intercultural development scores were found.

Interestingly, students' reflective writing essays and on-site program observations indicate that participants had multiple opportunities to take part in cultural activities and learn about the host culture as part of each study abroad experience. Students made many positive comments regarding the cultural components of the program in their reflective writing essays and particularly enjoyed opportunities to meet local people and learn about their cultures. However, the short-term study tour program format, during which students stayed in hotels and typically participated in cultural activities as a cohort, did not provide many opportunities for in-depth interactions with the host culture, especially in informal contexts. Additionally, only limited pre-departure preparation related to cultural knowledge or cultural sensitivity was provided as part of the orientation experience for the study abroad programs. Furthermore, the South Africa program was the only program that included any opportunities for group discussion and reflection about intercultural experiences.

According to several researchers, pre-departure orientation sessions regarding host country culture and reflection activities are critical components for promoting intercultural development on study abroad programs (Donnelly-Smith, 2009; Koenig, 2007; McGowan, 2007; Roberts & Jones, 2009; Sachau, et al., 2010). The fact that intercultural development was not included as an explicit objective in the syllabi of any of the programs and was thus not directly addressed during implementation of any of the programs may at least partially explain the participants' lack of intercultural development during this study.

Interestingly, when IDI pre-post data sets were analyzed for individual study abroad programs, significant increases in intercultural development were found for participants completing the China program, but pre-post IDI scores of participants completing the Brazil and South Africa programs did not significantly improve. On-site program observations indicate that the amount of time dedicated to cultural activities and individual exploration of the local culture varied greatly between the three programs, with the China program offering both the most organized cultural activities and the most free exploration time for the students. Conversely, the South Africa and

Brazil programs had fewer organized cultural excursions and less free time for independent exploration. Participants in both the South Africa and Brazil programs noted the lack of interaction with people from their host countries and made fewer comments about cultural activities in their reflective writing assignments.

Results of this study indicate that mere completion of a study abroad experience does not guarantee that changes in participants' levels of intercultural development will automatically occur. In particular, these findings substantiate Vande Berg's assertion that simply sending students abroad for academic study is not enough to achieve the larger goal of creating effective global citizens (Lederman, 2007). Furthermore, they validate Pedersen's (2010) contention that study abroad programs must include pedagogy focused specifically on intercultural competency to ensure participant growth in that area. It is also important to note that, until this study was conducted, the IDI had not been used to measure the intercultural development of science and engineering graduate students. It may be useful to examine this instrument more closely and perhaps modify it to better address the specific intercultural development needs of science and engineering graduate students completing study abroad experiences.

Implications for Practice

This study's results document the positive impacts study abroad experiences can have on science and engineering graduate students and support the argument for development of more international programs targeting students in these disciplines. However, the lack of significant improvement in some targeted outcome areas highlights areas of focus that need to be directly addressed when conceptualizing and implementing future science and engineering-related study abroad programs. The following sections outline specific recommendations for enhancing the academic STEM learning, personal growth and intercultural development outcomes of graduate students participating in science and engineering-related study abroad programs.

Academic STEM learning Outcomes

The lack of significant impact of SEAGEP study abroad programs on students' perceptions of professional self-efficacy in science and engineering and global science communication has several implications for future program design and implementation. To increase the professional self-efficacy of graduate students participating in science and engineering-related study abroad programs, opportunities to visit leading research institutions and meet with key faculty in participants' particular fields of study should be provided in all programs. Such visits expose participants to a wide variety of perspectives and facilities, which is a significant factor positively influencing perceptions of professional self-efficacy. In addition, graduate students have very specific research interests and, as part of the study abroad experience, networking opportunities within students' specific disciplines and fields of study are just as important as more interdisciplinary networking opportunities. These focused networking activities and research visits can provide participants with multiple opportunities to observe the on-going research and caliber of facilities in the host country and enable them to clearly see how their unique fields of study are addressed in other countries.

Program schedules and daily itineraries should be more flexible and include adequate time for participants to meet and engage in substantive discussions with researchers and graduate student counterparts at host institutions. These interactions not only have the potential to affect participants' perceptions of professional self-efficacy in science and engineering through discussions with their counterparts, but also provide opportunities to enhance perceptions of global science communication. Ensuring that participants have opportunities to make presentations about their research to host audiences is another component that may enhance students' perceptions of global science communication.

Ensuring that culturally competent and globally aware science and engineering faculty lead science and engineering-related study abroad programs is also a critical factor influencing the success of these programs. These same concerns also apply to the host country faculty and guest speakers selected to work with science and engineering graduate students on-site. Efforts should be made to recruit faculty who are experienced leading study abroad programs, are familiar with the cultural norms of the host country, and have expertise in the specific science and engineering disciplines relevant to the study abroad course topic. Furthermore, in non-English speaking countries, expert translators with a working knowledge of scientific terminology are essential to facilitate global science communication.

In this study, participants experienced significant increases in their perception of the socio-cultural role of science and engineering. These positive gains appear to be the direct result of the multiple opportunities provided for participants to learn about the impact of research on the local communities in the host country. Often science and engineering graduate students work in relative isolation, conducting field and/or laboratory research without the opportunity to explore or even understand the broader impacts of their work. These "impact-focused" study abroad experiences can provide participants with the chance to directly observe the positive impact of science and engineering research in a real-world context and can motivate students to pursue and persist engaging in research that can directly benefit human communities and natural ecosystems on a global scale. Therefore, future science and engineering-related study abroad programs should include a variety of site visits to expose participants to different perspectives regarding the socio-cultural role of science and engineering in the host country. In addition, providing opportunities for participants to directly engage in community-oriented projects or other service-learning activities could further enhance students' perceptions of the socio-cultural role of science and engineering in other countries.

Personal Growth Outcomes

The significant positive impact of the SEAGEP study abroad experience on participants' personal growth, including career-related perceptions, personal confidence and general global awareness, suggests that the inclusion of both cultural and professional activities in the programs provides an effective combination of learning experiences. In particular, as part of each program students were provided with information about various post-graduate and job opportunities and were encouraged to develop contacts for future career exploration. In addition, the program included a variety of activities during which students learned about the history, geography, and politics of the host nation. Finally, as has been documented by other research regarding the impact of study abroad programs, participation in international travel provides students with the opportunity to build their personal confidence.

These results imply that future science and engineering-related study abroad programs should include a similar combination of career-related and culturally-oriented activities to enhance participants' personal growth. However, the results also reveal the need to include additional focused activities, such as reflective assignments or discussions during the actual study abroad experience, to increase participants' awareness of personal confidence gains. Additionally, future programs should include formal presentations and organized discussions to enhance students' general global awareness.

Intercultural Development Outcomes

The results of this study suggest that future science and engineering-related study abroad programs should include a more extensive focus on cultural knowledge and awareness as part of their pre-departure preparation, perhaps with the assistance of a trained intercultural facilitator. Additional time for individual exploration and opportunities for informal culturally-related personal experiences should also be built-in to daily itineraries. Finally, program schedules should include both group and individual focused reflection exercises during the actual study abroad experience since previous studies indicate that these exercises enhance study abroad participants' intercultural development (Pederson, 2010). Finally, as mentioned previously, the IDI or other quantitative instruments for specifically assessing the intercultural development of science and engineering students also merit further examination and potential revision.

Limitations

Since this research study focused on previously planned and approved SEAGEP study abroad programs, the study sample was one of convenience, rather than random selection. All graduate students in the study sample self-selected to participate in the SEAGEP international programs and members of the comparison group were recruited based on the specific recommendations of the study abroad participants. These methods of study sample recruitment resulted in several study limitations. Firstly, self-selection of study abroad participants may have resulted in inclusion of individuals with more positive pre-existing international perspectives. A self-selection limitation is not uncommon in study abroad research studies and the use of a comparison group in this study did provide some control for most assessment parameters (Gray, Murdock & Stebbins, 2002). However, analyses of the study abroad group's pre-trip assessment instrument responses and those of the comparison group revealed that the study abroad participants' pre-trip career-related perceptions were significantly higher than those of the comparison group, indicating that self-selection may have influenced some targeted outcomes, especially related to the personal growth construct.

In addition, the inability to randomly select study participants produced other threats to internal validity, including selection-maturation and selection-history. Again, the use of an equivalent comparison group did provide some control for these effects, but I could not examine the differing maturation rates and effects of history for the two groups, as the comparison group participants only completed each assessment instrument once rather than pre-post and the groups had different experiences during the time period of the study.

Another limitation in this study was sample size. Due to funding constraints and the scope of the programs studied, the number of SEAGEP program participants was relatively small. This impeded my ability to make comparisons between different sub-groups, such as different ethnic groups and sexes. I did include comparisons between the three country groups and life and physical science vs. engineering participants. However, small group sizes limit the power of these statistical comparisons and conclusions related to differences in the specific trips and disciplines are therefore preliminary in nature. Furthermore, the variety of participants' personal backgrounds, ethnicities, nationalities, second language abilities, and previous travel experiences may have affected study outcomes, but again, groups were not large enough to make these comparisons.

