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Examining the Development of Global Competencies Among Engineering Undergraduates

Social, political, and economic factors are making it necessary for engineering undergraduates to be proficient in content knowledge but also acquire a set of skills that will enable them function seamlessly in a work environment that has both national and international components[1,2]. Ideally, the undergraduate experience would create an engineer that would have a skill set that has been referred to as "global competencies." Global competencies have been broadly defined as "a set of cognitive, affective, and behavioral skills and characteristics that support effective and appropriate interaction in a variety of cultural contexts" [3]. Specifically, attributes of a global engineer have been identified as "a solid grasp on engineering science fundamentals…as well as an understanding of the design and manufacturing process" [4]. This includes an understanding of the context in which engineering is practiced, an awareness of the boundaries of one's knowledge and appreciation for other areas of knowledge, and an awareness of and strong appreciation for other cultures and their diversity[4]. Additional skills cited include a commitment to team work, good communication skills, ethical standards, ability to think critically, and flexibility that allows for accommodating rapid change[4].

Professional organizations such as National Academy of Engineering (NAE) suggest the undergraduate curriculum should be amended so that international experiences, development of cultural competencies, and foreign language skills become integral components[2] and would lead to the development of a global engineer who possesses appropriate competencies for practice in a professional setting with a global reach. Foreign travel experiences and courses tailored to teach these skills have been identified as a means to encourage these qualities in engineering undergraduates[5,6,7, 8, 9]. In response, many institutions have adopted these practices[7,8,10].

At Virginia Tech, engineering undergraduates are provided with an opportunity to participate in the Rising Sophomore Abroad Program (RSAP). RSAP is coordinated by the College of Engineering and combines a semester-long three credit course with a two week in-country experience that occurs in early May of a freshman engineering student's academic career. The class is designed to introduce undergraduate students to global teaming and leadership in engineering. The course is taught by a full-time faculty member and emphasizes leadership, the importance of achieving cultural competency among engineers, as well as the cultural, social and economic aspects of practicing engineering abroad. Students also study historic innovations and modern technology and how different cultures shape how engineering is practiced. By giving students a taste of an international experience and increasing their comfort level with global travel, the program intends to promote additional, more extended international academic experiences such as international internships, study abroad programs, or other faculty-led programs. RSAP also allows students the opportunity to make initial contact with an industry or university in another country to further their student experience or career prospects.

First-year students apply to the program and are selected based on their academic and extra-curricular accomplishments. Typically, about 20 students participate in the program out of the 60 or so that apply. The course is offered in the second semester of the students' freshman year. Because the program takes place in their freshman year, students are taking the RSAP course while enrolled in general engineering courses and before they have chosen a major. The

international experience is pre-organized and the faculty member teaching the course as well as two additional faculty and/or staff members attend. Travel destinations have included: Germany, Switzerland, Italy and France (2011, 2010, 2008); Japan, Singapore, and Hong Kong (2009).

A number of studies have documented that it is possible to both identify and measure global competencies among undergraduates and the impact curricular interventions might have on the development of this skill set[3,11]. However, formal instruments that measure development of global competencies vary in scope and scale[12]. Many commercial instruments are designed for corporate settings rather than groups of undergraduates. Very few tools are suited to measure the impact that experiences more typically found in the undergraduate setting might have on a group of first year engineering majors. The RSAP program provided an opportunity to examine how skills identified as important in a global engineer developed as a result of participation in an experience that was designed to enhance these skills among engineering undergraduates[9]. Given the importance of assessing the development of these skills and determining the type of impact programs such as RSAP are having on that development, this paper is designed to address a much needed gap. This paper describes the assessment process used to examine student perceptions of global competencies changed as a result of an international experience and a related course designed to expose students to global engineering concepts. It also examines long-term impacts the experience had on global competency development.

Methodology

Supported by the best practices in assessment[13,14,15,16], we outlined an assessment strategy that would provide information that would help us begin to determine whether program outcomes and goals were being met. During the fall semester prior to the 2011 spring RSAP course, an assessment plan was identified to provide information that would inform future program design. Following approval from the Institutional Review Board, current students and the 2008 cohort of RSAP students were identified as the sample for this study.

