Preparing Students for Intensive Global Fieldwork

Mary K. Pilotte
Engineering Education –UG Programs
Purdue University
West Lafayette, IN USA
mpilotte@purdue.edu

David F. Radcliffe
STEM Innovation Centre
Swinburne University of Technology
Melbourne, VIC, Australia
dradcliffe@swin.edu.au

***Abstract*— This paper argues that by carrying out an integrated series of technical investigations and cultural activities in a foreign country, students can have a realistic experience of global engineering field work. This work-in-progress explores the conception, design, implementation and preliminary review of a week-long study abroad course that simulates an intensive field investigation in a remote context, something that most practicing engineers experience. The course provided a series of scaffolded experiences designed to enable the students to produce authentic engineering artifacts, demonstrate professional skill formation (impromptu oral presentations; use of unfamiliar facilities), increase cultural awareness, and begin to develop professional habits (critical incident reflection). Preliminary analysis of the initial offering of this course suggests that while many of these goals were achieved, the students are still processing the experience as a whole.**

Keywords— study abroad, authentic learning, global field work, engineering practice

I. INTRODUCTION

Research in engineering education has demonstrated that students both prefer and have increased motivation in courses where the learning activities and assignments are experienced as being "authentic" [1]. Also, numerous studies and national governing bodies call for attending to topics that prepare engineering students for practice in dynamic, global contexts [2-4]. ABET specifically calls for engineering students to "understand the impact of engineering solutions in a global and societal context" [5]. Yet defining what is essential for a course or its activities to be considered "authentic" or preparatory for professional engineering practice in a global context is a non-trivial challenge [6]. This is especially true for many educators who may lack applied engineering experience themselves [7]. Further, to execute a course to ABET outcomes requires thoughtful care in organizational structure, planning and execution [8].

Concurrently, student interest and desire for study abroad course offerings is on the rise [10], with much of the growth being in shorter stay offerings [7]. Research examining the value of study abroad experiences suggest that not only do these courses lead to greater intellectual learning in the topics covered while abroad, but they provide deeper learning, promote personal growth, heighten intercultural awareness, and expand professional development [11]. Further, providing authenticity in study abroad experiences is considered the ultimate goal of such programs. Engle and Engle [12] describe these study abroad programs as incorporating real-lifeapplication of course materials with directed and reflective engagement with the host culture. Yet, in examination of study abroad programs, they posit that while these idealized experiences are the most beneficial, they are "not possible" in what they classify as a level two, or short term study abroad program [12, p11]. In an attempt to overcome this potential limitation, the innovation presented here makes a virtue of the short duration of some study abroad trips to simulate a week in the life of a practicing engineer who is tasked with conducting a field investigation into an unfamiliar engineering problem on the other side of the world.

II. FIELDWORK AS AUTHENTIC EXPERIMENTATION

Most practicing engineers have had the experience of being dispatched, usually at short notice, to investigate a technical or production problem at a remote facility or project site. In collaboration with a local team whom they have typically never met before, they have to troubleshoot the problem working in an unfamiliar context with limited access to their usual tools and resources. Within a constrained time frame the visiting engineer has to devise a suitable means to gather data the best way they can with the limited equipment in the field as part of an initial investigation, in hopes of better defining the problem. Based on preliminary findings the engineer is then expected to make recommendations on next steps to resolve the issue for the longer term. Such field investigations require making adjustments to unfamiliar work and cultural practices and frequently involve interacting socially with the local team out of hours; the technical work and the socio-cultural context are difficult to separate. While this type of work is a ubiquitous part of engineering practice, it is seldom, if ever, mentioned in the context of engineering education.

A student outcome in ABET Criterion 3 [6] is "an ability to design and conduct experiments, as well as to analyze and interpret data." The normative assumption presumes ability is demonstrated through activities in a technical university laboratory. However, as class sizes have grown while laboratory facilities have not, the quantity and quality of such direct access to experimental hardware and software has diminished. Even where students still get access to authentic lab equipment, very few get the opportunity to plan, design and conduct an experiment, *ab initio*. Furthermore, engineering practice is becoming much more attuned to the personal, socio-

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cultural and environmental needs of multiple, diverse stakeholders. Future engineers will have to adopt a more user-centric approach, one that relies increasingly on all manner of non-technical information and cultural awareness in addition to command of technical data. So, while learning experimental techniques in a conventional laboratory remains a critical facet of engineering education, we argue that this needs to be complemented by the development of investigative skills that are effective in understanding the non-technical aspects of an engineering problem.

