

## **Short-term Study Abroad: Engineers Gaining Intercultural Competency**

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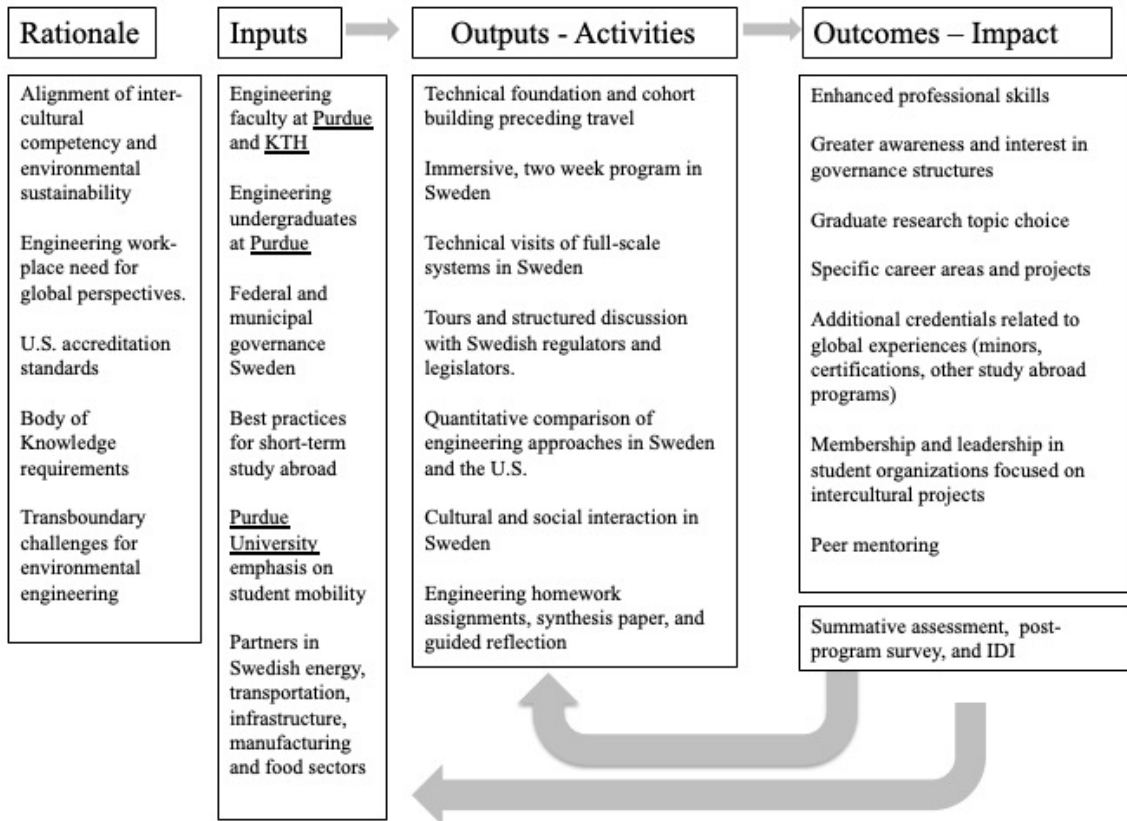
## Introduction

Intercultural knowledge and competency encompass skills and personal characteristics that enable a person to interact successfully in a variety of cultural situations [1]. University intercultural programs include short-term study abroad, longer term exchange programs, research experiences, and service learning, among many others. Engineering students in the United States may choose from a variety of program types [2]–[5], which have increased in number over the past few decades. Short-term study abroad programs are more accessible to students and have demonstrated success in developing intercultural competency [5]–[7]. Many environmental engineering undergraduate degree programs include objectives or outcomes related to intercultural competency, and the necessity is acknowledged by ABET, Inc. for accreditation [8].

A parallel development is the demand for engineering approaches that support environmental sustainability, as defined by the U.S. Environmental Protection Agency (U.S. E.P.A): “to create and maintain conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations”[9]. The Environmental Engineering Body of Knowledge and a recent report on future challenges for environmental engineering both include explicit mention of the intercultural competency, with phrases such as “Globalization and other contemporary issues” [10] or “global cultures” [11]. At the same time, environmental sustainability is a consideration for all fields of engineering.

These needs motivated the development of a short-term study abroad program at Purdue University for any engineering major, with a thematic focus on comparing approaches to sustainability in the U.S. to that of Sweden. The U.S. and Sweden have different governance structures, and based on international rankings, Sweden consistently outperforms the U.S. on many environmental metrics [12]. This study provides detailed information about program development, content, evaluation and longer-term student outcomes of the program “Sustainability Across Sectors-Sweden.”