Finally, this study did not investigate the impact of faculty program leaders on student learning outcomes. Qualitative data such as onsite program observations do suggest that different faculty, with different levels of experience, had different impacts on students' learning. However, without detailed information about their backgrounds, I am unable to determine how they may have enhanced or limited the success of each study abroad program.

Recommendations for Future Research

In order to gain a more accurate picture of how participation in study abroad programs affects the academic STEM learning, personal growth and intercultural development of science and engineering graduate students, it will first be necessary to develop additional international programs in these specific disciplines. As previously mentioned, science and engineering students are currently underrepresented in study abroad programs nationally and relatively few science and engineering-related programs exist compared to those in business, social studies and the humanities. Thus, new and expanded programs must be developed and recruitment of science and engineering student participants must be intensified if future research studies are to provide greater insight into the impacts of such programs. Additionally, while this study focused on graduate students from minority populations, future studies are required to examine the effects of study abroad participation on both graduate and undergraduate science and engineering students of all ethnicities.

Future studies could also explore the effectiveness of different methods of assessing student-learning outcomes resulting from study abroad program participation.

One possible modification might be to include more discipline-related items and constructs on the academic STEM learning and personal growth assessment instrument. For example, it would be useful to include items to investigate how students' perceptions of their disciplinary knowledge, understanding of technical concepts or specific skills were impacted by participation in the study abroad experience. Items that ask students to rate their levels of disciplinary knowledge or confidence in their laboratory skills before and after completion of the study abroad experience could enable faculty and administrators to more directly document the impacts of these program and help design activities to promote discipline-specific student learning during the study abroad experience. The use of the IDI to investigate science and engineering students' intercultural development as a result of study abroad participation also requires further investigation.

Finally, as study abroad programs in the science and engineering disciplines evolve, researchers may want to consider investigating longer-term impacts of these programs. For instance, it would be of interest to understand how study abroad participation influenced students' career decisions or behaviors after graduation. The level of future engagement in global activities, such as international research collaborations by study abroad alumni would also contribute to long-term outcome assessment.

Conclusion

With increased focus on the creation of a globally engaged workforce of scientists and engineers, and with an increased emphasis on study abroad at the college level, the ability to document the learning outcomes of students participating in these programs is of increasing significance. To address this need, a academic STEM learning and personal growth assessment instrument for science and engineering-related study abroad programs was developed and validated as part of this study.

Additionally, the results of this study demonstrate that short-term study abroad experiences can have significant positive impacts on the academic STEM learning and personal growth of science and engineering graduate students. However, the impact of such experiences on the intercultural development of science and engineering students is still not clear. Finally, this study provided a set of best practices and recommendations for the design and implementation of more effective graduate-level study abroad programs in the sciences and engineering.

APPENDIX A
IRB PROTOCOL

1. Title of Protocol: An assessment of outcomes for under-represented graduate students as a result of participation in science, technology, engineering and mathematics (STEM) study abroad programs.

2. Principal Investigator: Nicola Kernaghan, Assistant Director, Educational/Training Programs and Doctoral Candidate, University of Florida, School of Teaching and Learning,

3. Supervisor (If PI is student): Dr. Linda Jones, Associate Professor of Science Education, University of Florida, School of Teaching and Learning,

4. Date of Proposed Research: April 20th 2011 – April 19th 2012

5. Source of Funding: None

6. Scientific Purpose of the Study: The purpose of this study is to determine the academic learning, personal growth and intercultural development outcomes for under-represented graduate students who participate in science, technology, engineering and mathematics (STEM) study abroad programs. In addition, faculty interviews, review of syllabi and program observations will be used to provide information about how program implementation can affect student outcomes.

7. Describe the Research Methodology in Non-Technical Language: This study will invite current UF under-represented graduate students, who are registered for three 2011 Summer study abroad programs, to participate in two surveys and a series of program observations. The programs in the study are:
   - UF in China – Global Science and Engineering – May 6 – May 18, 2011
   - UF in South Africa – Global Science and Engineering – June 10 – June 21, 2011
   - UF in Brazil – Global Science and Engineering – July 22 – August 3, 2011

   The students will be invited to complete a STEM Outcomes assessment and an Intercultural Development Inventory (IDI) assessment approximately 2 weeks prior to their departure on each of the study abroad programs and again, approximately one week after they return to the U.S. In addition, 30 under-represented graduate students who do not participate in the study abroad programs will be recruited to form a comparison group and these students will be invited to complete the STEM and IDI surveys at the same time intervals.

   The STEM Outcomes assessment is a researcher designed tool, while the IDI is a commercially available, pre-existing, tool that has been statistically validated and that is widely used to assess study abroad programs. Both surveys will be implemented electronically and invitations will be sent to the students via email. Each electronic survey will include the informed consent form and will take no longer than 30 minutes to complete. Results obtained from the electronic survey tools will be maintained by the researcher in a confidential and locked office in the UF International Center.

Faculty leading the study abroad program will be invited to participate in a single, semi-structured interview about their objectives, expectations and anticipated outcomes for the program. Signed informed consent forms will be collected at the beginning of the interview. The interview will be conducted on the UF campus and the session will be audio recorded. The interview should last no less than 20 minutes and no longer than 30 minutes and all audio-taped data will be assigned numerical codes and the participants will be assigned pseudonyms to ensure anonymity.

The graduate students will be invited to participate in a series of program observations associated with their study abroad experience. These will include observations of the pre-departure session that will be conducted on the UF campus approximately 2 weeks prior to departure on the study abroad program. Signed informed consent forms will be collected from students at the beginning of the pre-departure orientation. Additional observations of a research facility visit a commercial facility visit, and a cultural activity will be undertaken during each of the study abroad programs in China, South Africa and Brazil. Each program observation session will last between one and two hours. The researcher will make observational field notes, focusing on key learning themes and will take photographs to record the context of the activity. The researcher will adopt an observational stance and will refrain from interacting with the students, faculty or guest speakers during these periods. As soon as possible following the activity, the jot notes, photographs and unwritten recollections will be used to prepare expanded field notes. These will include a much greater level of detail, including a description of the physical context, the people involved, as much of their behavior and nonverbal communication as possible, and, to the greatest extent possible, the actual words used by the participants. The researcher will also include her impressions, thoughts, concerns and explanations related to the activity observed. The jot notes and expanded field notes will originally be recorded using paper and pencil and will ultimately be transcribed into a Word document in preparation for analysis. All field notes and photographs will be maintained on a password protected laptop computer while in Chile and will be transferred to a secure office in the UF International Center for storage upon return to the U.S.

Student consent will be requested from those participating in the South Africa and Brazil programs to review the two reflection assignments submitted for these study abroad courses. The signed informed consent forms giving permission for the researcher to review this material will be collected from the students at the pre-departure orientation for the South Africa and Brazil programs. Upon receipt of the signed informed consent forms, copies of the student essays will be requested from the lead faculty member for the course. All material will be kept confidential and will be stored in a locked office at the UF International Center.

Finally, the researcher will review archival material for the China study abroad program that was submitted in the form of two reflective essay course assignments. Data collected from these assignments would also be kept confidential and would be maintained in a locked office at the UF International Center. Please see attached copies of the two survey instruments and the protocols for the program observations and faculty interviews.

8. Describe Potential Benefits: The potential benefit of this study is to assess the potential outcomes for STEM students who participate in study abroad programs and to improve the design, implementation and assessment of future study abroad programs for STEM students.

9. Describe Potential Risks: There are no anticipated risks associated with this study.

10. Describe How Participant(s) Will Be Recruited: The 38 study abroad participants, who will all be under-represented graduate students in the STEM disciplines, will be recruited via email from the group that is registered for the 2011 Summer study abroad programs:
    - UF in China – Global Science and Engineering – May 6 – May 18, 2011
    - UF in South Africa – Global Science and Engineering – June 10 – June 21, 2011
    - UF in Brazil – Global Science and Engineering – July 22 – August 3, 2011

    The 30 participants for the comparison group will also be recruited via email using the South East Alliance for Graduate Education and the Professoriate (SEAGEP) list serve. This program provides professional development and support to the under-represented graduate student STEM population and is the lead for the STEM study abroad programs to China, Brazil and South Africa. To the extent possible, the comparison group will be comprised of students of similar disciplinary and demographic to those who are participating in the study abroad programs.

    The faculty who lead the three study abroad programs to China, South Africa and Brazil will be invited to participate in interviews prior to the programs. These faculty will be contacted via email.

11. Maximum Number of Participants 68 graduate students and 3 faculty members

12. Age Range of Participants: 18 – 65

13. Amount of Compensation: 0

14. Describe the Informed Consent Process. The prospective participants who have registered for the 2011 Summer study abroad programs to China, South Africa and Brazil will be sent individual emails inviting them to participate. The prospective participants for the comparison group will also be sent individual emails inviting them to participate in the study. These emails will include the informed consent forms for the individuals to read, sign, and return to the researcher. The emails will be

individually sent with no other information about other prospective participants included in the content or address boxes of the email.

