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Developing Globally Competent Engineering Researchers: Outcomes-Based Instructional and Assessment Strategies from the IREE 2010 China Research Abroad Program

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ABSTRACT

Responding to globalization trends, many engineering schools are internationalizing their courses and curricula to prepare graduates for careers that involve working across countries and cultures. As a result, both students and staff are looking beyond study abroad to international work, research, and service learning opportunities as alternate pathways for high-impact experiential learning in global context. However, such programs can also pose unique challenges related to preparing students for professional practice abroad and systematically evaluating program outcomes and impacts among students and other stakeholders. This paper responds to these challenges by reporting on International Research and Education in Engineering (IREE) 2010 China, a summer engineering research abroad program. It describes orientation strategies designed to improve student readiness for global practice, and presents mixed-method assessment methods and results for global engineering competency and other key learning outcomes. The main audience for this paper includes faculty and staff who develop and support global learning experiences in engineering and other professional degree programs.

Key Words: experiential learning, global engineering education, global competency

INTRODUCTION

Over the last decade, international education has gained significant prominence and visibility in many professional schools, in part reflecting broader globalization dynamics and increasing demand for a globally competent workforce. Bousquet (2003), for example, summarizes internationalization trends and drivers in schools of business, engineering, and medicine, while Ferguson (2010) documents similar movements in law schools. Nonetheless, there remain many challenges associated with expanding participation in global education programs among students pursuing professional degrees. In fact, NAFSA: Association of International Educators has identified "science and technology majors" and "students from professional schools" as among populations of special interest in ongoing efforts to scale up education abroad (NAFSA, n.d.; Anderson, 2009). Specific difficulties faced by these groups include fitting study abroad and related coursework into already full schedules, transferring academic credit from institutions abroad, a lack of support from faculty and administrative staff, and weak connections between professional schools in the U.S. with their counterpart institutions abroad (Bousquet, 2003).

Similar patterns are evident in the field of engineering education. For more than a decade, many influential stakeholders have argued that global competency is crucial for cultivating a new generation of "global engineers" who are ready to work an increasingly diverse, interconnected, and rapidly changing world (e.g., Boeing, 1997; Wulf, 2003; Katehi, 2005; Sigma Xi, 2007; Grandin & Hirleman, 2009). Yet as many of these same reports explain, most degree courses and programs fail to produce truly global engineers, leading the authors to call for reforms. Parkinson (2007) has estimated that only about 7.5% of engineering students study abroad, while Shuman adds that just 10-15% of engineering schools are taking global education seriously (Bremer, 2008). Another group of reformers noted the lack of a widespread tradition of "sending engineers to study or work abroad," and they went on to identify sixteen contemporary obstacles to scaling up global engineering education (Grandin & Hirleman, 2009).

Historically, study abroad programs have been the primary means by which students in engineering and most other fields add an international dimension to their education. In addition, many organizations and institutions have tended to report international education trends by tracking only those students who receive academic credit for their participation in global programs, which further exaggerates the visibility and prominence of study abroad. To be sure, study abroad and other for-credit activities are essential parts of the global learning portfolio. However, another important strategy for promoting global learning experiences among students in engineering and other professional schools centers on looking beyond traditional credit bearing *study* abroad programs and toward curricular or extracurricular *work, research,* and/or *service learning* experiences abroad.

These alternative program formats offer participants a wider range of opportunities for relevant, experiential learning, including hands-on and/or project-based work situated in global context. Programs of this type also have other features that can appeal to many professional school students, such as better scheduling flexibility, work positions that may include some sort of salary, research options for graduate students, and less problems with determining course-to-course equivalencies for credit transfer. As a result, many professional schools are expanding their global offerings to include programs of this type. Yet in doing so they face many new challenges, such as getting students ready for these unique experiences, identifying sources of funding, sustaining cross-national relationships, and systematically evaluating learning outcomes and other kinds of impacts.

As a contribution to the literature on global professional learning, this paper reports on International Research and Education in Engineering (IREE) 2010 China, an engineering research abroad program. More specifically, it discusses orientation strategies designed to better prepare engineers for professional work abroad, as well as leading-edge assessment techniques to measure how programs of this type impact student learning and develop professional competence. Our work is unique given its discussion of a program serving both undergraduate and graduate students, along with its specific focus on *global engineering competency*. As discussed in more detail below, we propose that this construct is comprised of a variety of attributes that are particularly relevant for engineering practice in cross-national/cultural contexts.

The literature review that follows is focused on program formats and assessment strategies for international education. We begin with a discussion of general trends in professional schools to help show how our efforts are situated and relevant in a wider context. We then turn to engineering more specifically, including strategies for developing and assessing global engineering competency and related capabilities. This is followed by a summary description of the IREE 2010 China program, with emphasis on orientation content and learning activities. The final sections of the paper discuss assessment methods and results related to participants' perceived readiness to go abroad, foreign language learning, cross-cultural competence, and global engineering competency. The paper concludes with a brief discussion of best practices for faculty and staff who develop and support global learning experiences in engineering and other professional degree programs.

LITERATURE REVIEW

International Education in the Professions: Learning Outcomes, Program Formats, and Assessment Strategies

Data collected by organizations like Institute for the International Education of Students (IES Abroad) and Institute of International Education (IIE) provide important evidence regarding benefits often associated with participating in educational experiences abroad (Dwyer & Peters, 2004; J. Walter Thompson Education, 2003). Many of these benefits are in turn frequently linked to the concept of "global competency." As summarized by participants at the 2007 Lincoln Commission

Forum on Study Abroad and Economic Competitiveness, "Studies show that business has a growing expectation of new employees having global competency, and that there is a growing appreciation by employers of the strong correlation between study abroad and global competency" (Stearns, 2009, p. 68). The extant literature on international education also reveals many other attributes frequently associated with educational experiences abroad, such as *intercultural competency*, *intercultural communication competence*, *world-mindedness*, *cross-cultural knowledge/awareness*, *open-mindedness*, and *global citizenship*, to name a few (Byram & Nichols, 2001; Beamer 2011; Douglas & Jones-Rikkers, 2001; Deardorff, 2009). The specific concepts used to define global competency and related constructs vary considerably depending on the program and discipline, and the associated terminology is often used ambiguously and interchangeably.

Definitional issues are among a longer list of challenges faced when studying the impacts and outcomes of global experiences. In fact, many discussions of international education use the word *assessment* rather loosely and broadly. In this paper we distinguish between *program evaluation* and *assessment of learning outcomes.* While both are important to the success of a study abroad program, each approach involves partially distinct data and goals. Program evaluation typically looks at overall measures of program quality and success, including various participation benchmarks (e.g., how many students in what programs and to what destinations) and perceptions of program quality (e.g., program format, logistics, student support, financial aspects, etc.). Evaluation studies are often focused on gauging the overall success of a program, while potentially fulfilling various institutional reporting requirements.