Fig. 1 depicts a logic model for the program, highlighting the connections between program elements and desired outcomes. The *rationale* includes engineering workplace needs for global perspectives, and environmental engineering Body of Knowledge requirements. *Inputs* include engineering faculty, staff and undergraduates, best practices for short-term study abroad, and partnerships in various Swedish sectors. *Activities* consist of technical visits of full-scale systems in Sweden, quantitative comparisons of engineering approaches in Sweden and the U.S., and cultural and social interaction in Sweden. The *impacts* of the program include enhanced professional skills, additional credentials related to international experiences, and selection of research topic or career direction related to environmental sustainability.



**Fig. 1:** Logical model for the Sustainability Across Sectors-Sweden short-term study abroad program. The program content and structure were updated three times, based on student assessment.

## Program Development and Implementation

The program entitled “Sustainability Across Sectors-Sweden” was developed to help engineering students at Purdue University meet specific learning outcomes required by their majors, including an understanding of how engineering fits into a global, economic, environmental and societal context. The program provided an opportunity for undergraduate engineering students to understand how culture and technology contribute to differences in environmental sustainability practices and environmental quality in Sweden and the United States (U.S). A primary element of the program was integration of industry experiences into student learning. All industry visits were centered on actions and policies being implemented by the companies to preserve or enhance environmental sustainability. Students participated in technical tours and discussions sponsored by companies such as Skanska AB (sustainability and construction), the Stockholm Arlanda Airport (plane side visit), and E.ON Värme Sverige AB (a power company), Iggesund paperboard (a commission company of the Holmen Group), Kinnarps (furniture manufacture), and several others. Students also visited full-scale drinking water and wastewater treatment facilities, including the Käppala Wastewater Treatment Plant.

This plant in particular was unique: the facilities were entirely sub-surface, whereas similar facilities in the U.S. are located above ground. The full portfolio of student experiences included visits with the government sector (the Swedish Environmental Protection Agency, Naturvårdsverket) and the municipality of Stockholm, and research seminars and discussions at the partner university, The Royal Institute of Technology (KTH) in Stockholm, Sweden.

During travel to Sweden, the students were accompanied by the program leader, Inez Hua, and an additional university staff member. The program has been offered three times (2015, 2017, 2019). Most of the itinerary in 2015 and 2017 was based in Stockholm and surrounding areas. In 2019, the geographical scope of the program expanded, and details of that year's program activities are detailed below. Many of the activities combined both technical and cultural elements (for example, the technical visit with the reindeer herders).

Students began the program in Kiruna, Sweden, and visited the world's largest iron ore mine. A key theme of the visit was understanding the intersection between industry, sustainability, and infrastructure. During the visit, students heard from a variety of stakeholders, as much of the city of Kiruna will be re-locating because of the environmental impacts of the mine. While in Kiruna, students also had a chance to interact with the Sami (Sápmi) people of Sweden, who have traditionally herded reindeer. During the tour, the students were able to observe the reindeer and herders, and have a detailed discussion about the impacts of climate change and industrial growth on reindeer and herders' livelihoods. Students also interacted with the local tourism industry, to learn about solar energy initiatives for generating electricity in the region. The students then traveled south to Hudiksvall, and spent the day learning about an integrated forest products facility: starting with tree saplings and ended with paper and wood products. This technical tour was hosted by Iggesund Paper, associated with the Holmen Group. This experience provided an opportunity for students to understand how ecosystems (forests) support manufacturing, as the group visited managed forests, and the facility which housed paper and wood product manufacturing processes.

The class then travelled further south to Stockholm, where they learned about various urban development initiatives guided by environmental sustainability goals (Grow Smarter and the Royal Seaport development), and toured a full-scale wastewater treatment plant that was entirely underground (Käppala Wastewater Treatment Plant) for aesthetic and environmental reasons. Students also learned about urban food production, in a central area of Stockholm, and learned about Swedish governance during a visit to the Riksdag (Swedish Parliament) and Stockholm City Hall.

Following Stockholm, the program group then travelled further south to Falköping, and visited a full-scale furniture manufacturing facility, hosted by Kinnarps, a furniture company that prioritizes environmental sustainability. Students learned about environmental sustainability as applied to the entire supply chain of manufacturing furniture. The next site visit was in the city of Gothenburg, where the students visited several energy companies and learned about the district heating system in Sweden as well as different methods for generating heat and electricity, including heat pumps and municipal waste as fuel. The final visit was to Copenhagen, Denmark, and the program participants were able to learn about sustainability initiatives including urban

development and infrastructure, waste-to-energy plants, and public transportation systems.