The researcher will discuss the study and review the informed consent forms with the graduate students at the beginning of the pre-departure session for each program. Any questions regarding the study will be answered at this time by the researcher and the signed consent forms will be collected by the researcher at the pre-departure session. Contact information for those who wish to ask questions after the focus group will also be provided.

The researcher will discuss the study and review the informed consent form with the faculty member at the beginning of the individual interview. Any questions regarding the study will be answered at this time by the researcher and the consent form will be collected by the researcher.

In all modes of communication, it will be stressed that the participants can opt out of the study at any time and have the right to refuse to answer any questions they wish. A copy of each signed consent form will be given to each participant. Please see attached copies of the informed consent forms.

____

Principal Investigator(s) Signature: Date:

____

Supervisor’s Signature (if PI is a student): Date:

____

Department Chair Signature: Date:

APPENDIX B
INFORMED CONSENT

Protocol Title: An assessment of outcomes for under-represented graduate students as a result of participation in science, technology, engineering and mathematics (STEM) study abroad programs.

Please read this consent document carefully before you decide to participate in this study.

Purpose of the research study: The purpose of this study is to determine the academic learning, personal growth and intercultural development outcomes for under-represented graduate students who participate in science, technology, engineering and mathematics (STEM) study abroad programs. In addition, faculty interviews, review of syllabi and program observations will be used to provide information about how program implementation can affect student outcomes.

What you will be asked to do in the study: In this study you will be asked to complete two electronic surveys. One survey will investigate the STEM related outcomes and the other will investigate the intercultural development of participants. Each survey has a pre and a post phase that will be completed approximately four weeks apart.

For those participating in the study abroad program: For participants on the “Global Science and Engineering” program, you will be sent both pre-surveys to complete approximately two weeks prior to departure on the study abroad program and the post-trip surveys will be sent approximately one week after you return to the U.S. Names will be used an initial method of tracking surveys, but these will be immediately removed and the surveys will be assigned numerical codes to ensure participant anonymity. You do not have to answer any questions you do not want to answer and have the right to withdraw from the study at any time. The survey data will be used to improve the design and implementation of a future study to assess the potential outcomes for STEM students who participate in study abroad programs.

You will also be asked to participate in the program observations that will be conducted for the study abroad program. Please be aware that these observations are part of the research project, but are not part of the program syllabus. The purpose of including these program observations is to determine the extent of alignment between the intended and delivered curriculum and to understand how students make meaning out of these experiences by comparison with the learning objectives identified by faculty before the trip and students’ perceived learning outcomes after the trip.

You do not have to participate in the observations to participate in the program and you may opt out of the research study at any time.

A researcher will make four separate observations during the planned activities of the program, including the pre-departure session, a visit to an academic facility, a visit to a commercial facility and a cultural activity. These sessions are all part of the syllabus for the course and you will not be asked to do anything extra for the observations. The researcher will take notes during these sessions and some photographs of students participating in the sessions. Personal information, including names or other identifying data will not be recorded during the sessions and all participants will be assigned pseudonyms to ensure confidentiality. Notes and photographs will be stored on a password protected laptop that will be kept in a locked location while overseas and all data will be transferred to a secure location at the UF International Center upon return to the U.S.

Finally, you will be asked to give permission for the researchers to review your two reflective writing assignments (pre and post-trip). These documents will be used to develop a better understanding of how students learn key concepts during the study abroad program. As with the survey and program observations, the review of the reflective writing assignments will be used for research purposes only and is not part of the program syllabus. Names will be expunged from all documents and they will be maintained in a secure and locked location at the UF International Center. Upon conclusion of the study, all survey results, photographs and copies of program observations and archives will be destroyed.

For those not participating in the study abroad program: For those who are not participating in a study abroad program, you will be sent the pre-survey in early May and the post-survey approximately four weeks later. Names will be used an initial method of tracking surveys, but these will be immediately removed and the surveys will be assigned numerical codes to ensure participant anonymity.

You do not have to answer any questions you do not want to answer and have the right to withdraw from the study at any time. The survey data will be used to improve the design and implementation of a future study to assess the potential outcomes for STEM students who participate in study abroad programs. Upon conclusion of the study, all survey results, photographs and copies of program observations and archives will be destroyed.

Time required: Approximately 15-30 minutes to complete each of the surveys. Approximately 60 – 120 minutes for each observation session.

Risks and Benefits: There are no anticipated risks associated with this research study. There are no direct benefits to you for participating in the study. However, a potential benefit of this study is to assess the potential outcomes for STEM students who participate in study abroad programs and to improve the design, implementation and assessment of future study abroad programs for STEM students.

Compensation: There is no compensation for this study.

Confidentiality: Your identity will be kept confidential to the extent provided by law. Your information will be assigned a pseudonym and numerical code. The list connecting your name to this pseudonym and numerical code and any audio recordings will be kept in a locked file in the supervisor's office. All print documents will be destroyed within one year after the study's conclusion.

Voluntary participation: Your participation in this study is completely voluntary. There is no penalty for not participating.

Right to withdraw from the study: You have the right to withdraw from the study at anytime without consequence.

Whom to contact if you have questions about the study: Nikki Kernaghan**,** M.S., Assistant Director: Educational/Training Programs, University of Florida International Center, 170 HUB, PO Box 113225, Gainesville, FL 32611; Ph: (352) 273-1521, Fax: (352) 392-5575, Email: nikkik@ufic.ufl.edu

Dr. Linda Jones, Associate Professor, School of Teaching and Learning, University of Florida, 2408 New Norman Hall, PO Box 117048, Gainesville, FL 32611; Ph: (352) 273-4423 Fax: (352) 392-9193; Email: lcjones@coe.ufl.edu.

Whom to contact about your rights as a research participant in the study: UFIRB Office, Box 112250, University of Florida, Gainesville, FL 32611-2250; ph 392-0433.

Agreement: I have read the procedure described above. I voluntarily agree to participate in the procedure and I have received a copy of this description.

Participant: ____ Date: ____________

Principal Investigator: ________________________________ Date: ____________

APPENDIX C

ACADEMIC LEARNING AND PERSONAL GROWTH ASSESSMENT INSTRUMENT

Academic Learning Outcomes

1. I believe that I can learn new knowledge from scientists/engineers in other countries
2. It is important to understand the perspectives of people from other countries have regarding science/engineering
3. I believe that English is the most important language in the communication of science/engineering
4. I am aware of scientific/engineering research opportunities in other countries
5. I value research conducted by scientists/engineers in other countries
6. I feel I can apply my research in global settings
7. I think it is important for scientists/engineers to speak more than one language
8. I am comfortable discussing my research with people from other countries
9. I think science/engineering are communicated using similar methods in other countries
10. I am comfortable giving an academic presentation in an international setting
11. I have a clear understanding about the role of science and engineering in other countries
12. I have a clear understanding about the role of science/engineering in other countries
13. I believe that I can learn new skills from scientists/engineers in other countries
14. My discipline has an important role to play in solving global problems
15. I think STEM education in other countries is not as advanced as it is in the U.S.*

16. I think that technology transfer in science/engineering occurs differently in other countries compared to the U.S.*
17. Science policy is the same around the world*
18. I think research in science/engineering is more advanced in the U.S. than in other countries*
19. I think commercial opportunities in science/engineering in other countries are similar to those in the U.S.*
20. I think that science/engineering research in other countries is similar to the U.S.*

Personal Growth Outcomes Scales

1. I feel confident about practicing my discipline in a different country
2. I am knowledgeable about international issues
3. I am a self-sufficient person
4. I am competent to work as a scientist/engineer in other countries
5. I feel prepared to work on a multinational research project
6. I am interested in working as a scientist/engineer in another country
7. I am confident that I can deal efficiently with unexpected events
8. I am confident in my abilities as a scientist/engineer
9. I am prepared to live in another country
10. I am confident that I can take care of myself in a new situation
11. I have the ability to make a difference in the world
12. I am familiar with current events in other countries
13. I aspire to work in another country
14. I am familiar with current events in China/South Africa/Brazil

15. I am interested in working on a multinational project

16. Career opportunities in other countries are not interesting to me*

17. I believe that people from other countries view the U.S. positively*

Demographic Information

1. What is your name?

2. What is your sex?

3. How old are you?

4. What is your race/ethnicity

5. What is your nationality

6. How many times have you travelled outside your home country

7. Do you speak a language other than English

8. If yes, please indicate which languages you speak and the level of fluency

9. Have you previously visited China/South Africa/Brazil?

Note that items marked with an * were excluded from the assessment instrument following the pilot testing phase.

APPENDIX D
INTERCULTURAL DEVELOPMENT INVENTORY

The Intercultural Development Inventory (IDI) is a pre-existing, commercial available instrument for assessing an individual's level of intercultural competence along a six-item continuum. The survey will be independently scored by the Intercultural Communication Institute and individual profiles will be generated and provided to the researcher.

One purpose of this study is to determine how international experiences, such as the Global Science and Engineering study abroad programs, help students develop global awareness and the ability to effectively interact in culturally diverse settings. The intercultural development inventory is a widely used and a statistically reliable, valid measure of intercultural sensitivity. A summary of the IDI introduction/instructions for students is provided in the following paragraphs.