In contrast, we understand assessment in education abroad as focused on measuring specific learning outcomes among participants, including those related to global competency. Approaches to assessing such outcomes vary widely and often fall short (e.g., Deardorff, 2009a; 2009b). Many of the instruments employed by faculty and administrators are custom developed for specific programs and thus lack content validity and empirical strength. Another prominent pitfall in assessing learning outcomes involves overreliance on students self-rating their proficiency or competence in specific areas, where it is often unclear whether there is a shared understanding of how outcomes are defined, much less whether or not respondents possess the abilities they report (Podsakoff & Organ, 1986). In other instances, program staff and researchers struggle to find and implement methods that can detect meaningful changes in global competency resulting from various kinds of global learning experiences (Stearns, 2009, Ch. 9).

These difficulties are not surprising, especially given the complexity of the constructs involved and the large number of extant papers and tools focused on global competency. A comprehensive overview of theories and research on intercultural competence by Spitzberg and Changnon (2009), for example, identified more than a hundred instruments available to measure many different facets of intercultural competence and related constructs. Along similar lines, Fantini and Tirimizi (2006) identified 69 instruments that measure various aspects of intercultural competence, e.g., tolerance, foreign language proficiency, individual-collective orientation, openness, and so on. Given such challenges, programs often adopt assessment tools that are readily available or easy to deploy, even if they are not well aligned with their participant populations and/or the intended program learning outcomes.

Nonetheless, over the last decade a handful of quality instruments have gained considerable prominence in ongoing efforts to measure intercultural competence and related constructs, including through the efforts of a number of international programs run by professional schools. Representative examples include: Intercultural Development Inventory (IDI), which assesses the extent of an individual's intercultural development along a continuum ranging from extreme ethnocentrism to ethnorelativism (Hammer, Bennett, & Wisemen, 2003); Beliefs, Events and Values Inventory (BEVI), which measures whether, how, and to what degree people are (or are likely to be) "open" to various transformational experiences such as studying abroad (Shealy 2004, 2005); and the Cross-cultural Adaptability Inventory (CCAI), which evaluates some key qualities associated with cross-cultural effectiveness, including personal autonomy, perceptual acuity, flexibility and openness, and emotional resilience (Kelley & Meyers, 1992). As this summary suggests, each of these instruments assesses different dimensions of intercultural competence. This can in part be attributed to the complexity of the constructs involved, as well as a general lack of consensus regarding how intercultural competence and related concepts might best be defined.

The professional schools face further challenges related to defining and assessing key learning outcomes that are partially or wholly specific to their fields, especially given the wide variety of global program formats open to students. Since at least the 1980s, for example, international education has gained considerable momentum in the business and management fields, and coverage of international business and globalization topics is increasingly the norm in most degree programs (Kwok, et al., 1994; Bousquet, 2003; AACSB, 2011). In fact, by 2009-2010 business/management students represented 20.8% of all American students studying abroad, second only to students in the social sciences (22.3%) (IIE, 2011), while a 2009 study found that 55 of 70 (or almost 80%) of surveyed MBA programs had some kind of global requirement (D'Angelo, 2012). Interest also continues to grow around providing business and management students with experiential learning opportunities through work and/or study abroad (Edwards et al., 2003; AACSB, 2011), and evidence suggests that short travel programs and virtual teamwork experiences are prevalent formats, especially at the Master's degree level (Forray & Woodilla, 2011).

Yet despite the apparent relevance of global themes in business and management schools, there remains a lack of valid and reliable strategies to specify and assess related facets of global competence. One literature review of leading business journals from 1976-2004 revealed a lack of agreement about how experts in the field define cross-cultural competence (Johnson, Lenartowicz, & Apud, 2006). They also noted a lack of in-depth studies focused on specific knowledge, skills, and attitudes underlying cross-cultural competence. A recent report from the Association to Advance Collegiate Schools of Business (AACSB) similarly points to both definitional and assessment challenges as business schools internationalize, including too little attention paid to identifying specific learning outcomes related to international competencies, conceptual ambiguity around popular terms like "global mindset," and a tendency to narrowly focus assessment on knowledge gains rather than changes in values and attitudes (AACSB, 2011).

As many recent reports indicate, the impacts of globalization are also evident in many U.S. medical schools (Chase & Evert, 2011). For example, the number of medical students reporting participation in "global health experiences" doubled from 15% in 1998 to more than 30% in 2011 (Chase & Evert, 2011; AAMC, 2011). The field also has its own particular array of program formats, including somewhat less emphasis on formal coursework abroad in favor of opportunities for global learning through student and other non-profit organizations, global health initiatives, and clinical rotations at institutions abroad (Drain et al., 2007; Chase & Evert, 2011). Other typical activities include training in foreign language and culture, working in health clinics and community outreach programs, performing comparative studies of U.S. and foreign medical systems, and deploying and maintaining medical devices. Opportunities for research abroad are also reasonably common in graduate medical education (Chase & Evert, 2011; McKinley et al., 2008).

While such programs provide medical students with meaningful and eye-opening experiences, efforts to systematically measure related learning outcomes remain underdeveloped. For instance, Mustchnick, Moyer, and Stern (2003) conducted a review of forty-two papers on the impacts of cross-cultural exchanges on medical and nursing students. While most of the papers they surveyed described increases in global competence and personal development among participating students, they largely failed to demonstrate clear benefits to those who participated in international education as compared to those who did not. In fact, the paper cites only three studies that comment on the validity of the assessment tools used, with much of the rest of the literature relying on subjective, self-reported outcomes. The authors conclude by calling for further investigation of behavior-based outcomes, including those that utilize patient evaluation and patient satisfaction scales to more systematically and rigorously measure the effectiveness of professionals-in-training. As another notable contribution in this space, a recent guidebook on *Global Health Training in Graduate Medical Education* proposes six specific areas of competence for students in residency global health training programs (Anspacher et al., 2011). While the authors tend to emphasize self-assessment strategies in their report, they do list a number of more rigorous approaches such as knowledge tests, direct observations of performance, patient surveys, 360-degree evaluations, etc.

As international education continues to expand and diversify to suit the needs of the professional fields, there will likely be increasing need for definitional clarity of learning outcomes and associated assessment tools that are valid, reliable, and scalable. In addition to measuring global competency in general, effective assessment strategies must also investigate how different kinds of program formats and learning experiences are contributing to the formation of global professionals.