Among current students we wanted to examine how they developed the cultural competencies that we identified as important in a global engineering context. To do this we had students engage in a writing activity. Students were assigned to answer a brief essay question at the beginning of the semester and then were presented with the same essay question at the end of the semester. In the essay, the students were asked to address the following three questions: a) What skill set does one need to possess in order to be an effective (successful) engineer? b) What issues face an engineer who practices in a global context i.e., what is a global engineer? c) How is the skill set of a global engineer different from someone who is not practicing so broadly?

We hypothesized that students would have a more limited perspective in relation to this question prior to the RSAP course. At the end of the course we anticipated that the students would be able to apply concepts and information learned during the semester to answer this question in more detail. A rubric was designed to assess whether this change occurred in the pre-post writing assignment and was used by a panel of four individuals. The criteria or levels used to assign student scores was derived primarily from the literature that outlines desired skills for a global engineer as well as the Association of American Colleges and Universities VALUE Rubric for Intercultural Knowledge and Competence[17].

Given the aims and goals of the program, it was also of interest to see whether the RSAP experience had any long-term impact on global competency development. In order to gauge this, we held a focus group that all of the students who comprised the 2008 cohort were invited to participate in. All sixteen participants from the 2008 cohort were invited with eight students total attending. At the time of the focus group, all of these students were either completing the final semester of their senior year or going into their fifth and final year of the BS degree in engineering. This timing allowed perspective on how participating in the RSAP experience in their freshman year had affected the rest of their undergraduate experience and career goals upon graduation. The questions for this group interview were designed to elicit information about students' motivation for participating in the RSAP experience, whether that participation shaped their motivation to pursue future international experiences, and the extent to which the program contributed to how they thought about a global engineer. The focus group lasted about one hour in length. The session was audio recorded and transcribed.

Findings

Assessment results indicate that students who have completed the course have obtained specific levels of global competencies. Our findings also indicate that there are direct and positive long-term implications related to global competency development among student participants.

Writing Assignment. In terms of the writing assignment scores, students earned higher scores on the post-assignment across questions than on the pre-assignment. A higher score indicates that reviewers found that students' understanding of the skills needed by an engineer, the skill set needed by a global engineer, and issues that might be faced by a global engineer had improved after participation in the RSAP program.

Table 1. Writing Scores by Question Among 2011 RSAP Participants

Question	Average Pre-Score	Average Post-Score
Q1. *What skill set does one need to possess in order to be an effective (successful) engineer?*	46.4	55.6
Q2. *What issues face an engineer who practices in a global context i.e., what is a global engineer?*	40.2	49.6
Q3. *How is the skill set of a global engineer different from someone who is not practicing so broadly?*	37.4	48.2
Total Score	123.8	153.4

In the pre-writing, students identified the ability to solve problems, understand engineering content (science, math) and creativity as key skills for an engineer. Upon review and discussion of the writing assignments, the reviewers felt that lacking from pre-writing was an indication that students needed to consider the impact of solutions provided in a professional setting to real-world situations. There was a very absolutist view expressed by students about knowledge, that there was a clear right or wrong answer and that they, as a working engineer, need to be the ones to be able to provide the right answer. In terms of a global engineer they saw

a global engineer as someone who travelled and provided solutions to foreign clients. In the post-writing there was some indication of development in the way students thought of themselves as a global engineer and the skills needed to work in a global engineering context. In the post-writing, students expressed the need to be able to work in teams; they talked about leadership and the importance of being a "good leader." Students also indicated that engineers needed to have "good communication skills." The greatest change in how they thought of themselves as engineers was that they needed the ability to adapt, to be flexible, and to work as a team.