Each of us has a worldview that is related to participation in one or more culture groups. These groups are typically defined by national and/or ethnic boundaries, but they may also represent other affiliations. In the IDI, terms such as "our culture" or "my culture" refer to the culture group(s) to which you feel you "belong" the most. The terms "other cultures," "people from different cultures," or "different cultures" refer to groups to which you do not feel you belong. Try to think about the other culture groups with which you are familiar. Please avoid considering cultures that you know only from media. Respond to each item in the IDI in terms of the specific culture groups with which you have had the most contact or experience. Confidentiality: Your honest responses to the IDI are crucial to its effectiveness. If your name or identification is asked for, your individual responses will be kept in strict confidence by the IDI administrator.

Instructions: For each statement, please click the button that most accurately indicates your agreement or disagreement with the item. When a statement presents an opinion or viewpoint, respond to that item as if you overheard someone making that statement. Also, be sure to respond to each item in terms of the specific culture(s) with which you have had the most contact or experience.

There are no right or wrong answers, nor "good" or "bad" responses. Respond to each statement based on your first, initial reaction. You should not respond based on whether you believe certain type of statement should or should not be made or whether you like or dislike the way a statement is worded. .BE SURE to respond to each and every item. Ignoring some statements will mean that your total responses will not reflect your own personal viewpoint, and your completed survey cannot be properly analyzed.

Some of the items in the IDI express a viewpoint that you might not feel comfortable expressing to others. When responding to these types of statements in the IDI, you should think about the degree to which you agree or disagree with the overall content or meaning of each statement as if you "overheard" someone make that statement.
Response Options:

- Disagree

- Disagree somewhat more than agree
- Disagree some and agree some
- Agree somewhat more than disagree
- Agree

Questions:

1. It is appropriate that people do not care what happens outside their country.
2. I feel rootless because I do not think I have a cultural identification.
3. I have observed many instances of misunderstanding due to cultural differences in gesturing or eye contact.
4. When I am with people from different cultures, I act differently than when I am with people from my own culture.
5. I have seen many situations where cultural differences in the way people express their emotions led to misunderstanding.
6. People of other cultures are more interested in improving themselves than we are.
7. People are the same; we have the same needs, interests, and goals in life.
8. Technology is creating a single world-wide culture.
9. I can look at the world through the eyes of a person from another culture.
10. I do not feel I have a culture.
11. When I come in contact with people from a different culture, I find I can change my behavior to adapt to theirs.
12. I use different cultural criteria for interpreting and evaluating situations.
13. While I see myself as a member of my own culture, when I am in one or more other cultures, I find myself
14. I evaluate situations in my own culture based on my experiences and knowledge of other cultures.
15. It is appropriate that members of our stronger culture have more opportunities.
16. Human behavior worldwide should be governed by natural and universal ideas of right and wrong.
17. There would be fewer problems in the world if culturally different groups kept to themselves.
18. People from our culture are lazier than people from other cultures.
19. I can change my behavior to adapt to other cultures.
20. I do not feel I am a member of any one culture or combination of cultures.
21. Many times I have noticed cultural differences in how direct or indirect people are in conversation.
22. If only other cultures were more like ours, the world would be a better place.
23. I am often aware of cultural differences in how decisions are made.
24. People from our culture are less polite compared with people from other cultures.
25. I do not identify with any culture, but with what I have inside.
26. My cultural identity is not clear to me because it is not grounded in the values and patterns of any particular cultural group.
27. Too much attention is directed toward other cultures.
28. People from other cultures are more sophisticated than people from our culture.
29. Other cultures relate to technology better than our culture does.

30. Despite some cultural differences, it is more important to recognize that people are all alike in their humanity.
31. If only our culture was more like other cultures, the world would be a better place.
32. I often act as a cultural bridge between people from different cultures.
33. People from our culture are less tolerant compared with people from other cultures.
34. People from other cultures are not as interested as we are in improving themselves.
35. Too much cultural diversity is bound to lead to divisive conflict.
36. People are fundamentally the same despite apparent differences in cultures.
37. Family values are stronger in other cultures than in our culture.
38. It is appropriate that people do not socialize very much with individuals from different cultures.
39. People in our culture work harder than people in most other cultures.
40. Our culture's way of life should be a model for the rest of the world.
41. Cultural differences are less important than the fact that people have the same needs, interests, and goals in life.
42. Family values are stronger in our culture than in other cultures.
43. People should avoid individuals from other cultures who behave differently.
44. People from our culture are not as open-minded as people from other cultures.
45. Our common humanity deserves more attention than cultural difference.
46. Because there are universal values, cross-cultural conflicts can be resolved.
47. I have frequently observed cultural differences in how problems are defined and solved.
48. It is best to form relationships with people of your own culture.
49. Universal moral principles provide an effective guide for behavior in other cultures.
50. I frequently change my behavior to deal with cultural differences in gesturing or eye contact.

Demographic Information:
Name
Gender
Age category
The longest period of time you have lived in a culture other than your own
Education level (completed):
Nationality and/or ethnic background
In what world region did you primarily live during your formative years to age 18
Are you currently or have you ever been an ILA member?
How many ILA conferences have you attended?
Which ILA Member Interest Group (MIG) are you a part of?
What is your background (professional and personal) regarding contact with cultural difference?
What is your philosophy or viewpoint regarding cultural difference?
What initiatives or programs have been undertaken in your organization to address cultural difference, and how successful do you think they have been?

What kind of additional efforts do you think your organization should undertake to address cultural difference?

To learn more about the Intercultural Development Inventory or to receive technical assistance with the online IDI assessment, please contact:

Debra Freathy, Assessment Coordinator
The Intercultural Communication Institute
8835 SW Canyon Lane, Suite 238
Portland, Oregon 97225, USA
Phone: +1.503.297.4622
Fax: +1.503.297.4695
Email: idi@intercultural.org

APPENDIX E
OBSERVATION PROTOCOL

(1 – 2 hours)

Several observation sessions will be conducted during each study tour program. These sessions will occur during the pre-departure orientation, site visits to a research facilities (university or government), site visits to commercial facilities, and cultural activities.

Prior to departure on the study tour, a copy of the syllabus for the course will be obtained and analyzed for themes related to student learning objectives during each activity. These will be used to prepare a key, which will be used as a reference to determine the focus for each of the program observations sessions (see Table below).

Program Session	Learning Themes
Pre-departure	• Discussion of course objectives and expectations • Information on history, geography, language, politics and government, traditions and other cultural aspects of destination country • Intercultural awareness discussion
Research Facility Visit	• Opportunities to network with students, faculty and/or government researchers • Opportunities to develop an understanding of the differences in STEM education and research cultures between the U.S. and the host country • Opportunities to give presentations in an international context
Commercial/industrial Facility Visit	• Opportunities to interact with researchers, entrepreneurs and scientific business leaders • Opportunities to learn about differences in science and technology and technology transfer between the U.S. and the host country
Cultural Activity	• Opportunities to learn about history, geography, and other cultural aspects of host country • Opportunities to meet community members • First-hand cultural experiences

Each program observation session will last between 1 and 2 hours and observational field notes will be created, focusing on the key learning themes. The researcher will adopt an observational stance and will refrain from interacting with the students, faculty or guest speakers during these periods.

The preliminary field notes will be in the format of jot notes, in which words or short phrases will be recorded in relation to the activity undertaken, behaviors observed, and group and individual dialogue when appropriate. Photographs will also be taken to record the context of the activity.

As soon as possible following the activity, the jot notes, photographs and unwritten recollections will be used to prepare expanded field notes. These will include a much greater level of detail, including a description of the physical context, the people involved, as much of their behavior and nonverbal communication as possible, and, to the greatest extent possible, the actual words used by the participants. The researcher will also include her impressions, thoughts, concerns and explanations related to the activity observed.

The jot notes and expanded field notes will originally be recorded using paper and pencil and will ultimately be transcribed into a Word document in preparation for analysis.

APPENDIX F
SEAGEP SYLLABUS

Science & Engineering in the Global Context

Spring/Summer A/Summer B 2011
ALS 5905/EIN 6905

Instructors:

Dr. Samesha Barnes	sbarnes@aa.ufl.edu
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Course Description

To address the need for global experience at the graduate level, the South East Alliance for Graduate Education and the Professoriate (SEAGEP) has developed an international project and 3-credit course in collaboration with the University of Florida International Center entitled ***Science & Engineering in the Global Context***. The program will consist of short duration trips to Chile, China, South Africa and Brazil that will allow a total of 54 SEAGEP scholars to develop global competencies that will give them a competitive edge in their preparation for and pursuit of academic careers. Each trip will include a schedule that will include visits to local industries and academic institutions, meetings with research and government agencies and a cultural experience. SEAGEP scholars will participate in discussions at local universities and have an opportunity to network with faculty & students. The team of scholars in each country will be divided into groups which will be assigned to one of four research topics (science and technology, science communications, technology transfer, education) to investigate during the trip. Upon return to the U.S., participants will write a report covering the assigned research topic. The final SEAGEP Annual Meeting, which will be held at the University of Florida in September 2011, will be an international symposium featuring presentations from all Science and Engineering in the Global Context program students. Participants will draft a comprehensive report that will be published to capture the knowledge gained from these experiences.