Global Engineering Education: Learning Outcomes, Program Formats, and Assessment Strategies

Historically, the impact of internationalization trends on most engineering degree programs has been modest. However, there is evidence of a long tradition of engineering students engaging in many kinds of experiential learning abroad, from volunteer activities and service learning projects to working in foreign labs, firms, or branch offices (Jesiek & Beddoes, 2010). Many contemporary discussions of global engineering education have acknowledged and discussed these different modes of global learning. For example, Downey et al. (2006) present a typology of methods for achieving global competency, including international work placements. Along similar lines, Parkinson's (2007) review of global learning opportunities in engineering mentions intern/co-op and research abroad, including specific examples of programs in each category. Also of note is a recent paper by Arzberger et al. (2010) that compares and contrasts four programs that provide science and engineering students with research and/or study abroad opportunities.

While a comprehensive review is beyond the scope of this paper, it is worth discussing some of these initiatives in more detail to gain further insights regarding the kinds of orientation and assessment strategies utilized by such programs. For instance, Arzberger et al. (2010) present an in-depth profile of Pacific Rim Experiences for Undergraduates (PRIME), a summer research abroad program that from 2004 to 2009 sent more than a hundred students for nine-week research placements in the Pacific Rim. Pre-departure training included a two-hour session on culture, and students were asked to write weekly responses to reflection questions while abroad. In discussing assessment strategies and metrics, the organizers emphasize cultural awareness as a key outcome, and present preliminary results suggesting positive pre/post-travel trends in Intercultural Development Inventory (IDI) scores for 21 PRIME participants.

A somewhat more ambitious approach is evident in NanoJapan, a summer nanotechnology research abroad program for undergraduate students based at Rice University. To begin, participants are required to complete a robust three-week orientation program in Japan that covers: relevant technical topics; language, including technical Japanese; and an introduction to Japanese culture, society, and history (Matherly, Phillips, & Kono, 2011). This is followed by eight-week placements in university research labs across Japan. The program's ambitious assessment plan includes data collected using the Pittsburgh Freshman Engineering Student Attitude Assessment (PFESAA), Oral Proficiency Interview (OPI) for language capabilities, weekly blog posts, and longitudinal tracking of graduates (NanoJapan, n.d.). However, little in the way of results has yet been reported.

As part of its International Plan (IP), Georgia Institute of Technology has also facilitated expanded global learning opportunities for its engineering students, including research and work abroad placements that can be used by students to fulfill some program requirements. Explicitly framing their approach to global education as oriented toward "competency" rather than "activities," IP has been intentionally designed as a structured and multi-faceted intervention that lives within the context of existing degree programs (Gordon & Lohmann, 2008). The evaluation framework for the program is also ambitious and robust, involving multiple measures of second language proficiency, comparative global knowledge, intercultural assimilation, and intercultural sensitivity (Lohmann, Rollins, & Hoey, 2006). While findings have not yet been widely published, early results presented in institutional reports and at conferences suggest substantial improvements in IDI scores among participants, as well as evidence of enhanced career satisfaction and success (Georgia Institute of Technology, 2011; Gordon & Henry, 2011).

The University of Rhode Island's International Engineering Program (IEP) also has an internship abroad requirement for participating students as they work toward dual Bachelor's degrees in engineering and foreign language (German, French, Spanish, or Chinese) (Grandin, 2006). Faculty and administrators who have been involved with the program have generated a number of notable publications reporting student outcomes, including a book by Grandin (2011) that profiles fifteen graduates of the program, largely based on interviews. In addition, Erickson (2011) reports on exit survey and interview data collected from eleven IEP graduates, placing particular emphasis on language competency, technical abilities, and cross-cultural sensitivity.

While further review of programs offering students research or work placements abroad is beyond the scope of this paper, other examples worth noting include the University of Cincinnati's well-known International Co-op program (Elliot, 2006) and Purdue University's Global Engineering Alliance for Research and Education (GEARE) (Allert et al., 2007; Groll & Hirleman, 2007; Chang, Groll, & Hirleman, 2011). Many individual students and universities have also benefited from services provided by the International Association for the Exchange of Students for Technical Experience (IAESTE), which has been helping American students find technical internships abroad since at least the 1950s (Jesiek & Beddoes, 2010). NSF has played an important role in this area by providing support for undergraduate and graduate research abroad under the auspices of International Research Experiences for Undergraduates (IREUs), East Asia and Pacific Summer Institutes (EAPSI) for U.S. Graduate Students, Partnerships for International Research and Education (PIRE), and other programs.

As this overview suggests, there is considerable diversity in the preparation and orientation strategies employed by programs that send engineering students abroad for research and/or work, ranging from relatively brief one-time training sessions to immersive, multi-week (or even multi-semester) courses of study. Yet there is little evidence regarding the variable effectiveness of preparatory activities depending on their scope, duration, and content. Investigating such variables is made even more challenging given that it is often very difficult to separate the impacts of orientation from other kinds of program components, activities, and experiences.

Additionally, the extant literature on outcomes and assessment reflects a historical emphasis on conventional technical skills, along with various capabilities typically associated with globally competent individuals from most any professional field, such as language skills, and intercultural competency and related constructs. Much less attention has been paid to evaluating what we call "global engineering competency," which includes a range of attributes uniquely or particularly relevant for practicing engineering in cross-national/cultural contexts. Johri and Jesiek (in press) propose a preliminary list of thematic areas that may in part constitute this domain, including: global engineering ethics, cross-cultural technical teamwork, international standards and regulations, and knowledge brokering. These authors also draw on the work of Downey et al. (2006) to discuss related attributes in the area of "engineering cultures," including the ability to understand and work in the midst of patterned differences in engineering work practices across cultures, countries, and regions. Parkinson (2009) similarly points to the importance of being able to "[u]nderstand implications of cultural differences on how engineering tasks might be approached" (p. 11).

Assessment strategies targeting these kinds of specialized yet very important areas of competence remain underdeveloped. As Lohmann et al. note in their discussion of global competency in engineering: "Largely absent are studies featuring rigorous methods for assessing … competencies specifically related to professional practice within the academic discipline" (2006, p. 125). In response, Georgia Tech has been assessing "global disciplinary practice" through employer surveys and rubric-based evaluations of senior design projects. However, little has yet been reported on the success of these approaches, and their portability and scalability remain unclear.

Other related work includes Ragusa's Engineering Global Preparedness Index (EGPI), a 30-question survey covering four subscales: engineering ethics, engineering efficacy, engineering global-centrism, and engineering community connectedness (Ragusa, 2011). Although early results show promise, this instrument's basis in global citizenry theory may restrict its relevance to certain contexts and program types (e.g., academic rather than industry settings), and its validity is limited by its reliance on self-efficacy data. Downey et al. (2006) have taken a different approach to assessing students in an undergraduate elective course (n = 146) that aims to develop global competency. Their open-ended scenario-based instrument is designed to evaluate the ability of students to "explain how national differences among engineers are important in engineering work" (Downey et al., 2006, p. 117). A pre/post-course multiple-choice quiz was also used to measure attainment of course content knowledge, and a final course survey asked students to self-report their gains related to specific course learning outcomes. This research showed significant pre/post-course increases in student attainment of key aspects of global engineering competency. Amelink et al. (2012) have probed some similar themes in a short-term engineering study abroad program through analysis of qualitative data collected via a pre/post-course writing assignment and a focus group session.