**Table 1: Major activities, as related to application of technical or cultural topics, and years included in itinerary. All topics were within the context of environmental sustainability.**

<b>Technical or Cultural Topic</b>	<b>Activity</b>	<b>Year(s)</b>
Governance and federal policy	Swedish Parliament	All
Municipal governance	Stockholm City Hall	All
Federal environmental policy	Swedish Environmental Protection Agency	2015, 2017
Full scale heat and electricity generation and environmental impacts	E.ON (Järfälla)	2015, 2017
	Rya CHP and Renova (Gothenberg)	2019
Air transportation systems	Arlanda International Airport	2015, 2017
Urban infrastructure	Hammarby Sjöstad (Eco-City)	2015, 2017
	Royal Seaport	2019
Full scale municipal wastewater treatment	Käppala Wastewater Treatment Plant	2015
	Bromma Wastewater Treatment Plant	2019
Sustainable building construction projects	Skanska Headquarters (Stockholm)	2015, 2017
Pilot scale innovations in wastewater treatment	Hammarby Sjöstadswerk	2015
Royal Institute of Technology (KTH) research presentations	Ocean farming research Fossil-free bus fleets Automation in manufacturing Forest products engineering Biofuels and bioplastics Sustainable urban planning	2015, 2017
Urban Food Production	Rosendal's Garden	2017, 2019
Integrated forestry and wood and paper production	Iggesund paperboard/Holmen Group	2017, 2019
Large scale extractive processes	Kiruna Iron Ore Mine	2019
Climate change impacts on indigenous culture	Sápmi (reindeer herders)	2019
Municipal drinking water treatment plant tour	Stockholm Vatten - Lovö	2017
Sustainable Furniture Manufacturing	Kinnarps	2019

Students made progress towards their degrees, by earning technical elective or selective credit. The students spent Spring semester completing academic and cohort building activities on campus at Purdue University, and then traveled to Sweden in May. The course combined traditional classroom teaching with experiential activities abroad, to ensure academic rigor while developing intercultural competency. Specific learning objectives included: (i) applying material and energy balances to full-scale systems in Sweden, (ii) analyzing how environmental policies

are implemented with technical or non-technical solutions in Sweden, and comparisons with the U.S., and (iii) evaluating the scientific basis of selected metrics for ‘environmental performance’ for Sweden and the U.S. Students met these objectives by completing written homework assignments, discussions and small-group activities, and during their program experiences abroad. In 2015 and 2017, students earned 3 credits based primarily on activities during the two week travel period (summer semester). In 2019, the academic credit was re-allocated to 2 credits (Spring semester) and 1 credit (travel period/summer semester). The number of written assignments was about the same each year. However, the 2 credit spring course allowed for more thorough preparation for the many site visits in Sweden, including detailed discussion of the technical aspects of the environmental sustainability, as well as cultural aspects, such as the role of indigenous populations in Sweden.

The program was limited to students with a minimum 3.0/4.0 GPA and who were engineering majors. A majority of students were from two majors: Environmental and Ecological Engineering, and Civil Engineering, although there were also students who were majors in Chemical, Mechanical and Industrial Engineering. Of the 55 students who have completed the program so far, 62% are women and 38% are men. This is a notable difference compared to the overall percentage of engineering majors who are women (~20%) at Purdue University.

### **Evaluation Methods**

Student outcomes were evaluated with summative course evaluations, a post-program survey (alumni who were 2 years, 4 years, or 6 years post-program). The students who participated in the 2019 program also completed the Intercultural Development Inventory (IDI) pre- and post-program.

#### *Summative Teaching Evaluations*

Students completed summative course evaluations approximately two weeks after the course concluded. The evaluation was administered electronically by the Center for Instructional Excellence and results were not available to the instructor until course grades were released. The evaluation incorporated a 5 point Likert scale (5 = strongly agree; 4 = agree; 3 = unsure; 2=disagree, 1=strongly disagree).

**Table 2: Summative Teaching Evaluation Questions**

<b>Question</b>
1. This class provides a meaningful learning experience.
2. I learned new ways to think about the issues dealt with in this course.
3. The local cultural context was integrated into the academic content of this program.
4. I am better equipped to deal with intercultural issues.
5. This program enhanced my overall Purdue University education and training.