Course Objectives

1. Participants will learn about the history, culture and traditions of the host country
2. Participants will develop an understanding of the differences in STEM education and research cultures between the U.S. and the host country
3. Participants will investigate one of the four research topics below with an assigned team:
   a. Science and Technology
   b. Science Communications
   c. Technology Transfer
   d. Education
4. Participants will network with students, faculty, researchers and government agencies abroad
5. Participants will engage in discussions on the research topics in the host country
6. Participants will develop a presentation summarizing the international experience
7. Participants will draft a comprehensive report of findings for publication in conjunction with students from all four destinations

Destinations

Four destinations were selected where UF, the lead alliance institution, has liaisons and established partnerships to help facilitate the international experience. The country descriptions and tentative departure and return dates are summarized below.

Chile

In recognition of the global importance of energy management in 2007 the UF College of Engineering established cooperative agreements with several South American Universities including the Pontifica Universidad Catolica de Chile. An International Industrial Energy Management Course was also established at that institution. Two years later, the College of Engineering undertook a formal internationalization of the curriculum, specifically targeting our Latin American and South American engineering institutions, who are partners with UF in the Latin American and Caribbean Consortium of Engineering Institutions. A leader in this effort is Dr. Cristian Cardenas-Lailhacar, Executive Director of the National Energy Efficiency Program for the Chilean Department of Energy. Dr. Cardenas, who has worked with the SEAGEP program in the past, has agreed to serve as host for the Chilean SEAGEP group so that they can explore current issues in this area, as well as gain a general understanding of issues surrounding research in this part of the world.

China

Beijing is the political and cultural capital of China and one of the country's most industrialized cities. Beijing has more than 70 colleges and universities, including several of international recognition. The University of Florida Beijing Center opened in June 2005, and offers study abroad programs for UF students, recruits students from China to UF and markets UF distance learning programs in China. In addition, the UF Center in Beijing assists UF faculty in establishing relationships with faculty at Chinese universities. UF has cooperative agreements with at least 17 universities in China and recently signed an agreement with the China Scholarship Council to increase the number of Chinese students and faculty coming to UF. Working closely with the UF Beijing Center, this trip will provide opportunities to visit Chinese universities, and tour cutting edge facilities with an emphasis on engineering.

South Africa

The international experience to South Africa will include visits to multiple STEM-oriented institutions with which UF has established relationships. Students will spend approximately half the trip in Johannesburg and Pretoria, where they will visit a variety of sites, such as the National Research Foundation, the Council for Scientific and Industrial Research (CSIR), Tswane University of Technology, and the University of Pretoria. In addition, UF will collaborate with E-Florida's South African representative, Ms. Tongila Manly, to arrange site visits to private sector facilities in Johannesburg. Meetings with scientists working on natural resources, water, and wildlife management of the Kruger National Park, the largest park in South Africa will be combined with visits to local communities "living with wildlife" in Mpumalanga Province. Options to visit water and agricultural research sites in the Limpopo Transfrontier area will be possible. Early human archeology sites and several World Heritage sites of cultural and environmental interest will be explored.

Brazil

The University of Florida has a long and extensive relationship with Brazil. The Center for Latin America Studies houses the Florida-Brazil linkage program (www.latam.ufl.edu/research/fbi) as a formal recognition of the importance between the two countries. Many Brazilian students benefit from this program by reduction of out-of-state tuition to attend UF. The Tropical Conservation and Development (www.tcd.ufl.edu) has been conducting interdisciplinary research in conservation and sustainable practices for decades in numerous Brazilian communities. This has resulted in multiple publications and a heightened prominence of the Center for Latin American Studies at UF across the world. Finally, UF has cooperative agreements with more than 30 Brazilian institutions to further research and student exchanges. This combination makes Brazil an ideal choice for multi-disciplinary STEM students to visit.

Country	Tentative Dates*	Focus
Chile	March 4 – March 14	Energy
China	May 6 – May 18	Engineering
South Africa	June 10 – June 22	Ecology/Conservation
Brazil	July 23 – August 3	Agriculture & Natural Resources

Orientation

An extensive orientation will be held prior to departure for each country. Itinerary, travel and accommodation details, cultural awareness, do's and don'ts, health and safety issues, and other important information will be discussed. The orientation will be held at the University of Florida. Clemson and University of South Carolina students will participate by videoconference. **Attendance is mandatory for all students.**

Attendance/Participation

Full participation is expected and will constitute a significant portion of your grade. Please approach this experience with an open mind and fully engage in all planned activities.

Assignments

Written assignments should to be submitted to Dr. Barnes (sbarnes@aa.ufl.edu) by 5:00 pm on the specified due date. Assignments should be double-spaced with 1" margins. Please use 11 - 12 pt font.

Assignment 1: Destination Summary

Prepare an overview (2 pages) about your destination highlighting the history, culture, government, and facts of interest. This assignment is due one week prior to travel.

Assignment 2: Group Discussions

Prepare for two 1-hour group discussions on learning from assigned readings and various research groups in South Africa: research organizations (in Pretoria), observations of farmers' research (in Polokwane), and observations of the research done by SANParks in Kruger National Park. Each group will have 15 minutes to lead the discussion of their assigned research topic based on the assigned readings and South Africa experiences. All students are expected to share and be actively engaged in the dialogue.

Assignment 3: Research Topic Report

Prepare a report (4 pages) on the research topic that you investigated with your team during the study abroad program. Incorporate specific details from your international experience whenever possible. Include references using a citation style that is customary for your discipline. Team interaction is encouraged during preparation; however each student must submit an individual report.

Reflective Writing

Journaling can significantly enhance your study abroad experience by allowing you to document what you see, hear, and learn and to record your thoughts and feelings about what you encounter. Journaling will also allow you to reflect back on your experiences long after the trip is over. Students are strongly encouraged but not required to keep a journal, however daily journaling during the trip may make it easier to complete the reflective writing assignments below.

Reflective Writing 1:

Discuss (1 - 2 pages) your expectations for the study abroad program. What do you hope to gain from the experience both personally and professionally? How might you expect to utilize what you learn on this trip in your professional career? What are you expecting based on any prior knowledge of the host country? What are you looking forward to the most? Share any concerns or reservations that you may have about the visit.

Reflective Writing 2:

Reflect on your experiences abroad. Discuss (1 - 2 pages) the differences between what you expected and what you actually experienced. Have your experiences met, exceeded or fallen short of your expectations? What have been the most memorable or valuable aspects of the visit so far? What have been the greatest challenges? If you had to choose a set of criteria that would best detail and evaluate your learning process on this trip, what would they be and why?

Due Dates

Due dates for assignments will vary by destination as shown below.

Country	Due Date			
	Assignment 1 (Overview)	**Reflective Writing 1**	**Reflective Writing 2**	**Assignment 3 (Report)**
Chile	February 25	March 8	March 12	April 4
China	April 29	May 5	May 16	June 6
South Africa	June 3	June 9	June 28	July 11
Brazil	July 15	July 21	August 1	August 22

Additional Requirements

In addition to the graded assignments above, participants will be expected to complete the following:

SEAGEP Annual Meeting Presentation

Prepare a presentation with your host country team for the SEAGEP Annual Meeting at the University of Florida in September 2011. This is a group project that will require cooperation from all participants. Your team should designate a leader(s) to organize and coordinate this effort and ensure communication with and participation from the entire group. Each country's team should prepare a presentation that gives an overview of the international experience and addresses the four research topics. Creativity is encouraged.

Final Report

Prepare a professional comprehensive report that captures the knowledge gained from the international experience encompassing the findings from the four research topics for all destinations. This is a group project to be completed with contribution from all participants from each country.

Grading

Students will earn a letter grade in the course. Assignments will be weighted as shown below.

Participation	30 %
Assignment 1	10 %
Assignment 2	10 %
Assignment 3	30 %
Reflective Writing 1	10 %
Reflective Writing 2	10 %
	100 %

Class policies

Attendance

This is a graduate course. It is expected that all students will attend every activity and participate fully. The only allowed absences will be for serious illness or observance of personal religious holidays.

Late Work

Late work will not be accepted.

Academic Honesty

As a result of completing the registration form at the University of Florida, every student has signed the following statement: “I understand that the University of Florida expects its students to be honest in all their academic work. I agree to adhere to this commitment to academic honesty and understand that my failure to comply with this commitment may result in disciplinary action up to and including expulsion from the University.”