In part building on the work of Downey et al. (2006), this paper represents another contribution to the small but growing body of literature discussing training and assessment strategies for global engineering programs that send students abroad for research and/or professional work. In the sections that follow we turn to a more detailed description of the IREE 2010 China program, followed by a discussion of our assessment methods and findings.

IREE 2010 CHINA: PROGRAM OVERVIEW AND INSTRUCTIONAL STRATEGIES

Initiated in 2006 by NSF Divisions in the Directorate for Engineering (ENG) and Office of International Science and Engineering (OISE), the International Research and Education and Engineering (IREE) program originally had two main objectives: 1) "providing early-career researchers in engineering with international experience in research and education," and 2) "enhance and broaden engineering research and education activities in current engineering awards by initiating closer linkages between awardees and their foreign counterparts" (NSF, 2006). During its first two cycles (FY2006 and FY2007), IREE was run as a supplemental funding program, where existing NSF grantees could apply for additional financial support to send early career engineering researchers (including students, post-docs, and faculty) to collaborating institutions outside the U.S. for medium-duration visits (3-6 months). A total of 247 awards were made during this period, supporting grantee travel to collaborating institutions in 45 different countries (Chang & Hirleman, 2008; Chang, Atkinson, & Hirleman, 2009).

The focus of IREE shifted in 2010 when a team from Purdue University was awarded a grant (NSF EEC-0965733, "IREE: Developing Globally Competent Engineering Researchers") to administer a new version of the program. The original IREE objectives – namely, promoting international research collaborations and developing global competency among participants – were coupled with a mandate to set the stage for a future scale-up, including by systematically evaluating and studying all aspects of the program. Other major changes for IREE 2010 included limiting research placements to China and restricting eligibility to undergraduate and graduate students. Additionally, participants were given two options for research placements. In line with the original IREE framework, a "self-placement" option allowed applicants to propose going to a specific host institution or lab, often identified with the help of a faculty advisor or mentor. In addition, a new "site-placement" option was added, allowing IREE staff to arrange placements for some awardees at select partner sites and labs.

Intensive promotion of the IREE 2010 China program led to receipt of more than 360 applications. A group of program staff reviewed 278 complete applications (i.e., those not missing any materials) to develop a ranked list of prospective awardees based on ten evaluation criteria (e.g., quality of personal statement, academic qualifications, quality of recommendation letters, evidence of enthusiasm for working in China, etc.). A total of 58 participants ultimately accepted an IREE grant. After completing orientation activities in May 2010, participants traveled to China for 10-12 weeks to work on frontier science and engineering research projects in university, industry, and government labs. Grantees were also required to participate in a re-entry meeting held about one month after they returned to the U.S. (September 25-26, 2010 in Chicago). The total award amount averaged approximately $7,500 (undergraduate students) or $8,500 (graduate students) for all research stipends and reimbursable expenses, and another $1,400 in additional expenses that were covered directly by the program.

Given the focus of this paper, it is worth describing in more detail how the program supported development of global competency among participants. One centrally important feature of IREE was an extensive orientation curriculum that the IREE team developed and ran in three different formats during May 2011. Of the 58 grantees: (i) 19 students were hosted by the IREE team for a two-week orientation session in Shanghai, China; (ii) 19 students were hosted by the IREE team for a two-week orientation session at Purdue's main campus in West Lafayette, Indiana; and (iii) 20 students were assigned to a flexible five-week online orientation program, allowing them to participate from their own workplace or residence. All orientation programs offered instruction in Chinese language (Mandarin), including nine half-days of instruction for face-to-face orientation groups, and roughly equivalent coverage recommended for the online group using an introductory Chinese language textbook and accompanying audio lessons (Jianfei, 2004). In addition, Chinese culture and history were introduced to students in five half-days of instruction for the face-to-face groups, and reading assignments paired with online discussion activities for the online group. Both formats utilized an appropriate and accessible introductory textbook (Morton & Lewis, 2005).

Finally, participants were taken through an Engineering Cultures China curriculum, which was delivered to the Purdue and Shanghai groups during four half-day sessions, and to the online group via a comparable series of multimedia lectures and accompanying discussion forum activities. These materials were in part based on an instructional model originally developed by Downey

• Engineering Cultures China – Introduction*
• Science and Technology in Ancient China
• Engineering Education and Profession in Early Modern China
• History of Engineering Education, 1911-1976*
• Engineering and Engineering Education in the Post-Mao Era*
• Interview Excerpts - Perspectives on Chinese Engineering, Education, and Culture
• Imitation or Innovation*
• Engineering Problem Solving with People*
*Available as narrated PowerPoint presentations on GlobalHUB.org (Jesiek, 2010)

Table 1. Engineering Cultures China Learning Modules.

and Lucena (Downey et al., 2006; Downey, 2008) and used to support production of online learning modules focused on a number of different country contexts (Downey & Lucena, 2008). The new Engineering Cultures China curriculum that we developed for the IREE program provided grantees with a wealth of information about the historical development and contemporary state of engineering education and the engineering profession in China, as well as specific participant observation methods and strategies to enhance their ability to work more effectively in diverse global contexts. Table 1 gives titles for each discrete Engineering Cultures China presentation, and also indicates which modules are freely available online. Some existing secondary sources were used to develop and scaffold the module, including Andreas' (2009) book titled *Rise of the Red Engineers: The Cultural Revolution and the Origins of China's New Class*. The creation of instructional materials is also leading to a series of derivative publications on the history of engineering in China (e.g., Jesiek & Shen, 2012).

A number of strategies were used to promote reflective learning and support learning outcomes among students throughout their IREE experience. For example, students in the face-to-face orientation groups were asked to write and perform a brief dialog or script portraying a small group of American and Chinese engineers working collaboratively on a project or problem, with the goal of helping them think about how engineers from diverse backgrounds may define and solve problems differently. Additionally, during their research placements participants were twice asked to respond to a set of reflective writing prompts in blog/journal entries posted to the GlobalHUB web site. As summarized in Table 2, these prompts were based on a critical incident framework that encourages individuals to proactively identify, analyze, and respond to specific challenges they face (Crisp et al., 2005; Hanson & Brophy, 2012; Walther et al., 2011). Still other opportunities to productively reflect on the IREE experience were enabled through a variety of activities at the required re-entry meeting (e.g., interviews, focus groups, etc.), as well as a final trip report that encouraged participants to write about the broader impacts of their experience. Select blog posts and trip reports from IREE 2010 grantees are available on GlobalHUB (http://globalhub.org/iree).