Questions 2-4 are closely related to intercultural competence, while questions 1 and 5 measure the value of the experience in the larger context of the student’s undergraduate experiences. The teaching evaluation did not capture any free-form student responses related to these questions.

### *Post-program survey*

All fifty-five alumni of the program were invited to complete an electronic survey via Qualtrics. The survey was developed to match education research best practices [13] and approved by the Purdue University Institutional Review Board, IRB-2021-138. The purpose of the survey was to assess post-program experiences, especially in the context of longer term career and academic development. The survey included questions about current professional or academic status, post-program intercultural or international experiences, and questions about the impacts of specific elements of the program. Table 3 below includes the survey questions, and the text of the full survey instrument is included in Appendix A.

**Table 3: Post-Program Alumni Survey Questions**

<b>Question</b>
1. Current status: full time employment, part time employment, full time student, part time student, other. If “other,” please describe.
2. In what year did you complete the program: 2015, 2017, or 2019.
3. After completing the program, did you participate in any additional academic or professional intercultural activities? If yes, please describe the activities. If yes, please describe why you chose the activities.
4. Did any elements of the program influence your post-program academic and/or professional development? If yes, please explain.
5. Please provide any other comments about the program as related to your professional development.

### *Intercultural Development Inventory*

Students who completed the program in 2019 also participated in pre- and post-program administration of the Intercultural Development Inventory (IDI), and were given the option of a de-brief with an IDI Qualified Administrator. The IDI, which consists of 50 questions, has been used by number of universities in various countries to assess intercultural competency [14]. The IDI has been used extensively to assess the impact of a variety of intercultural experiences, including study abroad [2], [4], [15].

### **Evaluation Results**

#### *Summative evaluations*

Students completed summative course evaluations approximately two weeks after the course concluded. Responses to questions related to intercultural competency, or how the program fit into a larger context of learning, are shown below. The evaluation incorporated a 5 point Likert scale (5 = strongly agree; 4 = agree; 3 = unsure; 2=disagree, 1=strongly disagree) and results are shown in Table 4. Response rates vary from 65% - 100% each year.

**Table 4: Arithmetic mean of student responses to summative course evaluation questions**

<b>Question</b>	<b>2015 (11/17)</b>	<b>2017 (15/20)</b>	<b>2019 (18/18)</b>
This class provides a meaningful learning experience.	4.7	4.4	4.9
I learned new ways to think about the issues dealt with in this course.	4.6	4.8	4.8
The local cultural context was integrated into the academic content of this program.	4.7	4.2	4.9
I am better equipped to deal with intercultural issues.	4.4	4.2	4.6
This program enhanced my overall Purdue University education and training.	4.8	4.2	4.8

Based on the responses, students perceived that the program provided benefit to their undergraduate studies, and that their intercultural skills improved. Because “issues dealt with in this course” were focused on environmental sustainability, students also developed multiple perspectives on the topic. The summative evaluation did not elicit any free-form student responses related to the five questions above, so it is not possible to determine which elements of the program contributed to these gains.

#### *Post-program Survey Results*

Twenty-seven program alumni completed all questions of the survey (49% response). Eight respondents partially completed the survey. Only responses from complete surveys are included in this analysis. Twenty respondents reported full time employment, and seven were full-time students. Twelve respondents completed the program in 2015 (6 years post-program), seven completed the program in 2017 (4 years post-program), and 9 completed the program in 2019 (2 years post-program).

#### Impact of program elements

Twenty-three of twenty-seven respondents answered yes to the question: “Did any elements of the program influence your post-program academic and/or professional development?” and provided a free-form response. The responses were coded and could be categorized broadly into experiences that were mainly technical (n=13) or mainly cultural (n=6). Seven participants reported experiences from both categories were impactful. For example, Respondent A states: “*After visiting a few treatment plants in Sweden, I was interested in learning more about water treatment... I now work for a firm that specializes in water treatment and have spent my young career working on solutions to different issues related to water,*” indicating the impact of a primarily technical visit on career direction and choice. On the other hand, Respondent B writes, “*Taking a tour of the Swedish Parliament and learning more about the local governance of Stockholm got me interested in how government and policies made such a big difference in climate education and understanding in Sweden compared to the US. I studied more about environmental policy and decision making in grad school and currently working for the government on capacity building and environmental literacy of the general public.*” Other



students report pursuing additional academic credentials after completing the program, such as a minor in environmental politics and policy.