APPENDIX G
SEAGEP ITINERARIES

Science & Engineering in the Global Context
Itinerary for Chile Trip (Energy)
Friday, March 4, 2011 to Monday, March 14, 2011

Friday, March 4 → Saturday 5, 2011 (Travel Day from Gainesville, Florida to Santiago, Chile)

10:00am	Arrive in Santiago, Chile (Saturday 3/5/2011) – Aeropuerto Internacional Comodoro Arturo Merino Benítez; Quilicura, Santiago, Chile
12:00pm – 2:00pm	Hotel check-in - Time Suites Hotel
1:00pm – 2:00pm	Travel to downtown Santiago for Lunch
2:00pm – 3:30pm	Lunch at the Downtown Market Place
3:30pm – 6:30pm	“Guided Tour” of Santiago with an English-speaking guide: Historical Sites, Arts & Crafts areas, etc.
6:30pm – 8:00pm	Dinner at typical Santiago style pizza place (Strongly recommended by Dr. Cardenas)
8:00pm – 8:30pm	Drive back to hotel (Retire for the evening)

Sunday, March 6, 2011 (Cultural Tours within and outside Santiago)

8:00am – 9:45am	Rest morning and Breakfast in Hotel
9:45am – 10:00am	Fellows board charter bus to begin Cultural Tour
10:00am – 11:45pm	Travel to Pablo Naruda’s Museum & burial site at Isla Negra
12:00pm – 1:00pm	Tour Pablo Naruda’s House at Isla Negra
1:00pm – 1:30pm	Drive to “EL QUISCO” for lunch
1:30pm – 3:00pm	Lunch by the seashore
3:00pm – 4:30pm	Walk around “THE ROCKS BEACH”: A beautiful site with waves smashing on the rocks
4:30pm – 6:00pm	Return to Santiago through “CASABLANCA VALLEY” (Cultural area with several wineries)
6:00pm – 7:30pm	Stop in Santiago to enjoy Chilean pastries at a “tea house” during “TEA TIME”

Monday, March 7, 2011 (in Santiago, Chile) – (Research presentations and University tour)

8:00am – 12:45pm	Breakfast and Lunch on you own (**Time to work on assignments)
1:30pm	Arrive at the U.S. Embassy-Chile to check-in
2:00pm – 3:00pm	Briefing with Ms. Mary Brett Rogers-Springs, Science, Technology and Health Officer
3:30pm – 4:00pm	Meet Dr. Rios at 3:45pm at the Engineering building, Pontifica Catolica Campus San Jaquin
4:00pm – 6:00pm	Student presentations at Pontifica Universidad Catolica de Chile
6:30pm – 8:30pm	Early dinner or “Chilean Tea time” with Dr. Cardenas & Dr. Rios,
9:00pm	Return to hotel

Tuesday, March 8, 2011 (Travel from Santiago to UTFSM University campus in Valparaiso)

7:00am – 8:00am	Breakfast at Hotel
8:15am – 9:45am	Drive to Federico Santa María Technical University (Valparaiso Campus) Fellows will have an opportunity to meet with faculty, researchers and students who share similar fields and research foci.
9:45am – 10:10am	Meeting with International Office – Ms. Karol Trautmann, Director
10:15am – 11:25am	Meeting with Centro de Energía Renovables, Chilean Government – Mr. Nicolás Faúndez
11:30am – 1:00pm	Meeting with CIE (Center for Energy Innovation), USM – Prof. Jaime Espinoza; Prof. Pedro Serrano; and, Prof. Andrés Olivares
1:05pm – 02:00pm	Lunch gathering with USM researchers and invited students.
2:05pm – 3:00pm	Meeting with GEA (Group for Alternative Energy), USM – Mr.Vicente Olavarría)
3:30pm – 4:00pm	Pontifica Universidad Catolica de Valparaiso
4:00pm – 5:30pm	Visit the Energy Biotechnology Center –student presentations
5:30pm – 7:00pm	Return drive from Valparaiso to Santiago
7:00pm	Arrive at Hotel (Dinner on your own)

Wednesday, March 9, 2011 (Tour of Hydroelectric power plant operations)

7:30am – 8:15am	Breakfast in Hotel
9:00am – 9:15am	Arrival and Welcome from Senior Juan Andres Morel at Colbun

9:15am – 9:45am	Company's presentation and Chilean Energy brief with Colbun's management
10:00am – 11:45am	Travel to the Aconcagua Hydroelectric Plant
11:45am – 12:00pm	Group reception and registration at Los Quilos Hydropower Plant gate
12:00pm – 12:15pm	HSE General Instructions
12:15pm – 12:45PM	Aconcagua Hydropower Plant presentation
1:00pm – 1:45pm	Lunch at Los Quilos
2:00pm – 2:30pm	Visit to Los Quilos Installation
2:30pm – 3:30pm	Visit to "embalse Hornitos"
4:00pm – 4:30pm	Visit with the experts at Chacabuquito Hydropower Plant
4:30pm – 5:00pm	Final Question and Answer time
5:00pm – 6:45pm	Arrive at hotel (Dinner on your own)

Thursday, March 10, 2011 (Visit Energy facility – Biogas)

8:00am – 9:00am	Breakfast in Hotel
9:00am – 12:00pm	"La Farfana" landfill site where Biogas is recovered
	Afternoon and evening free time

Friday, March 11, 2011 (Morning "off" to work on Reflective Writing Assignment & Evening Cultural Tour)

8:00am – 2:30pm	Breakfast and Lunch on your own
3:00pm-4:00pm	Travel to Winery Industry visit (A leading export industry in Chile. The group will have a private, behind-the-scenes tour.)
4:40pm--6:30pm	Private Winery Tour (Presentation by sustainability expert about their energy processes).
6:45pm –7:45pm	Travel back to Santiago (Dinner on your own)

Saturday, March 12, 2011 (Cultural Excursion on Chilean coast: Vina del Mar and Valparaiso area Tour)

7:00am –8:00am	Breakfast at Hotel

8:15am – 9:30am Travel to Vina del Mar

9:30am – 2:30pm Students on their own for cultural excursion at Vina del Mar

2:30pm – 5:00pm Drive through Valparaiso and Tour the historic sites

5:00pm – 6:30pm Return drive to Santiago, Chile (Hotel)

8:00pm – 11:45pm End of the trip dinner at “LOS ADOBES DE ARGOMEDO”

11:45pm – 12:00am At Midnight – drive back to Hotel

Sunday, March 13, 2011 (Santiago, Chile) – (Packing Day for students and Evening Flight from Chile to the US)

8:00am – 5:00pm Breakfast, Lunch and Dinner on your own

6:00pm – 7:00pm Drive to Santiago Airport and unload luggage (Aeropuerto Internacional Comodoro Arturo Merino Benítez; Quilicura, Santiago, Chile)

Monday, March 14, 2011 (Arrive back in the US – Orlando Airport → Return drive to Gainesville)

Science & Engineering in the Global Context
Itinerary for China Trip (Engineering)
Friday, May 6, 2011 to Wednesday, May 18, 2011

May 6 Friday	1:25 AM – Meet at O'Connell Center Parking Garage 1:30 AM – Leave to Jacksonville International Airport 5:45 AM - Flight departs
May 7 Saturday	Arrival in Beijing at 2:20 PM (United Air, UA897) - Dr. Chonghua Zhang will be at the airport to welcome SEAGEP group Transfer to SARIZ INTERNATIONAL HOTEL
Chonghua Zhang	7:00 PM – GROUP DINNER (1), restaurant is located in the commercial section of the same building of Sariz Hotel - welcoming dinner - after dinner adventure around hotel area
May 8 Sunday	Breakfast at Hotel Free Morning for rest or window shopping around hotel area, with many IT shops and shopping mall
Tour Guide: Emma Gao	Lunch on your own 12:40 PM - meet at hotel lobby. We will be accompanied by a tour guide Ms. Emma Gao. 13:20-15:40 PM - Cultural activity – Tour of Forbidden City, Tiananmen Square 17:15-18:30 PM - Hong theatre "Kongfu legend" 18:50-19:40 PM – GROUP DINNER (2) – Bian-Yi-Fang Peking Duck 5/15/Restaurant for Dinner 19:40 PM - Return to Sariz Hotel
May 9 Monday Joined by Dr. Chonghua Zhang	Breakfast at Hotel 9:30 AM - Academy of Art and Design Greeting by the international office of the college and touring the college, joined by Ms. Song Yang, a Ph.D. candidate student and she will soon visit UF on Fall 2011 as visiting scholar for one year. Ms. Song is happy to be your resource person. 12:00 PM - GROUP LUNCH (3) joined by 5 students associated with Tsinghua University Exchange Association. 1:30 PM - 5 Tsinghua University Exchange Association students will give presentation about Tsinghua University and opportunity for questions and establish contact. They can be your resource persons too. SEAGEP student group presentation and discussion (2 groups): Science and Technology in USA Science Communication in USA 3:30 PM - College of Environmental Engineering – visit to the energy saving building and water chemistry laboratory when students are having experiment classes. 5:00pm - return to Hotel Dinner (on your own)
May 10 Tuesday	Breakfast at Hotel 9:30 AM – Meeting with Ms. Li, international Affair Office – will lead the university tour
Tour Guide Dr.	Department of Mechanical Engineering – visit to student labs (incl. Industrial Design Lab)