1. Since starting your research assignment, what is ONE significant challenge you have SUCCESSFULLY faced or resolved? In your 1+ paragraph response, make sure you:
   a. Describe the challenge.
   b. Discuss what you have learned from this experience.
   c. Reflect on how this experience might help you in the future.
2. Since starting your research assignment, what is ONE challenge you have NOT been able to resolve? In your 1+ paragraph response, make sure you:
   a. Describe the challenge.
   b. Discuss what you have learned, or not learned, from this challenge.
   c. Reflect on how you will deal with this type of challenge in the future.
3. During the past 2-3 weeks, what is one trait/practice/behavior/way of life that you have observed in China that is most different from your native culture/background? In your 1+ paragraph response, make sure you:
   a. Describe the trait/practice/behavior/way of life.
   b. Discuss similarities/differences compared to your own culture/background.
   c. Reflect on how you reacted to this trait/practice/behavior/way of life.
4. Identify and describe one specific goal for personal and/or professional development that you hope to achieve within the next month.

Table 2. Reflective Writing Prompts for IREE Participant Blogs/Journals.

ASSESSMENT METHODS

Participant Demographics

Among IREE awardees, 27 (or 46%) were women, 5 (or 9%) self-identified as underrepresented minorities (Hispanic/Latino or African American), and 14 (or 24%) as Asian. A total of 55 grantees (or 95%) were U.S. citizens, 2 (or 3.5%) were U.S. permanent residents, and one (or 1.7%) was a Nigerian citizen with a U.S. visa. At the time of application, 28 awardees (or 48%) were undergraduate students and 30 (or 52%) were graduate students. Awardees represented more than 40 different home universities in the U.S., and their most common home department affiliations were: electrical/computer engineering (13 participants), biomedical engineering (7), civil engineering (7), mechanical engineering (6), and environmental engineering (5). There were 37 self-placement and 21 site-placement participations, with the largest number of students at Shanghai Jiao Tong University, Tsinghua University, and Xi'an Jiao Tong University.

Data Collection and Analysis

As summarized in Table 3, we used a variety of strategies to collect a wealth of research and assessment data during every major program phase, with highlighted rows indicating sources of data reported in this paper. Our efforts followed accepted best practices for assessing learning outcomes in international education (Deardorff, 2006), including through use of a concurrent mixed methods approach to collect and analyze both quantitative and qualitative data (Creswell and Plano Clark, 2011, Ch. 3). We also leveraged indirect sources of evidence, primarily surveys,

Data Source	Before orientation	During orientation	At end of orientation	During experience	At or after re-entry meeting
(a) Demographic survey	✓				
(b) Sojourn readiness assessment	✓		✓		
(c) Self-reports of language proficiency	✓				✓
(d) Diversity survey (MGUDS-S)	✓				✓
(e) Global competency scenarios	✓		✓		✓
(f) Reflective activities and blogs*		✓		✓	✓
(g) Orientation evaluation survey			✓		
(h) Program evaluation survey					✓
(i) Interviews and focus groups					✓
(j) Trip report*					✓
(k) Research host/sponsor survey					✓
(l) Final program survey					✓

*Sample participant responses are available on GlobalHUB (http://globalhub.org/iree).

Table 3. Data Collection Plan for Program Evaluation and Outcomes-Based Assessment.

along with more direct measures, such as scenario-based tasks and reflective journal entries. Our findings begin by reporting on a number of more general aspects of global competence investigated using a variety of self-report survey instruments. These data sources include a new 15-item Sojourn Readiness Assessment questionnaire that we developed for the program, the 15-question Miville-Guzman Universality-Diversity Scale – Short form (MGUDS-S) (Fuertes et al., 2000), and self-reported levels of Chinese (Mandarin) language proficiency. We selected the MGUDS-S instrument due to its relative brevity, free availability for educational and research purposes, coverage across three domains, and demonstrated validity and reliability. Additionally, we were aware of prior uses of MGUDS-S in engineering education, potentially allowing us to compare results with other relevant student populations.

Given this paper's significant focus on global engineering competency, we also report data from orientation and program evaluation surveys, a scenario-based global competency question, and re-entry interviews. While the survey questions asked participants to self-report levels of competence in specific areas, the scenario question and interviews are potentially more reliable sources of data since they make it less likely that respondents can fake or exaggerate their responses, misunderstand question statements, and/or respond to questions quickly and thoughtlessly. During the interviews, we also specifically probed participants' observations about how their Chinese colleagues defined and solved technical problems by using prompts such as: "Did your Chinese colleagues ever approach or solve technical problems in ways that were unusual or different from what you expected? Can you give any specific examples?"

When possible, paper forms were used for data collection. The Qualtrics survey platform was used for data collection in other situations (e.g., surveying the online orientation group, and administering the host/sponsor survey and final program survey). In all cases, appropriate data collection procedures were approved and followed under Purdue IRB protocol #1004009220. All quantitative data for this study was compiled and analyzed in Microsoft Excel. Qualitative interview data was organized and analyzed using the Dedoose application. The specific procedure involved a group of researchers using a small set of *a priori* codes to identify passages in the interview data relevant to global engineering competency. And while this paper is unique given its primary focus on global engineering competency, in prior publications we have reported select MGUDS-S, global scenario, and program evaluation results for the IREE 2010 China program (Jesiek et al., 2011; Jesiek & Woo, 2011; Jesiek et al., 2012).

FINDINGS

Our findings report learning outcomes from IREE from lesser to greater specificity, beginning with perceptions of readiness for a sojourn abroad, foreign language abilities, and other aspects of cross-cultural competence. We then turn to a more in-depth review of findings related to global engineering competency based on three main sources of data: a set of self-evaluation questions, an open-ended global scenario question, and post-experience interviews.

Sojourn Readiness Assessment

A 15-item Sojourn Readiness Assessment (SRA) instrument was developed to evaluate IREE awardees' general sense of preparedness for a sojourn abroad. Sample survey items are presented in Table 4, and were ranked by respondents on a six-point Likert scale ranging from Strongly Disagree

Dimension	Sample Question
Cognitive Preparedness	I have adequate knowledge about the host country.
Doubt	I question if going abroad was a good decision.*
Perception of Benefits	The benefits of going abroad outweigh the challenges.
Anxiety	I am anxious about going abroad.*

*These items are reverse scored.

Table 4. Sample Sojourn Readiness Assessment (SRA) Questions.

Group	n	IREE Pre-Orientation Average Total Score	IREE Post-Orientation Average Total Score	Score Change
Purdue	17	64.4	68.7	+4.4[1]
Shanghai	18	63.9	69.1	+5.1[2]
Cyber	17	67.4	67.3	−0.1
All	52	65.2	68.4	+3.2[1]

[1]Score change is statistically significant (p<0.01) based on a paired t-test.
[2]Score change is statistically significant (p<0.05) based on a paired t-test.