A few students described the impact of multiple types of experiences and significant long-term impact on academic and professional direction. Respondent C reports, *“The emphasis on sustainability in the transportation sector while visiting Arlanda airport as well as visiting Hammarby Sjostad both were huge reasons that I shifted my passion to sustainable infrastructure and transportation planning. I also think the presentation at the EPA led me to be interested in the sustainability focused goals of Sweden and the UN through environmental policy. It ultimately became a key part of my master’s thesis.”* Thus, the impact of the program took shape even several years later when the student was at a different institution for graduate studies.

Other students reported benefits from the theme of the program, or the experiential nature of study abroad. For example, Respondent D: *“I think the sustainability focus helped me in my job search because many companies are trying to be more sustainable. The study abroad itself also showed potential employers that I was a well-rounded candidate for their position.”* Student E reports greater confidence in the professional realm, *“I believe that it was something more intangible that I got out of the program. The key thing was the confidence I developed to reach out to people, strangers, etc. in fields that I am interested in. The opportunity to see a different country, culture and different area of engineering (coming from mechanical engineering) was priceless and influenced me in how I approached classes.”*

Many students reported that the impact of visiting manufacturing or construction facilities shaped their career interests. Respondent F concludes, *“The portion of the trip where we visited the Paper Company opened my eyes to the resource use of manufacturing and influenced my decision to pursue a career in industrial/corporate sustainability.”* The impact of the lectures by KTH faculty is also apparent, and allowed students to think about U.S. adoption of specific technologies. Respondent G states, *“In retrospect, the Fossil-Free Bus Fleet was my first exposure to solids digestion. I am currently helping in the commissioning phase for a thermal hydrolysis system in Texas. It's not as exciting as running an entire bus fleet on gas, but it is becoming a more financially viable option in the US.”*

Eighteen participants provided a free-form response to the question: “Please provide any other comments about the program as related to your professional and/or academic development.” Participants report greater awareness of environmental sustainability in different cultural contexts, several mentioned benefits related to expanding professional networks, and others describe growth in higher order thinking skills. For example, Respondent H writes, *“While I am not really in a sustainability focused role right now, this trip proved to be a great resume builder, and always came in handy when interviewing for internships and full time jobs. Even now post grad almost 4 years, I still talk about it during interviews and it helps me build connections at the office.”* Respondent J concludes, *“The program taught me to think critically about the major differences between sustainability in the United States and sustainability in Sweden while introducing me to a new culture. It was eye-opening to see the cultural and political differences first-hand.”*

### *Post-program intercultural activities and student motivations*

The influence of the short-term study abroad program can be interpreted in a larger context of additional intercultural experiences that followed the program. Eight respondents describe additional intercultural activities and explain their choices of activities, in response to Questions 3a and 3b of the survey. The most common responses included additional study abroad courses (either short-term or longer term exchange programs), academic credentials such as minors or certificates, and participation in organizations such as the Peace Corp and Engineering Without Borders (EWB). Questions 3a and 3b appeared before Question 4 so that students would report on their activities without necessarily connecting them to the Sweden study abroad program. The intent of Questions 3a and 3b was to elicit information about students' interests and motivations aside from the Sweden study abroad program. Most students report a long-standing interest in visiting non-U.S. countries as a motivation for choosing the additional experiences. For example, Respondent K explains, “*I enjoy traveling and living in new cities/countries. I also enjoy mentoring engineering students and felt I was able to provide advice on international, student engineering projects to more junior engineers.*” This participant had taken on a leadership role with their university's chapter of Engineers without Borders (EWB).

### *Intercultural Development Inventory Results*

Every student in the 2019 program completed the IDI in January (pre-program) and in June (post-program). The IDI is based on an Intercultural Development Continuum, which spans denial, polarization, minimization, acceptance and adaptation [15]. Additional information about the continuum is available in references [15]–[17]. In brief, the characteristics of respondents in each category are as follows: Denial: lack understanding of cultural differences; Polarization: views cultural differences as an obstacle; Minimization: neutral view of cultural differences; Acceptance: identifies and is interested in cultural distinctions and similarities; and Adaptation: Dynamic cultural perspective and behavior, responsive to context. The results are shown in Fig. 2.

There is extensive literature about interpreting IDI results as a measure of an individual's development of intercultural competency. Although Fig. 2 implies linear development, there is literature that supports a different model: progress towards intercultural competency may be better modeled as a “pendulum swing” rather than development in a single direction [18], and a decrease in the IDI score does not necessarily mean a “reduction” in intercultural competency.