Chonghua Zhang	State Key Laboratory for Advanced Metal and Materials – Meeting with Professor Ye who will explain the different new material products and lead the tour 12:00pm – GROUP LUNCH (4) at UTSB 1:15pm – Exhibition Center of USTB history 2:30-4:50pm - SEAGEP student group presentation and discussion (2 groups): Technology Transfer in USA Science Education in USA Joined by USTB students - Chinese students will be a mix of disciplines 5:00 PM - Return to Hotel Dinner (on your own)
May 11 Wednesday Tour Guide to accompany to Tianjin Dr. Chonghua Zhang to join	Bring subway cards with you! Breakfast (pick up food box at check in counter) 5:45 AM - Meeting at hotel lobby and walk to Subway Station (Route #4) going to Beijing Train South Station 7:20 AM - Bullet train to Tianjin Tanggu (C2271) 8:30 AM – 11:00 AM – Touring Taida Industrial Park Mr Kang's instant noodle factory (2hr visit including factory visit by mini train and tasting Mr. Kang's instant noodle 11:30 AM – GROUP LUNCH (5) at revolving restaurant at the top floor of Taida Central Hotel 1:40 – 5:20 PM - Tianjin city tour to ancient cultural street & Tianjin Food Street 5:30 – 6:20 PM – Dinner on your own at Tianjin Food Street 8:40 PM - Bullet train back to Beijing 9:30 – 10:20 PM - Transfer by subway Route #4 (Huangzhuang Station)
May 12 Thursday Joined by Dr. Chonghua Zhang	Breakfast at Hotel 8:20 Meet at hotel lobby 8:30 AM - Bus depart from Hotel to China Agricultural University (East Campus) and arriving at CAU at 9:00AM Ms. Tang Ying of International Office will lead us for the visit. There will be a group of 9 students from IFAS of UF to join us. This visit will be combined with the visit by UF IFAS group 9:30 AM - Food Science Department Precision Agriculture Machinery Lab 12:00 PM – Return to Sariz Hotel Free afternoon Lunch and Dinner on your own
May 13 Friday Tour Guide Ms. Emma Gao	Breakfast at Hotel 8:15am - Bus departs to the Great Wall 9:40-11:15 AM – The Great Wall ((Ju-Yong-Guan Gate) 11:40 AM – GROUP LUNCH (6) 1:25 -2:25 PM – Take Bus to Chang Ling Imperial Tomb 2:35 – 4:00 – Return to Beijing 4:20-5:00 PM - Olympic Park, exterior view of Bird Next Olympic Stadium and Water Cube swimming pool 5:20-6:00 PM -Dinner on your own 6:00 PM – Depart to Peking Opera House 6:40 PM – Arriving at Opera House 7:30-8:45 PM – Perking Opera Performance 9:30 PM – Return to Sariz Hotel

May 14 Saturday Tour Guide Ms. Emma Gao Chonghua To travel to Shanghai	Last Day in Beijing! Breakfast at Hotel Free Morning for shopping and Lunch on your own 12:00 PM - Hotel check-out (leave luggage in the bus) 12:30 PM – Bus departs to Summer Palace 12:30-2:00 PM – Tour at Summer Palace 2:00 – 3:00 PM – Xiu-Shui Street Shopping Plaza Dinner on your own 8:00 PM – Bus departs to Beijing Train Station 10:15 PM – Train departs to Shanghai "T109" (evening sleeper train)
May 15 Sunday	11:39 AM - Arrival in Shanghai. Bus transfer to Baron Business Hotel Tour guide to meet us at Shanghai railway station Lunch on your own Free afternoon Dinner on your own
May 16 Monday Chonghua Zhang	Breakfast at Hotel 8:15am – bus to Suzhou (1.5 hour drive) 9:40 -10:40 AM - Visit to The Master-of-Nets Garden 11:00 – 11:40 AM - The Ancient Canal by boat 12:00 – 2:20 PM – GROUP LUNCH (7) at Suzhou Silk Factory and touring the factory 2:45 PM– Bus to Suzhou Industrial Park 3:20-5:00 PM – Meeting with Park Administration (learn about park planning, etc.) 5:20 PM– Return to Shanghai (1.5 hour drive) Dinner on your own
May 17 Tuesday Chonghua Zhang	Breakfast at Hotel 10:00 AM – bus tour of Shanghai – World Expo China Pavilion 12:00 –1:15 PM – Lunch on your own 1:15 -3:00 PM Shanghai Museum 3:00 – 5:00 PM - Shanghai Urban Planning Exhibition Center 5:00 – 7:00 PM – GROUP DINNER (8) at Oriental Pearl Tower (revolving restaurant) 8:00 PM - Return to hotel
May 18 Wednesday	Breakfast at Hotel Free Morning – packing/last-minute shopping 11:00 AM - Hotel checkout 11:30 AM – Depart to Shanghai International Airport Lunch on your own at the airport after flight checkin 3:55 PM - United Airlines flight departs
May 18	Arrival in Jacksonville at 11:00 PM Transfer to Gainesville

Science & Engineering in the Global Context
Itinerary for South Africa (Ecology/Conservation)
Friday, June 10, 2011 to Tuesday, June 21, 2011

10 June, Friday Jacksonville/FL	11:30 AM – FL students/faculty: Depart O'Connell Center Garage to Jacksonville (2 vans for 10 people) 3:16 PM – FL students/faculty: Flight departs from Jacksonville 5:45 PM – Group (UF & USC students/faculty) meet at the departing gate in Atlanta airport
11 June, Saturday Johannesburg	5:00 PM - Arrival in Johannesburg O.R. Tambo *International Airport* (ORTIA) 8:00 PM – Bus to the Hotel Hotel check-in
12 June, Sunday Johannesburg	Morning – recovery 10:50 AM – Meeting in the Lobby for Soweto Cultural Tour (bring snacks or have late breakfast) 11:00 AM – Bus depart to Soweto 5:00 PM – Group Dinner 7:00 PM – Bus to the hotel
13 June, Monday Pretoria	Drive to Pretoria: 8:30 AM – Check out from hotel 8:45 AM – Bus departs to Pretoria (65km away) 10:00 -11:00 AM - Innovation Hub (commercialize scientific and technological discoveries 11:30 AM - CSIR (Council for Scientific and Industrial Research) 12:30 PM – Bus transfer to University of Pretoria (UP) 1:00 PM – Lunch on your own at UP's campus 2:00 PM – University of Pretoria Campus tour (accompanied by Tourism Department students) 5:00 PM – Bus to the hotel 5:30 PM – Hotel check-in Overview of next day's itinerary and meeting with faculty Dinner on your own
14 June, Tuesday Pretoria	8:30 AM – Bud departs to the Zoo. Bring snacks as late lunch 9:00 – 10:45 AM – Pretoria Zoo (wildlife research) 10:45 – 12:30 PM – Tswhane University of Technology (TUT) (12:30 PM – Bus to the USDA office 1:00-3:00 PM – USDA office at the US Embassy - Corey Pickelsimer (Senior Agricultural Attaché) 3:00 PM – Late lunch (on your own) and return to the hotel 5:30 -6:00 PM - Overview of next day's itinerary and meeting with faculty 6:00 PM – Meeting with Dr. Amy Sullivan (agricultural project) at the hotel Dinner on your own
15 June, Wednesday Polokwane	Drive to Polokwane: 8:00–9:30 AM – Breakfast with Tongila Manly (Enterprise Florida Southern Africa Office) 9:30-11:00 AM - Student discussion at hotel

	11:15 AM - Hotel check-out 11:30 AM - Bus departs to Polokwane (4 hrs drive) Stop for lunch (on your own) on the way to the mine 2:00-4:00 PM - Cullinan Diamond Mine Tour 4:00 PM – Bus departs to Polokwane 5:00 PM - Hotel check-in 6:00 PM - Dinner with representatives from the Ministry of Ag Overview of next day's itinerary and meeting with faculty
16 June, Thursday Polokwane Public holiday: Youth Day	9:00 AM – Bus departs to the field Projects by the Ministry of Agriculture: Water management Alternative compost making project Biopesticide research project Lunch and dinner on your own. For lunch bring snacks, etc. as the group will be in the field 4:00 PM – Bus to the hotel Overview of next day's itinerary and meeting with faculty
17 June, Friday Phaloborwa	Drive to Phaloborwa 8:00 AM – Hotel check-out 11:00 AM-12:30 PM – Meeting with Louise Swemmer (Senior Social Scientist) SAEON/Scientific Services Office. 12:45 PM – Bus departs Amarula Factory visit 5:00 PM - Hotel check-in Overview of next day's itinerary and meeting with faculty Lunch and dinner on your own
18 June, Saturday Nelspruit	Drive to Nelspruit 8:00 AM – Hotel check-out Bring snacks! Drive via Blyde Canyon Scenic drive called the Panorama Route (80km drive) with stops such as God's Window, Bourke Luck Potholes, Mac-Mac Falls & Pools 5:00 PM - Hotel check-in Lunch and dinner on your own Overview of next day's itinerary and meeting with faculty
19 June, Sunday Nelspruit	Breakfast in the hotel Kruger National Park Lunch on your own Evening Game Drive in Kruger National Park – meet at Numbi Gate. Sanparks vehicles depart from Numbi Gate at 5:00 PM for a 3 hour game drive through the national park, returning to Numbi Gate at approx 8:00 PM. 9:00 PM – Return to the Hotel
20 June, Monday Nelspruit	5:00 AM – Bus departs to Skukuza via Paul Kruger gate 5:30 AM – Kruger National Park 5:00 PM – Return to hotel Lunch and dinner on your own

