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# Developing a Global Competency Mindset in an International, Faculty-led Program in Brazil Focused on Sustainable Energy

**Dr. Courtney Pfluger, Northeastern University**

Dr. Courtney Pfluger took a position in Fall 2011 as an Assistant Teaching Professor at Northeastern University as a part of the First Year Engineering Faculty and affiliated Faculty in the Chemical Engineering Department. Dr. Pfluger redesigned and piloted the first-year curriculum which included engineering design and computational problem solving using the Engineering Grand Challenges as real-world applications of global issues. She developed and ran for 8 years a faculty-led international program to Brazil focused on Sustainable Energy and Brazilian Culture. This program educates students on the effects of various energy systems and the challenges of social and environmental justice in developing countries. In 2017, Dr. Pfluger moved into the ChE department where she implemented improvements in the Transport 2 Lab and Capstone courses. She assists Capstone students to develop dynamic design projects that address and help solve real-world, global challenges. Dr. Pfluger has served as the AIChE Student Chapter Faculty Advisor for 10 years and is chair of the AIChE Student Chapter Committee. She is a Mathworks Teaching Fellow and has won serval teaching awards such as Northeastern Chemical Engineering Department Sioui Award for Excellence in Teaching, Northeastern College of Engineering Essigmann Outstanding Teaching Award, AIChE Award for Innovation in Chemical Engineering Education, and the Northeastern Inaugural Global Educator Award.

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## 1. Introduction

With the globalization of our world, it is important for engineering graduates to not just gain an understanding of global issues that impact today's society but become global problem solvers. Studies have shown that there is a need for engineers to understand social, global, and cultural issues as they enter the workforce[1]–[4]. So much so that ABET accreditation updated their 2022-2023 student outcome 2 to state "an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors."[5] This paper investigates how a short-term (5 weeks), faculty-led, international program to Brazil, focused on sustainable energy, encouraged the development of global competency skills in the participating engineering students. Using the OECD Program for International Student Assessment (PISA) global competency framework and assessment questionnaire, to determine which global competencies may have been enhanced in the students after the completion of the program. The study discusses how strategic programmatic planning and execution can foster certain competencies in engineering students.

## 2. Literature Review

Global competencies are the ability to examine local, global, and intercultural issues, understand and appreciate different perspectives and world views, interact successfully and respectfully with others, and take responsible action toward sustainability and collective well-being.[6] International short-term study abroad programs are designed to offer experiential learning opportunities that students may not get in a traditional classroom setting and can help develop understanding of global competencies.[7],[8] Schenker studied how to foster global competence in a short-term (8 week) study abroad experience in Germany. The results show that short-term study abroad can have positive effects on several dimensions of global competence, namely internal readiness overall, open-mindedness, attentiveness to diversity, as well as historical perspective. [9] There are programmatic developments that can also enhance global competencies in these short-term study abroad global experiences. Specifically, a study by Berg et al. found that students who interact more with members of the target community have been shown to make stronger gains in intercultural competence during their time abroad.[10]

In addition, these global experiences offer informal learning opportunities, learning that is unstructured and happens outside traditional learning settings, which can assist students in gaining understanding of others' perspectives, adapt to uncomfortable situations, and enhance cross-cultural awareness. A study done by Sharma et al. found that the informal learning environment of preservice teachers during a short-term study abroad program in Honduras resulted in fostering enhanced socio-cultural awareness and were more sensitive to their own assumptions about race, class, and gender differences in the U.S. [11]

However, there has been evidence that shows simple cross-cultural contact may not be enough to gain global competencies.[12] It has been seen that for cross-cultural contact to have enhanced educational value, it must be prepared for, facilitated, and reflected on in particular ways and that "intercultural learning does not happen automatically". [13] Study abroad programs, especially short-term ones, need to carefully develop and plan a program that provides opportunities for enhancing global competencies. Especially knowing that immersion by itself is not sufficient for student learning and ensuring direct focus on cultural exchange and how intercultural learning happens is important for the success of short-term programs.[10] Davis and Knight found that well-structured study abroad programs that prepare students before departure, offer support for them to leave their comfort zone during their time abroad, and integrate their experience upon return help students make significant gains in intercultural and global competence. [14] Leading to the question, how can a short-term, faculty-led international program be designed and implemented in a way that maximizes students' global competencies and how can those competencies be measured?

3. Research Methods
    3.1.Research Questions
        3.1.1. What pedagogical and programmatic strategies can education practitioners develop and implement to foster global competencies in short-term, faculty-led, international programs?
        3.1.2. How did the student perception of the 4 domains of global competence change from before and after participating in the global experience?

    3.2. Global Competency Framework

There are many ways these competencies can be developed in engineering students. To understand how these can be fostered in students on international programs, a framework and model needs to be applied and used to assess student learning. OECD Program for International Student Assessment (PISA) developed a global competency framework which takes students' knowledge of global issues and culture along with cognitive skills to come up with four global competence dimensions.[6] The PISA global competence framework has four dimensions: 1. the capacity to examine issues and situations of local, global and cultural significance; 2. the capacity to understand and appreciate different perspectives and world views; 3. the ability to engage in open, appropriate, and effective interactions across cultures; and 4. the capacity to take action toward sustainable development and collective well-being.[6] Figure 1 shows how these four dimensions were derived from students' global understanding.