The objective of the study abroad experience described in this paper was to develop some of the critical knowledge and skills necessary to be an observant and reflective engineer who can appreciate the non-technical aspects of an engineering project being carried out in an unfamiliar global location. This experience was designed principally for students in their junior or senior year in the Multi-Disciplinary Engineering (MDE) program at a Midwestern university

III. COURSE CONCEPT AND OBJECTIVES

This study abroad course was designed to simulate the experience of a practicing engineer who is required to travel to a remote, unfamiliar global location to conduct an engineering field investigation and return in a week. Using this analogy, the remote location was the city of Melbourne, Australia. While at first glance a study abroad trip to Australia might not seem to present any major cultural challenges for US students, the apparent similarities between the two countries can be used as a major advantage. The students are not overwhelmed by adjusting to unusual sights, sounds and smells, dealing with exotic foods and navigating local customs or struggling to communicate through language barriers. Instead they are able to work effectively with their local peers and reflect on their implicit assumptions and their potential impact on solutions proposed for users. Besides, socio-cultural settings that are superficially familiar sometimes turn out to be quite different in subtle ways the closer you get to them. Further, Melbourne is a vibrant and proudly multi-cultural city with immigrants drawn from 180 countries and about a third of the population having been born overseas, providing a great tapestry of cultural diversity for the students to work within.

A. Goals and Enduring Understandings

The overarching goal of the course was to produce authentic engineering experiences and artifacts as well as cultural awareness. Through participation in it, students were expected to develop their ability to:

- Plan and execute an open-ended engineering investigation in an unfamiliar cultural setting.
- Identify, gather, log, analyze, and interpret field data using multiple approaches.
- Present ideas orally and visually in less formal modes during the course of an investigation.
- Undertake a structured reflection in order to learn lessons from an engineering experience.

With respect to planning and conducting a field investigation, the enduring understandings that the students were expected to acquire were;

- Disciplined approaches to making observations, unearthing stakeholder issues, making effective field notes and integrating information from diverse sources are essential skills for engineers.
- Success conducting an investigation depends critically on understanding the relevant cultural context.
- Effective communication (including listening) must be attuned to disciplinary differences and the cultural context of the end user in order to identify the real problem to needs to be investigated.

B. Knowledge and Skills Acquisition

Using the principles of Backwards Course Design [13], a series of knowledge and skills were carefully conceived and mapped to these course goals and enduring understanding. As a result of the study abroad experience the students were expected to know (i) the critical need to first clarify the task and set measurable objectives when planning an investigation (ii) the impact that careful planning has on the successful execution of that investigation, (iii) the sources of possible error in field data and how to interpret incomplete data from disparate sources, (vi) that cultural style differences exist and why these matter when working in global teams, (v) that Effective communication requires awareness of different cultural values, norms, and practices and (vi) how to orally present findings in a concise and culturally aware fashion.

In terms of skills development, the students were expected to be able to use conventional project management plus agile practices to plan an engineering investigation of an ill-defined problem and make keen observations plus use other methods to collect data in a "messy", real world environment, exploring multiple techniques and technologies to record data including making neat, clear, concise, and accurate field notes. They had to be able to generate and test working hypothesis, through iterative data collection and analysis. Where necessary, to reasonably estimate inaccessible data and integrate diverse data types and sources as part of experimental investigation and make effective, impromptu presentations of findings to a diverse audience of stakeholders as well as conduct disciplined reflection to improve knowledge and skills.

IV. COURSE IMPLEMENTATION

While most short-term study abroad programs include both technical activities and cultural excursions often there is little or no explicit connection between the two. In contrast, all the activities that occurred during this week-long study abroad course were designed as an integrated suite of events calculated to contribute to students' understanding, knowledge and skills in relation to carrying out a field investigation in an unfamiliar/ remote context, working with a local team. These activities included planned, unplanned and impromptu classroom activities, tours at the host institution as well as a series of planned and informal cultural experiences in Melbourne. The students completed a design investigation and a laboratory class

at Swinburne University of Technology. Before, during, and after the trip, students were guided through regular periods of structured reflection aimed at distilling lessons learned and broader understandings that arose from every experience, technical and cultural.