Some findings from the writing assignment that can be used for program development include the following and are discussed further in the recommendations section. Students considered a global engineer to be someone who traveled to foreign countries and that needed to be physically present in those countries. Language issues and ability to navigate in a foreign country (e.g., currency, public transportation) were issues that students expected to face and were the tangible issues discussed most in the writing assignments when responding about issues a global engineer might face. Students talked generally about cultural issues they anticipated facing in a professional setting as a global engineer but did not go into detail about what some of those issues might be. They also did not go into detail about how problems are bound by culture or how culture might impact the work that is done by an engineer. In many instances they talked about how solutions to a problem needed to apply or fit multiple cultures rather than identifying ways a solution needed to be flexible or be adapted to a different culture. Students generally separated an "engineer" from a "global engineer" as if they were two mutually exclusive concepts (Note: this may have been due to the way the writing questions were asked). They saw themselves as helping other countries and cultures rather than doing work collaboratively with engineering professionals representing international companies.

RSAP Focus Group. Data collected during the focus group indicates that students had several key factors motivating their participation in RSAP. Findings also show that participation in the program impacted students' interest in international experiences but also contributed to their academic trajectory and future career goals.

In terms of students' motivation for participation, students cited an opportunity to travel abroad with peers to experience a different culture as a main factor. Students selected the RSAP experience because of the ability to fit the experience into the first-year curriculum. One student explained, "coming in as a freshman I always thought that it was going to be very hard to study abroad at all. And I didn't really plan on having that opportunity. And [RSAP] kind of gave me the best opportunity to jump in and get my feet wet and then be able to open up to the global aspects that surround our career." The students were also motivated to participate because they saw it as a chance to challenge themselves through an experience that they felt would help them develop more maturity and additional skills that could be used to market themselves when seeking jobs.

In terms of whether the participation shaped future international experiences, students explained that an immediate result of the experience was that it encouraged them to take additional courses outside of the college of engineering that had a more liberal arts focus. Of the eight students who participated in the focus group, all commented that they had strong interest in traveling overseas again or working abroad in the future. Four of these pursued longer-term

study abroad or international internship programs during the course of their undergraduate degree, with two successfully completing programs. One spent a semester in Australia and another participated in a six-week research laboratory course in Denmark. A third student had applied for a semester-long program but did not attend because of problems with course transfer. A fourth applied and interviewed for an international internship in France but was not offered a position. Several of the participants went on to get involved in student-led initiatives to recruit other engineering students to study abroad. As a result of this experience, one student went on to take a part-time paid position in the university's Education Abroad Office, while five others became active members in the college's Student Engineers Abroad Council, a student organization whose mission is to encourage other students to study abroad. Students explained that while they may not have had an opportunity to travel abroad a second time, the experience did help them gain confidence related to foreign travel. If students had not had an opportunity to travel again, several of them mentioned that transferring credits or the additional time to degree that would have been required if they had undertaken such an experience prevented them from pursuing the travel while still an undergraduate. Interestingly, many of the students explained that while they would like to travel abroad again, the RSAP experience satisfied the immediate interest that they had for such an experience.

In terms of an impact on their career goals, several students explained that they wanted to pursue work with an international company. One student expressed the common sentiment among participants that they did not want to work for, "a larger company but one that has opportunities to travel or work outside the U.S." Several of the students explained that they switched their major as a result of the program. For instance, one student moved from chemical engineering to mechanical engineering because he felt doing so would open more opportunities for work in an international company. In addition to increasing student interest in international experiences, responses indicated that participating in the RSAP experience also affected students' choices in their academic path during their undergraduate career. One student changed his major after participation in the program, describing his new major of mechanical engineering as "more hands-on," "very global," and "a universal tool," a conclusion attributed to visiting industries during the RSAP program. For others, they incorporated international or liberal arts courses into their curriculum. Lastly, participation in RSAP also impacted future career goals and broader ideas about what it means to be a 'global engineer'. As one student explained, "the main thing I've noticed [after the program] is I have considered more employment abroad…I would not have done that otherwise." Students also expressed a strong awareness of the global aspects of engineering as they reflected on their disciplines. As one student described, "it's just another day in the office when you are talking to people in India and getting items from Shanghai. You definitely need to be open to it and know not to be afraid to interact with other cultures…you just never when it's going to pop up, you just have to be ready for it."