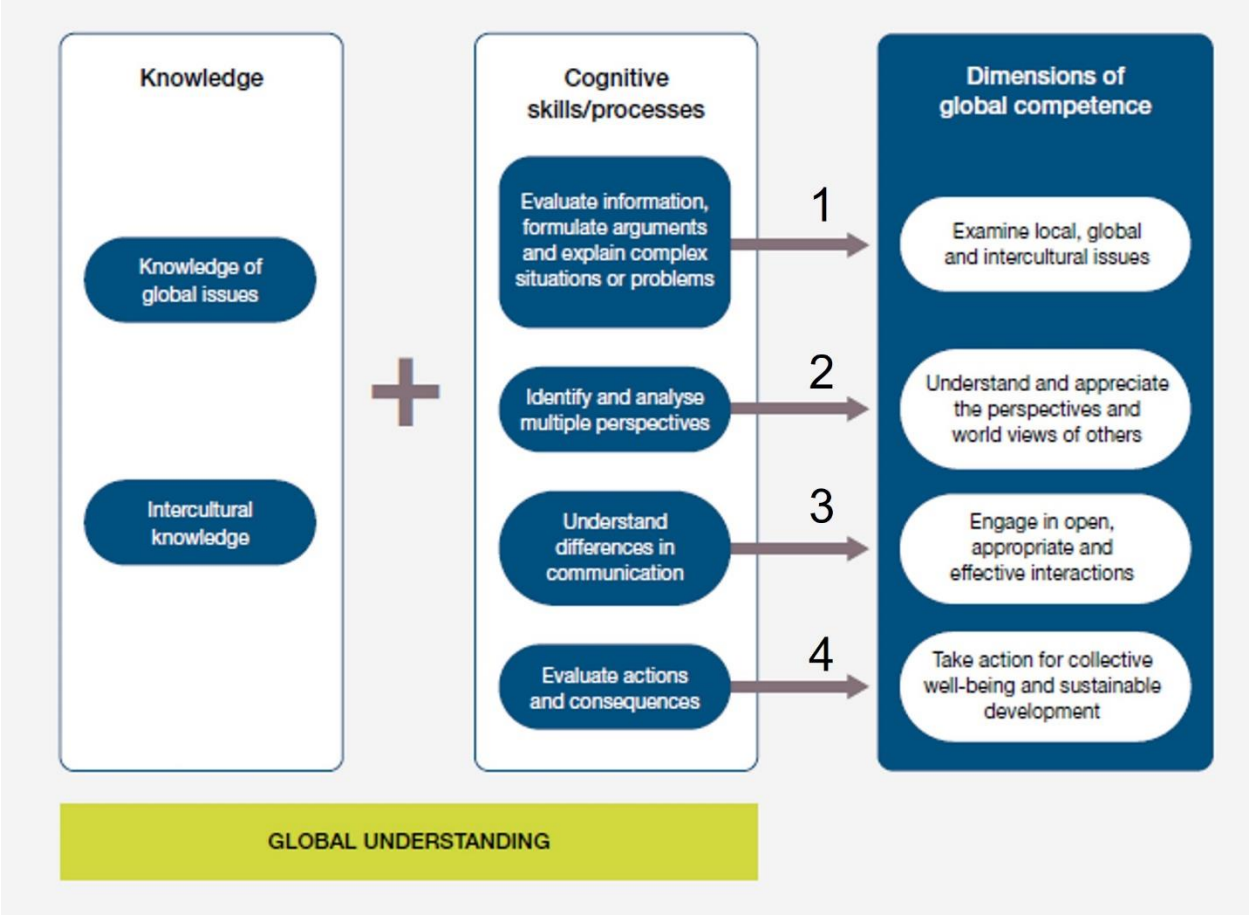


*Figure 1: PISA cognitive test of global understanding and the four dimensions of global competence.* [6]

The PISA global competence framework was used for this study because it incorporated the understanding of sustainable development. This was of particular interest in this program to Brazil which was focused on sustainable energy and had specific learning outcomes to sustainability and social responsibility. Ortiz-Marcos et al. used the PISA global competence framework to map the global competencies of students graduating engineering programs in 5 countries in Europe. They found that only five global competencies were common throughout the graduates of the five countries, which were flexibility, adaptability, teamwork, oriented to face challenges, and cooperation.[14] This study provided the evidence that this survey could be used for engineering programs at universities.

### 3.3.Methods and Survey

The development of global competencies in the students on this program were researched using the OECD PISA global competence framework and questionnaire.[6] The PISA global competence framework has four dimensions which were then mapped to different content domain questions shown in Figure 1. There were multiple questions in each content domain asking the students to self-report how comfortable they felt about certain topics or situations on a

Likert scale of 1-5. The content domains were then mapped and correlated to the dimensions of global competence from the PISA framework, shown in Table 1.