Table 5. IREE Pre/Post-Orientation Sojourn Readiness Assessment (SRA) Results.

(1) to Strongly Agree (6), giving the instrument a total scoring range of 15-90. The SRA was administered to participants at the beginning and end of their respective orientation program. As summarized in Table 5, the average total SRA score rose from 65.2 before orientation to 68.4 after, representing a statistically significant increase. Further analysis indicates no significant change in scores for the cyber/online orientation group, while the two face-to-face groups saw notable gains. We propose two explanations for these trends. First, many participants opted into the cyber/online group because they were already more prepared for a research sojourn, as indicated by their higher incoming SRA scores. Second, these participants were less likely to complete all of the required training, and what they did complete occurred with fewer opportunities to engage with and learn from their peers and the program staff.

Factor analysis of our results also allowed identification of four specific dimensions potentially measured by this instrument, namely Cognitive Preparedness, Doubt, Perception of Benefits, and Anxiety, as shown in Table 4. Based on these findings, a new 20-item version of the survey is currently being piloted.

Foreign Language Skills

Our assessment of foreign language ability (Mandarin Chinese) was based on a five-level self-report survey and scale originally developed by McNeil (2010). Table 6 presents pre/post-IREE data that was collected at the start of orientation and again at the re-entry meeting. In summary, 26 of 51 (or 51%) of respondents indicated an increase in language proficiency, with the average level increasing from 2.2 to 2.8. Additionally, the number of participants who indicated they could “engage in basic conversation” doubled, from 11 to 22. While many methods are available to more rigorously evaluate language capabilities (e.g., language proficiency tests and exams), our data nonetheless suggest notable gains in basic language skills among IREE participants. Our qualitative data (e.g., reflection journals and

Level of Language Proficiency (Mandarin Chinese)	Pre-IREE	Post-IREE
(1) No proficiency	16	0
(2) I know a few words a phases	18	22
(3) I can engage in basic conversation	11	22
(4) I could take engineering courses in this language	1	2
(5) This is my native language	5	5
Total	51	51

Table 6. IREE Participant Self-Reports of Language Proficiency (n = 51).

interviews) also revealed a handful of participants who were extremely diligent with their language training efforts during their sojourn, including those who actively sought out opportunities for further formal and informal language practice through hired tutors, conversations with peers, etc.

Universal-Diverse Orientation (UDO)

The Miville-Guzman Universality-Diversity Scale - Short Form (MGUDS-S) was used to evaluate aspects of cross-cultural competence among participants, including possible changes pre/post-IREE. This 15-item survey measures universal-diverse orientation (UDO), or "an attitude of awareness and acceptance of both similarities and differences that exist among people" (Miville et al., 1999). The instrument features three subscales that assess the extent to which respondents have *diversity of contact* with others (behavioral), *relativistic appreciation* of oneself and others (cognitive), and emotional *comfort with differences* (affective) (Fuertes et al., 2000).

MGUDS-S was administered to all participants before orientation and again at the re-entry meeting. As reported in more detail elsewhere, data analysis reveals small but significant pre/post increases in average MGUDS-S total scores, rising from 73.6 to 76.4 on a 90-point scale. This result suggests that the IREE experience had a positive impact on participants' UDO. Further analysis also revealed different impacts by sub-group (Jesiek et al., 2012). For instance, women tended to enter the program with higher UDO and had larger gains as compared to men, and the largest pre/post-IREE gains occurred among men *with* prior experience living abroad, and women *without* such experience. This suggests a possible priming mechanism at work, with men needing multiple immersive travel experiences to enhance their cross-cultural competence.

As indicated in Table 7 below, an increased sense of cross-cultural competence was also evident in IREE student responses to select re-entry survey questions. For example, 55 of 55 respondents agreed or strongly agreed with the statement "I will be able to work more effectively in diverse and multicultural environments." Additionally, when research hosts were asked about the cross-cultural skills of the IREE students who had worked in their labs, the respondents (n=34) gave an average rating of 4.32 on a 5-point scale ranging from Unsatisfactory (1) to Outstanding (5).

Global Engineering Competency: Self-Evaluation

Two primary strategies were used to investigate the global engineering competency of IREE participants. First, a series of self-evaluation questions were given at the re-entry meeting as part of a final program evaluation survey. The questions were in part based on prior work by Downey et al. (2006), which investigated learning outcomes among students in the Engineering Cultures undergraduate elective course at Virginia Tech. As summarized in Table 7, all but one question had average scores in the 3.3 to 3.5 range on a 4-point scale ranging from Strongly Disagree (1) to Strongly Agree (4). For the three questions that can be directly compared to results from students at Virginia Tech, we find identical average scores for statements (c) and (e). We suspect that notably higher scores among IREE students for statement (f) reflect enhanced self-efficacy resulting from an immersive global work experience, especially as compared to the non-travel experience at Virginia Tech. It is further worth noting that the statement "I gained significant knowledge about engineers and engineering in China" received the lowest average marks (3.1). We posit that this is due to the fact that participants' exposure to engineering in China was limited to interactions with small numbers of engineering students and faculty members, usually in one lab and focused on a specific research area.

(maximum n=55)	Strongly Disagree (1)	Disagree (2)	Agree (3)	Strongly Agree (4)	IREE Avg. Score	VT EC Avg. Score*
a. I gained significant knowledge about engineers and engineering in China	0	9	33	12	3.1	N/A
b. I am better prepared to meet and work with engineers from China	0	0	26	29	3.5	N/A
c. I am better prepared to meet and work with engineers from different countries	0	1	29	25	3.4	3.4
d. I will be able to work more effectively in the global engineering profession	0	0	25	30	3.5	N/A
e. I now have a better understanding of how my perspective as an engineer is different from those of engineers from other countries	0	2	27	26	3.4	3.4
f. I will now be better at working with people who define problems differently than I do	0	1	36	18	3.3	3.1
g. I will be able to work more effectively in diverse and multicultural environments	0	0	26	29	3.5	N/A

*These results originally reported by Downey et al. (2006).

Table 7. IREE Participant Self-Evaluation of Global Engineering Competency.

Global Engineering Competency: Scenario-Based Assessment

Utilizing a scenario-based assessment strategy (Jesiek and Woo, 2011) and building on previous work by Downey et al. (2006), the open-ended global scenario shown in Figure 1 was also used to assess the global engineering competency of participants before and after their IREE experience. Created by members of the lead author's research group, the scenario is designed to measure cultural sensitivity in the context of a realistic global engineering work situation, namely by juxtaposing a serious technical issue (i.e., a quality control problem) against disagreement with one's Chinese supervisor. The four-level scoring rubric shown in Figure 1 was created based on pilot scenario data collected from talk-aloud interviews with four subject-matter experts (engineers with extensive experience working in industry or academic settings in China) and written responses from 44 "novices" (first-year engineering students). The first three levels of the rubric reflect different levels of cultural sensitivity, while the fourth level adds a cognitive or knowledge dimension, namely understanding how to "save face" with one's superior and colleagues in a Chinese work setting. Two researchers used this rubric to analyze all pre/post-results for the IREE students, and all coding discrepancies were resolved on a case-by-case basis through discussion until consensus was reached.