In shaping their perceptions about a global engineer, many students discussed some of the skills they felt they would need in order to be considered a global engineer. This included learning a foreign language. Others explained that the experience helped them see the interconnectedness of what they are doing and learning in their courses at Virginia Tech and the global reach that the engineering profession has.

Discussion and Recommendations: Closing the Loop

RSAP provides a ready made group of students with similar interests, leading to an outlet for students that have identified an international experience during their undergraduate careers as an important goal. The timing of RSAP coupled with the inflexibility of the engineering curriculum makes RSAP an ideal venue for these students. From the information collected during program evaluation, the students are learning skills such as ethical leadership, team work, and communication. They also discussed the value of knowing about different cultures when undertaking their work, an important part of work in the global engineering context. The depth of student knowledge and the scope of their skills in relation to these areas were not gauged by this particular assessment. While the brevity of student responses in the writing assignment may be the reason that this group of students only generally acknowledged these items, lack of detail might also be attributed to the students' developmental level in that they are first year students. More explicit detail and examples could be added as students mature and make their way through their course work.

RSAP provides a lab experience for the students in relation to the topics covered during the class. Students were applying skills, terms, and ideas they learned during the class when they talked about what they gained from the RSAP experience and also demonstrated growth in these areas in the writing assignment. However, students did not make the connection back to the class topics or the time they spent developing relationships during the class with their peers. In many cases they identified the trip itself as the main event; it was the primary focus for the students in relation to the RSAP experience.

Assessment practice suggests that findings from the study need to be utilized to make adjustments in curriculum or common program practices in order to help close the loop or facilitate the continuous improvement process. Based on the results from this particular study, revisions were made to the class structure and materials. The syllabus was revised to reflect the desired goals and outcomes identified as part of the RSAP experience, including a greater emphasis on development of global competencies and related skills. Given the developmental level of the students enrolling in RSAP, the course was also revised to discuss leadership skills in more detail and how leadership involves team work. This was done to address the theme in the writing assignment that seemed to suggest that students thought leading and collaboration were mutually exclusive concepts. The course will also be revised to include more discussion on culture. While students referred to this term in their writing and during the focus group, it was unclear what they meant when using the term and few provided clear examples of how they thought culture might impact engineering practice.

We plan to conduct similar focus group assessments among graduating seniors that were part of the 2009 RSAP cohort. In addition, we hope to conduct assessments among the current (spring 2012) cohort to determine the impact of the RSAP experience on cultural competencies. In addition to the revisions to the class, we plan on also refining the assessment tools that will be used. The rubric will be revised to include more detail in terms of expected student behaviors. Some of this information will come from the students' work that was collected during this assessment. We also plan on having students list skills or behaviors in a pre-post assignment rather than writing paragraphs. This will be done so that the focus is on the skills students can

identify rather than on writing skills. The timing of the written exercise will be changed as well. Several students mentioned that being tired after the trip and beginning summer jobs and activities limited their response and reflection on the post-writing.

Conclusion

Overall, the findings point to some success in facilitating development of skills needed in a global engineering context and encouraging participants to undertake further international experiences. While this assessment does not account for possible predispositions these students may already have held before participating, this information can be used by other institutions to assess global engineering proficiency initiatives. Using direct methods of assessment and having students share their experience was a useful tool for the team involved in this project. The detailed responses and specific examples provided by the students provided multiple points for program directors to consider how global competencies develop among engineering undergraduates and what they might do to facilitate that development. Various groups will be able to use the information shared to consider how to assess initiatives underway at their own institutions that are related to addressing the need to provide students with experiences that encourage global competencies. Sharing information about the program goals, how the RSAP experience has been shaped to achieve those goals, assessment methods used to determine the degree to which those goals are being achieved, and how results have been fed back into the design of the RSAP experience is intended to allow for continued refinement and development of the undergraduate engineering curriculum. The curricular experience documented here has been shown to have a measurable and positive impact on development of global competencies.

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