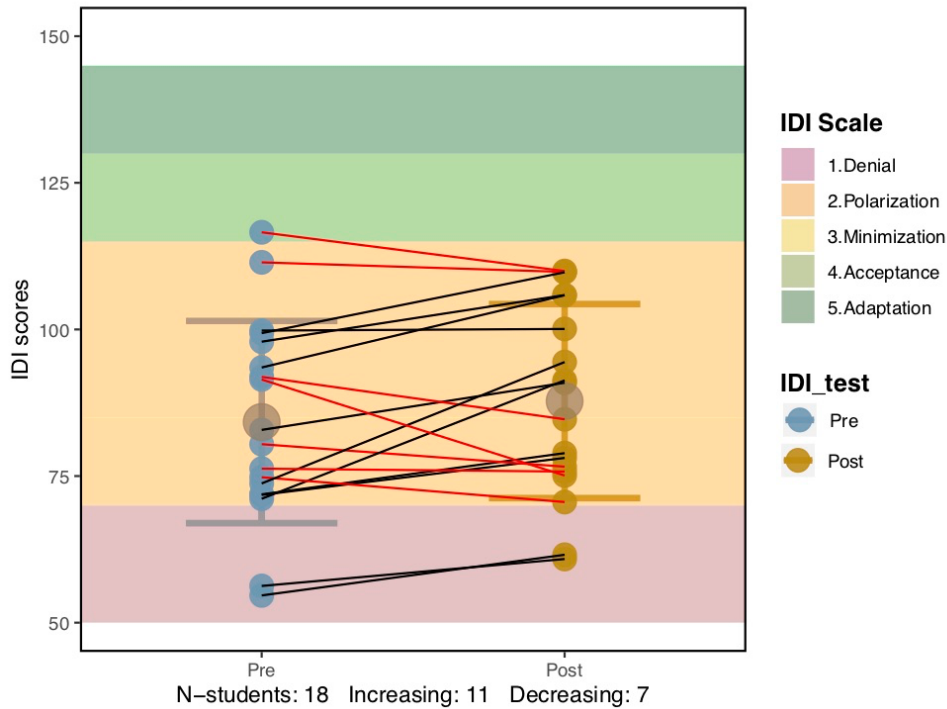


Fig. 2: Comparison of IDI scores pre- and post- program. Eleven students showed an increasing trend and seven students showed a decrease.

## Conclusions

The Sustainability Across Sectors – Sweden program impacted students’ short- and long-term academic and professional paths. The summative teaching evaluation scores reflect that students gained new cultural perspectives and that the program integrated Swedish culture into the curriculum. Students also recognized the program in the larger context of their engineering major at Purdue University. The short-term benefits continued and evolved to shape students choices regarding graduate school, thesis research topics, additional intercultural and international experiences, and career pathways. Most respondents were located in the United States when they completed the survey. Students also identified specific program elements that were particularly impactful. These elements included technical site visits (manufacturing, infrastructure, water and wastewater treatment plants) and in-depth tours and discussions related to national or municipal governance in Sweden. Several respondents reported a direct impact on the types of projects they chose to work on, or the type of employer they sought. The most recent cohort of students (from 2019) demonstrated advancement along the intercultural competence continuum. The three evaluation methods (summative teaching evaluation, post-program alumni survey, and IDI) were de-coupled, so it is not possible to synthesize responses from each method for individual students. However, results from all assessments are consistent, and suggest that students gained multiple skills by completing a short-term study abroad program.

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## Appendix A: Alumni Survey Instrument

Responses collected via Qualtrics XM.

The purpose of the survey is to gather information about the academic and professional development of Purdue University undergraduate students after completion of a short-term Study Abroad program. Students who completed the short-term Study Abroad program entitled “Sustainability Across Sectors-Sweden” are invited to complete the survey. Survey responses are anonymous. Responding to this survey is completely voluntary. You may stop at any time.

1) Current status: full time employment, part time employment, full time student, part time student, other.

If “other,” please describe.

2) In what year did you complete the program: 2015, 2017, or 2019.

3) After completing the program, did you participate in any additional academic or professional intercultural activities?

3a. If yes, please describe the activities.

3b. If yes, please describe why you chose the activities.

4) Did any elements of the program influence your post-program academic and/or professional development?

If yes, please explain. A copy of the itinerary from your year of participation is available at this link. (*Link was live in Qualtrics*).

5) Please provide any other comments about the program as related to your professional development.

Thank you for participating in this survey. Your input will improve development and implementation of intercultural programs for engineers.