As indicated in Figure 1, the average pre/post scores on this task rose from 1.62 to 1.96, representing a statistically significant increase (Jesiek and Woo, 2011). And while this task tends to elicit ambiguous responses that are difficult to score, it is notable that the number of respondents

Scenario: As an employee in a large multinational corporation, you are temporarily assigned to your company's branch operations in Shanghai, China. Your work team consists of three Chinese engineers, all at about the same rank as you. Your team reports to an engineering manager, who is also Chinese. In a recent team meeting, your manager presented a solution to a difficult quality control problem. However, you feel the proposed solution will likely fail. How would you handle this situation, and why would you handle it this way?

Response Level / Description / Count

n=45 valid data pairs	**0** Clear Evidence of Cultural Insensitivity or Inappropriateness	**1** Cultural Sensitivity Unclear (Response is Neutral or Ambiguous)	**2** Clear Evidence of Predisposition to Cultural Sensitivity (Not Context Specific)	**3** Clear Evidence of Cultural Sensitivity, Including Knowledge of Specific Context	**Avg. Score**
Pre-IREE	0	25	12	8	1.62
Post-IREE	0	23	1	21	1.96[1]

[1]Difference between pre/ post-IREE average scores statistically significant ($p<0.05$) based on a Wilcoxon signed-rank test.

Figure 1. Global Engineering Competency Scenario with Pre/Post Results.

Student Response, Pre-IREE (May 2010)	Student Response, post-IREE (September 2010)
""I would first discuss my opinion with my other these [sic] Chinese teammates (assuming we can communicate). If they agreed with my belief about the failure, then I would suggest we approach the manager as a team and confront him. If they disagreed, or suggested that it was a bad idea to confront the manager, I would still confront him especially if I felt SURE that the product would fail. If the team command me otherwise, I would obviously not go through with it (as long as their reasoning was based on sound engineering/science)."	"Even though Chinese people (particularly those of high rank) are constantly concerned about 'losing face', I think issues of quality control need to be addressed upfront and to the point. I would definitely approach the manager one-on-one though, so that the issue is just between he and I."
Score: 1 (Cultural Sensitivity Unclear)	**Score:** 3 (Evidence of Cultural Sensitivity, Context Knowledge)

Figure 2. Sample Pre/Post Responses to Global Engineering Competency Scenario.

demonstrating context-specific cultural sensitivity (Level 3) increased from 8 to 21. Additionally, four of the IREE students shifted from level 1 to level 3 responses. To further illustrate this type of shift, Figure 2 presents pre/post responses for a single IREE participant. Before IREE this student responded to the scenario by placing primary emphasis on making an evidence-based technical decision, yet after IREE this tendency is counterbalanced with a desire to deal with the situation in a more culturally appropriate manner. We propose that such changes in one individual's responses provide clear evidence of enhanced global engineering competency.

Global Engineering Competency: Interview Findings

Our re-entry interview data provides additional evidence of global competence among IREE participants. For example, some interviewees demonstrated both cultural sensitivity and context knowledge similar to what was expected for high levels of performance on the global scenario discussed above. When asked about adapting to the Chinese work environment, for example, one Ph.D. student described how he dealt with situations involving disagreements or competing approaches:

> Maybe if I'm in the U.S. and somebody in the research group brings up something, then maybe I see a problem, or I see, like maybe we should do it this other way, it would be more of a direct thing, say, "Oh but, you know, we could also do this and that." But when I was in China I think I usually just held my tongue a lot more and would just, you know, try to observe and listen first and then, I don't know, I guess depending on how the situation felt, I would approach it in a much more delicate way to, how to bring up my suggestion basically, you know. And, I guess, try to do it without making anybody lose face [...] or say that their plan is not good but say, "Well, your plan is also good but maybe, you know, maybe we could do it also, do this other part which is in addition to your plan."

In addition to being aware of the importance of saving face in a typical Chinese work environment, this individual demonstrates effective cross-cultural communication strategies by being less direct and confrontational than what is typical in many U.S. settings. It is further worth noting that this same individual had participated in a study abroad program in China prior to IREE. As noted below, this hints at the importance of developing sensitivity to the conditions of non-native work contexts through multiple, lengthy immersions.

The interviews also revealed that a number of IREE participants were able to describe how their colleagues in China approached technical problems differently, which we argue is another key marker of global engineering competency. Nonetheless, there was considerable variation in how they described these differences, including how they framed the relative merits of different approaches. For instance, one Ph.D. student criticized his Chinese colleagues for a tendency to both undertake “spin-off” studies and not interrogate fundamental principles and assumptions behind their research:

> People really wanted to look in the literature and see what the authoritative consensus was, and then they wanted to try and do a spin off of that. Their problem, there is some creativity in that obviously, but it’s really just applying what happened out there. You wouldn’t … almost ever [see] them sit down and brainstorm and say, “First principles, what’s happening here? What could be happening? What are the assumptions we’re making?” You know, and usually that’s a big source of your errors. Your assumptions were wrong or you’re missing some underlying principle. Whereas they’ll take that all for set in stone because they followed it by the book in making [it] up to that point or they followed it by some outline in the literature or they’re looking for the out … and the answer to be that clichéd phrase that you’re looking outside the box. You need to look at the bigger picture, need to look at the fundamentals.

To account for these differences in style, this individual went on to discuss potentially relevant factors such as the kinds of experiences and interactions that are typical in U.S. universities:

> In the United States I think that’s something we’re trained to do maybe through university courses or just because of our individualistic nature. That we’re prone to opinions, we’re encouraged to discuss them. […] You know, when you give presentations it’s very much like you give a talk but you discuss it. People quiz you. You really have to defend what your thoughts are.

As these passages reveal, this student was clearly able to identify how Chinese researchers approached problems differently and then posit possible underlying reasons for those differences.

However, such comments tend to frame U.S. research practices as superior to those observed in China. This tendency toward a kind of "engineering ethnocentrism" may limit the ability of this student to work in the midst of different perspectives and blind them to the potential advantages associated with alternate approaches to engineering research.