A. Student Recruitment

Recruitment for this program involved a two-page excursion brief shared with the academic advisor of the target student population, and promotion through the college Global Engineering Program (GEP). Because of the pilot nature of the program, admission was intentionally kept small (less than 10 students), and program applicants scrutinized through a brief questionnaire eliciting the learning intentions of the student (e.g. What is the nature of your interest in this study abroad program?). In general, students with prior international travel and clearly articulated deep desire for rich cultural understanding and awareness were selected. The roster for the trip consisted of seven students: six male, one female; six domestic, one international (Mexico); four MDE students, one mechanical engineering student, one industrial engineering student, and one civil engineering student.

B. Student Preparation

Idealized as a unique but critical practice-based experience for students, particular attention was placed on situating the cultural learning components within all aspects of the trip. To accomplish this, ten hours of direct intercultural awareness instruction was attended by the stateside course instructor. The instruction led by a university Center for Intercultural Learning, Mentorship, Assessment and Research (CILMAR), was devised to heighten the effectiveness of study abroad learning experiences, by helping faculty prepare and purposefully integrate periods of self-examination, cultural inquiry, and reflection into the topically oriented sojourn. Deliverables required for this instruction included a pedagogical and assessment roadmap outlining learning goals, learning activities, and assessment activities adapted from Fink's work on integrated learning experiences [14], and activating principles of the backwards course design framework [13]. Critically, the planned course design was created such that there were no explicit "class times" or "off times", rather a cohesive practice oriented, field experience, which by its very intensity and cadence was authentic in its execution.

Pre-excursion preparation challenged students to develop their observation and reflection skills, and use tools to support their emergent cultural understanding and to thereby propose more appropriate engineering solutions. Methods put into practice included cultural self-awareness worksheets and mindfulness activities known to develop leadership skills valuable in study abroad settings, including stress management, situational clarity, and personal wellbeing [15-17]. In addition, the SAID approach [18] was exercised for critical incident reflection and to develop acute field note taking skills. These practices provided an important foundation aimed at enhancing students' engineering design solutions, through increased self-awareness of authentic engineering contexts and an ability to "hear" the voice of the customer/stakeholders as they expressed needs associated with the design challenge [19]. This student preparation occurred over three pre-trip orientation sessions lasting one and one half to two hours each.

C. Integrated and Intensive Program of Activities

The study abroad trip took place during Spring Break 2017. The group arrived in Melbourne early on a Sunday morning, and after the long flight from the U.S., participated in orientation and sight-seeing and then were at the host institution at 8:30am the next morning embarking on their main assignment, a Global Design investigation. Their final presentation for this occurred late Thursday afternoon (4:30-6:30pm). Between the first and final class they worked on the project and also participated in other learning activities and tours. The week was interspersed with a series of cultural activities including an overview of 40,000 years of indigenous history and culture in Australia as well as insights into the more recent European history plus an experience of the unique fauna and flora of Australia. Evening meals were selected so the group could sample a wide variety of ethnic cuisines that form an essential aspect of this multi-cultural nation. These experiences of what shaped Australia, its environment, its history and diverse cultural influences were designed to help the visiting students to gain insights that might enhance their interactions with local students and the experience of the local educational environment. In keeping with a typical engineering field trip, the program was designed to be intensive, with little 'free time'. On the final morning, a working breakfast was held to capture the lessons learned and personal takeaways.

D. Global Desing Investigation

The major work activity during the study abroad week was an investigation linked to a Global Design project being carried out by Product Design Engineering (PDE) students at Swinburne. Their semester-long project had the goal to design an innovative product to would improve the experience or mitigate effects of annual urban flooding suffered in many cities globally. The context for the use of the proposed product was regular floods in neighborhood of Kampung Melayu in Jakarta, Indonesia. At the scheduled PDE design studio class on Monday morning, the visiting students were briefed by the local students and asked to identify issues that needed to be investigated. Between the conclusion of the Monday morning class and the next scheduled class on Thursday afternoon, the visiting students spent several days working on developing ideas and preparing recommendations for the local PDE students. At the Thursday class, the visiting students presented their ideas formally and received feedback from the local students and their instructors.

During the week, as they investigated many aspects of the Global Design project, the visiting study abroad students had a briefing by a post-doctoral fellow from Indonesia who was conducting research on humanitarian design as part of a collaboration between Swinburne's Center for Design Innovation (CDI) and Binus University Jakarta. Asking her questions about the social and cultural context of the Kampung Melayu and interpreting a variety of information gathered at this location (pictures, maps and reports) added considerably to the realism and authenticity to the task of data collection.