21 June, Tuesday Last Day	Drive to Johannesburg 8:30-9:30 AM – student group discussions 10:00 AM - Check out from hotel 10:15 AM - Bus departs to Johannesburg 5:00 PM – Arrival at O.R. Tambo Johannesburg *International Airport* 8:20 PM – Flight departs to USA (flight No. DL201)

Science & Engineering in the Global Context
Itinerary for Brazil (Agriculture & Natural Resources)
Saturday, July 23, 2011 to Monday, August 1, 2011

Date and Location	Activity Description
Saturday, 07/23 Sao Paulo	1:00 pm – Meet at O'Connell parking garage and drive to Jacksonville 5:34 pm – Flight departs from Jacksonville International Airport 8:30 pm – Group (UF, USC & Clemson) meet at departing gate in Chicago Airport for introductions
Sunday, 07/24 Sao Paulo	9:45 am – Arrive in Sao Paulo International Airport (GRU) 11:30 am – Transfer to Hotel and check-in 1:00 pm - Lunch (on your own) @ MASP 2:00 pm - Cultural: ▪ Street market at Paulista Avenue (the most important economic & cultural avenue in SP) ▪ FILE exhibition (Electronic Language International Festival) 6:00 pm – Group Dinner @ Angelica Grill (steak house) 8:00 pm – Return to hotel Optional: Skye Bar (design bar with a great view of Sao Paulo)
Monday, 07/25 Sao Paulo	Breakfast in hotel 10:00 am – Walk to UNICA (10 min) 10:30am -12:00 pm - UNICA (Brazilian Sugarcane Industry Association) 12:30 pm – Transfer to University of Sao Paulo (USP) Lunch (on your own) on campus @ Swedish Restaurant 2:30–4:00 pm - Institute of Electronics and Energy, USP 5:00 pm – Transfer to Hotel 6:30-7:30 pm – Group discussion (1)
Tuesday, 07/26 Sao Paulo/ Nazare Paulista	Breakfast in hotel 9:00 am – Hotel check-out and transfer to: 10:00–11:30 am – FAPESP (Foundation for Research Support of Sao Paulo) 12:00–1:30pm – Lunch (on own) @ Eldorado Shopping Mall 2:00–4:00 pm - ETH Bioenergia S.A., a company of the Odebrecht Group 5:00 pm - Transfer to IPE in Nazare Paulista (90kms)
Wednesday, 07/27 Nazare Paulista/ Piracicaba	Breakfast in IPE lodge 9:00-4:00 pm –Instituto de Pesquisas Ecologicas (IPE) Lectures: overview of IPE, history of deforestation, reforestation and research projects, animal research at IPE Participation in re-foresting effort (Plant a tree) 4:00 pm – Transfer to Piracicaba
Thursday, 07/28 Campinas/ Piracicaba	Breakfast in hotel 8:00 am – Drive to Campinas (85kms) 9:00–12:00 pm – NIPE (Interdisciplinary Center for Energy Planning) at University of Campinas (UNICAMP)

	12:30 pm – Lunch (on your own) in UNICAMP 2:00–5:00 pm - Sugar and ethanol factory in Easter
Friday, 07/29 Piracicaba	Breakfast in hotel 9:30 am – Transfer to USP Campus in Piracicaba 10:00 -11:30 pm – ESALQ (School of Agriculture), USP campus in Piracicaba National Bio-fuels Program 12:00-1:45 pm – Lunch (on your own) @ Rua do Porto 2:30–4:30 pm – CTC: Center of Sugarcane Technology 5:00-6:30 pm – USP campus in Piracicaba: CEPEA (Center for Advanced Studies on Applied Economics) Dinner on your own
Saturday, 07/30 Sao Paulo	Breakfast in hotel 8:30-9:30 pm – Group discussion (2) 10: 00 am – Hotel checkout and transfer to Sao Paulo (160 kms) 12:00 pm – Hotel check-in 12:30pm - Lunch (on your own) at Iguatemi Shopping Mall 2:00 pm – Cultural: Ibirapuera Park and Afro-Brazilian Museum 7:30 pm – Optional: Soccer game – Palmeiras vs. Atletico Mineiro
Sunday, 07/31 Sao Paulo	Breakfast in hotel 8:00 am – Drive to Peruibe (141kms) Parque da Jureia (Jureia Natural Park) 5:00 pm - Return to Sao Paulo
Monday, 08/01 Sao Paulo	Breakfast in hotel Free morning 12:00 pm – Hotel check-out 1:30 pm – Cultural: ▪ Walking tour of historic downtown (Catedral da Se, Benedictine Monastery, Santander Tower, etc.) ▪ Bovespa – Sao Paulo Stock Exchange 4:45 pm – Transfer to Sao Paulo International Airport (GRU) 9:10 pm – Flight departs Sao Paulo

APPENDIX H
SEAGEP STUDY ABROAD PROGRAM PARTICIPANTS

Student Code	Sex	Ethnicity	Discipline	Academic & Personal Assessment		IDI		Reflective Writing
				Pre-trip	Post-trip	Pre-trip	Post-trip	
C1	M	His	Eng	Y	Y	Y	Y	Y
C2	F	AA	L & P	Y	Y	Y	Y	Y
C3	F	His	Eng	Y	Y	Y	Y	Y
C4	M	His	L & P	Y	Y	Y	Y	Y
C5	M	AA	Eng	Y	Y	Y	Y	Y
C6	F	AA	L & P	Y	Y	Y	Y	Y
C7	M	AA	Eng	Y	Y	Y	Y	Y
C8	F	His	Eng	Y	Y	Y	Y	Y
C9	F	AA	Eng	Y	Y	Y	Y	Y
C10	M	His	Eng	Y	Y	Y	Y	Y
C11	M	AA	Eng	Y	Y	Y	Y	Y
C12	M	AA	Eng	Y	Y	Y	Y	Y
C13	M	His	Eng	Y	Y	Y	Y	Y
C14	F	AA	Eng	Y	Y	Y	Y	Y
C15	F	His	Eng	Y	Y	Y	Y	Y
SA1	F	AA	L & P	Y	Y	Y	Y	Y
SA2	F	His	L & P	Y	Y	Y	Y	Y
SA3	M	NA	L & P	Y	Y	Y	Y	Y
SA4	F	His	L & P	Y	Y	Y	Y	Y
SA5	F	AA	Eng	Y	Y	Y	Y	Y
SA6	F	AA	L & P	Y	Y	Y	Y	Y
SA7	M	His	Eng	Y	Y	Y	Y	Y
SA8	F	His	L & P	Y	Y	Y	Y	Y
SA9	F	AA	Eng	Y	Y	Y	Y	Y
SA10	M	O	L & P	N	N	N	N	N
B1	F	His	L & P	Y	Y	Y	Y	Y
B2	M	AA	Eng	Y	Y	Y	Y	Y
B3	M	AA	Eng	Y	Y	Y	Y	Y
B4	F	His	L & P	Y	Y	Y	Y	Y
B5	F	His	Eng	Y	Y	Y	Y	Y
B6	M	AA	L & P	Y	Y	Y	Y	Y
B7	M	His	L & P	Y	Y	Y	Y	Y
B8	M	AA	L & P	Y	Y	Y	Y	Y
B9	M	His	L & P	Y	Y	N	N	N
B10	M	NA	Eng	Y	N	N	N	N

Key for Table

Student codes	
C	China
SA	South Africa
B	Brazil
Sex	
M	Male
F	Female
Ethnicity	
AA	Black/African/African American
His	Hispanic/Latino/Spanish
NA	American Indian or Alaskan Native
O	Other
Discipline	
Eng	Engineering
L & P	Life and Physical Science
Survey/Writing Responses	
Y	Yes
N	No

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BIOGRAPHICAL SKETCH

Nicola Kernaghan was born in Northern Ireland and earned a Bachelor of Science in Geography from Queen's University Belfast and a Master of Science in Environmental Management from the University of Stirling in Scotland. Nikki immigrated to the United States in 1993 and worked as a biological scientist in several areas of Florida for over 10 years. She joined the University of Florida International Center in 2004 as an outreach coordinator and entered the Ph.D. program in the College of Education as a part-time student in 2005. While pursuing her doctoral degree, Nikki continued to work at the International Center, where she is currently the Assistant Director for Program Development. Nikki has participated in grant projects for several federal agencies and serves as Program Manager for a National Science Foundation grant integrating STEM education. In her current position, Nikki focuses on science education and evaluation of international programs.