Similar tendencies were observed among a number of other IREE interviewees, albeit to varying degrees. As one Master's level graduate student explained:

> I don't know if this is for everybody, but for our institution, our professor had so many people at his grasp, he just could be like I want you to try and solve this. So he would just send them into it without evaluating the situation, he would just say let's do this. And in America, I think a lot of people would be like, alright, let's take a step back, let's look at the problems, let's devise our best way of, try and figure out the most efficient way to try and solve these problems. And if we run into problems, let's fix it at that time. Well, it seems like China was more like, I think trial and error is the best way to describe it.

While this interviewee implies that the U.S. approach might have its advantages, he is cautious about overgeneralizing, including by declaring that this insight was based on observations made in just one local context. At other points in the interview, this participant also offered a further explanation for the observed style of research by discussing resource constraints, including how one's approach might change depending on the size of a research team. In addition, this student explicitly moderated their remarks by adding: "I'm not going to say this is the correct way to do things, because you're getting the same things done, just in a different way." In contrast to the previous respondent, this student seems to have a somewhat higher level of understanding and respect for alternate approaches to organizing and carrying out technical research.

Nonetheless, only a few interviews revealed this kind of ability to understand and tolerate different technical perspectives. As one final example, a Ph.D. student succinctly described how Chinese researchers tended to use very different approaches to transportation research:

> I'm a lot more hands on. I want to go collect data and let's do that. And for the most part, I mean, I haven't I guessed worked on many of their projects with them. But, just seeing what they do is a lot more theoretical maybe. They want to look at like, we might be thinking of the same things. I'm interested in what factors influence your transportation but I'm going to go out and collect data and then try and build a model on that and then they want to analyze the more theoretical aspects. It's maybe a little less hands on approach. For me, that's kind of a big difference.

As this quote reveals, this student is explicitly cautious about overgeneralizing. And in the longer interview passage on this topic, there is no evidence of judgment about the superiority of more empirical versus theoretical approaches to transportation system modeling.

The four students discussed here demonstrate an ability to identify and describe how their Chinese colleagues define and solve problems differently, albeit with different levels of sensitivity and tolerance toward these variations. Yet who are these students, and how and why have they developed such abilities? To begin, all four interviewees profiled here are graduate students. In contrast to most undergraduates, these individuals have spent more time working in academic research settings in the US, making it easier for them to compare and contrast their domestic and global experiences. From a developmental perspective, they also tend to be more mature, and have likely been given more significant and meaningful roles in research projects, both at home and abroad. Finally, it is essential to note that all but the Master's level student entered the IREE program after having already completed at least one extended (i.e., multiple months) research and/or study abroad experience in China. This finding suggests that the most marked improvements in global engineering competency may require multiple, lengthy exposures to work practices in diverse global settings. In addition to enabling development of cross-cultural competence in general, such experiences can also promote greater sensitization to local, national, and regional variations in engineering culture.

CONCLUSION

Responding to intensified globalization trends, many professional schools are internationalizing their courses and curricula to prepare graduates for careers that will likely involve working across countries and cultures. In professional fields such as engineering, medicine, business, and law, opportunities for research, work, and/or service learning abroad are becoming more common ways to give students authentic professional experiences in global context. Yet these new programs and initiatives often require significant investments of time, money, and energy, and it is often unclear whether their actual impacts live up to the goals and objectives promoted by their champions. Of particular note is the challenge of systematically demonstrating how certain kinds of experiences and program formats support attainment of discipline-specific competencies needed by global professionals.

Our results from the IREE 2010 China program contribute to a growing body of literature discussing specific strategies for developing and assessing effective global learning experiences. And while our paper is mainly concerned with engineering, our work is intended to provide inspiration and insights that are relevant to other professional fields. More specifically, we present the Engineering

Cultures China curriculum as one essential part of a comprehensive orientation strategy that attempts to align the major program objectives and learning outcomes with appropriate instructional content and learning scaffolds. The content and associated activities were intentionally designed to support attainment of global engineering competency, including the ability to work with colleagues who define and solve problems differently due to individual and geographic variability in professional identities, educational backgrounds, organizational contexts, and sociocultural norms. We also propose some other ways to help scaffold and support experiential learning abroad, including critical incident reflection prompts, and re-entry activities like interviews, focus groups, and trip reports. Many of these approaches can be adapted for use in other courses and programs, both within and beyond engineering.

The IREE program has also inspired ongoing efforts to enhance the Engineering Cultures China curriculum. For example, the scenario prompt presented in Figure 1 inspired the lead author to write a longer script that more completely illustrates how this type of work situation might play out in a real-world setting. The script was acted out by a group of graduate students, and the resulting video clips were edited to create Global Engineering Competency Vignette #1, as shown in Figure 3 Video link: https://www.youtube.com/watch?v=K5mA7yb14Gg&index=2&list=PL84VcUp5xaBsRutUS8KR2lwFxh8KfI9G. This brief video (less than three minutes in length) is intended for use by instructors who wish to seed and facilitate case-based conversations about typical situations encountered in global engineering work, particularly in China and other countries in East Asia. The video and an instructor's guide are freely available on YouTube (Jesiek, 2013).

Finally, this paper represents an important step toward developing more robust and scalable assessment strategies and frameworks for evaluating key learning outcomes that are uniquely or especially relevant for practicing engineering in cross-national/cultural contexts. More specifically, we describe a mixed-methods approach leveraging multiple direct and indirect measures. In addition to summarizing results related to sojourn readiness, foreign language proficiency, and universal-diverse orientation, we report data from self-assessment questions, an open-ended scenario prompt, and re-entry interviews as evidence of enhanced global engineering competency and related outcomes among IREE participants.

In general, our findings strongly resonate with results from the large-scale, multi-year Georgetown Consortium Project, which found that learning is maximized in well-structured programs with proactive learning interventions, and with the greatest gains in intercultural learning occurring among students who spend roughly a semester abroad (Vande Berg, Connor-Linton, & Paige, 2009). The present study also tentatively suggests that the largest gains in global engineering competency occur among students who have had multiple, in-depth exposures to different cultures of engineering. Such findings are important for program faculty and staff to consider as they design, deliver, and evaluate global learning experiences. However, additional research is needed to identify and better

Figure 3. Screen Capture from Global Engineering Competency Vignette #1 (Jesiek, 2013).

Video link: https://www.youtube.com/watch?v=K5mA7yb14Gg&index=2&list=PL84VcUp5xaBsRutUS-8KR2lwFxh8KfI9G

understand the specific kinds of critical experiences that maximize learning gains and development of key competencies.

The limited scalability of open-ended scenarios and participant interviews also suggests the need for more work on assessment tools and strategies. Given such challenges, the lead author's research team has undertaken a new research project that involves refining our definition of global engineering competency. This effort will in turn support development of a valid and reliable Situational Judgment Test (SJT) that can be used to assess 3-4 major dimensions of global engineering competency in six national contexts. We expect that creating such tools will help scaffold ongoing efforts to understand and enhance how students and professionals are prepared for the global realities of engineering practice.

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