E. Rapid Prototyping Workshop

Another major hands-on assignment undertaken by the visiting students was a half-day workshop on design thinking and rapid prototyping as part of a scheduled class for honors students studying communications and graphics design at Swinburne. In response to a client need, solutions were generated and ideas tested by making physical prototypes. Students presented their prototypes for end user feedback, and an intensive debrief was held immediately following the workshop to extract lessons that could be applied to the Global Design investigation. This workshop took place in the Design Factory Melbourne, a 'Living Lab' that brings together end-users and researchers with companies and other organizations in the early stages of product and service development, to experiment with concepts and their potential value. It is a member of the Design Factory Global Network, with partners in Finland, Netherlands, Switzerland, Portugal, Latvia, China, Korea, Chile, and the US.

F. Laboratory Tours

The visiting students also toured the state of the art laboratory facilities in the Factory of the Future. This included the 3-D Visualization and Design Studio, featuring advanced visualization tools that allow for intuitive real-time interaction with realistic 3-D imagery; the Rapid Manufacturing Studio equipped with advanced additive manufacturing tools that facilitate conversion from digital concepts to metal, plastic or ceramic prototypes; the Advanced Inspection and Machining Studio and the quality components and the Biodevice Innovation Studio which integrates electronics, optics, chemistry and biomaterials-handling with rapid prototyping to produce innovative new medical devices.

V. PRELIMIANARY FINDINGS

A preliminary analysis of written reflections by the students throughout the trip indicates that they tended to focus on lessons learned around discrete events rather than distilling holistic insights from the overall suite of activities they experienced. For example, from the prototyping workshop the students all took away an abiding appreciation that disciplined approaches to design thinking opened up the ideation space to incorporate cultural understanding making for "better" design solutions. It was very evident by their actions in subsequent days that they transferred this learning into how they tackled the Global Design project. The students all commented that taking field notes and allocating time to reflect on experiences produces more "real" lessons that are likely to be retained and reused. Their reflections also demonstrated an understanding that effective communication, including listening, must be "adjusted" for disciplinary differences and the cultural context of the end user, in order to identify the real problem and offer solutions that might one day be used.

The repeated use of open-ended reflection prompts throughout this course tended to produce narrow "snapshots" and quick impressions from the students. Yet in *ad hoc* conversations with individual faculty, all the students exhibited rich elaborations about things they had learned and their developing understandings. It was clear that an appreciation of "how an engineer really works in practice" was emerging. These passing conversations showed that multiple experiences were coalescing into valuable insights. However, such insights were largely absent from the final video reflections that each student made in the weeks following the trip.

In part this may reflect their inability to effectively capture and collate (at a cognitive level) what they experienced and learned from the technical and cultural activities and communicate the complexity and depth of their learning in written form. Perhaps, in spite of our efforts to reduce the cognitive stress associated with cultural overload often experienced in study abroad trips (by remaining in a relatively similar cultural setting), we created a new form of cultural overload as we fully immersed students into a completely foreign cultural world of engineering practice? Alternatively, student assessment results could simply be evidence suggesting that reflection prompts should be more tightly aimed at eliciting a targeted range responses that validate broader course outcomes, and move them toward accumulated deeper formative response.

There are indications that the study abroad experience has caused some students to reflect on their core values and how they act. All the students were very environmentally conscious before taking this course. On many occasions in Australia they experienced and commented on various impactful ways that environmental consciousness was manifest in everyday life there, especially in green practices around food production and in the reduction of waste in restaurants. Several weeks after returning to the US, one of the students suggested changes to the practices in their student common-room that would reduce waste, based on what they had observed in Australia. This is one example of how several of the students have begun to reflect on the less individual-centric and more community-minded sensibility they experienced in Australia and what it means for them personally and professionally as future engineers working globally.

Some important insights and learnings for the course developers include: (i) planning, preparing, and executing practice based course materials takes time; (ii) integrated cultural/contextual learning reaps benefits; (iii) the details matter; (iv) build-in time for mindfulness; (v) choose authenticity in all things. The instructors plan a more extensive review of the student reflections and artifacts as a basis for the iterative refinement of the course design. While the preliminary analysis presented here suggests that students' may not have fully achieved the somewhat idealistic learning outcomes, it is clear that this novel, integrated approach toward study abroad, emulating an authentic engineering practice context is extremely promising.

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