*Table 1: Mapping Content Domains to Global Competency Dimensions from the PISA global competency framework*

| Q # | Content Domain | Dimension of Global Competence |
|---|---|---|
| **1** | Self-efficacy regarding global issues | 1 |
| **2** | Awareness of global issues | 1 |
| **3** | Perspective-taking | 2 |
| **4** | Respect for people from other cultural backgrounds | 2 |
| **5** | Adaptability - Personal adaptions in behavior in uncertain/ uncomfortable situations | 3 |
| **6** | Awareness of intercultural communication | 3 |
| **7** | Global mindedness | 3 |

In addition, open-ended questions were asked the students. These questions were:

1. *Explain your thoughts on the importance for engineers to understanding global issues and other cultures.*
2. *What parts of the trip you think will/did helped them learn about global issues and Brazilian culture?*

The students were given the voluntary questionnaire before and after the program to Brazil which also included information on demographics, languages spoken, and personal cultural influences.

### 3.4 Positionality

The author is a non-tenure-track teaching faculty, minoritized who self- identifies as a woman. She developed this faculty-led, international program to Brazil focused on sustainable energy in 2013 at Northeastern University. It has run in-country 8 times and virtually once. Development of in-country and virtual programs have been discussed in other publications by the author. [15, 16] Additionally, the author has taught design related courses with a focus on sustainability and social responsibility for over 10 years, 6 years in First Year Engineering design courses including developing and implementing the redesign of the first- year engineering curriculum incorporating design and problem solving focused on the Engineering Grand Challenges. They taught unit operations laboratory courses for 3 years and senior capstone design for 4 years.

## 4 Program Details

### 4.1 Participants

This study specifically investigated students that participated in a 5-week, faculty-led, global program to Brazil focused on Sustainable Energy in the Summer of 2022 through Northeastern University. The demographics and breakdown of students can be found in Table 2.

*Table 2:Northeastern University Student Demographics for the 2022 global, faculty-led program*

| | | |
|---|---|---|
| Number of students | | 16 |
| Identified Gender | Female | 11 |
| | Male | 5 |
| Race/Ethnicity | White | 12 |
| | Asian | 2 |
| | Black | 1 |
| | Two races (Asian and white) | 1 |
| Speak more than one language | | 8 |
| Major | Chemical Engineering | 7 |
| | Environmental Engineering | 4 |
| | Civil Engineering | 2 |
| | Bio Engineering | 1 |
| | Industrial Engineering | 1 |
| | Mechanical Engineering | 1 |

4.2 Programmatic Development and Execution

This international, faculty-led program in Brazil, focused on sustainable energy was designed to meet certain learning goals, which are: (1) technical engineering concepts on how energy systems work and how they can be designed sustainable with real world examples, (2) how these sustainable technologies are implemented in Brazil and what policies are used to develop and regulate them, and (3) provide experiences to engage in authentic and open discussions to learn about Brazilian culture through a variety of different audiences and venues.

To meet the first goal, two second year level courses, General Engineering *Energy Systems* and Chemical Engineering *Conservation Principles*, were taught to provide background knowledge of how energy systems work, concepts of material and energy balances, and how chemical reactions can be manipulated in processes for sustainability and energy efficiency purposes. There were lectures and readings to develop understanding of the second goal, how sustainable technologies are implemented and regulated in Brazil. However, most of the learning of these concepts happened in interactions and visits to companies, government agencies, and/or communities to discuss how they implement technologies, policies, and/or engage in entrepreneur activities to implement sustainable technologies. Some examples of visits include a sugarcane ethanol production plant, a biogas-producing landfill to produce energy, and the largest electricity producing hydroelectric plant in the world, Itapúa.

Lastly, to meet the third goal, a project was developed where students worked with Brazilian university students alongside a Brazilian energy technology company, CPFL Energia. CPFL Renováveis is a company of the CPFL Energia group and explores opportunities in the Brazilian market for generating electricity from renewable sources. During this 5 weeklong project, the students were asked to design and suggest improvements for CPFL to be more sustainable in 4

sectors/processes by reducing the company's energy and material usage. These 4 sectors and project teams were:

1. Develop an integrated model of management and operational control of aquatic macrophytes, to promote cost reduction, optimization of water areas for the community, and potential use of plant biomass.
2. Propose sustainable sources for green hydrogen, specifically to foster Brazilian perspective and opportunities in this market.
3. Define a viable destination/reuse solutions for tree pruning residue, analyzing effects to communities and propose alternatives for destinating those residues.
4. Propose alternatives for the noble disposal/reuse of waste from packaging, in order to reuse it in its entirety and avoid disposal in landfills or inappropriate formations.

As part of this program long project, the students worked with the Brazilian students to develop a team agreement on how they planned to communicate and work together for the duration of the project. This helped the teams discuss communication, team dynamics, and expectations for the project and how project management can be different across cultures. Each project team had two company liaisons that they also communicated with about project details and questions. The deliverables were a mid-project google site proposal and presentation to the company liaisons and a final project design proposal and presentation.

The students participated in four pre-departure meetings which discussed safety, Brazilian culture, and program expectations. Each meeting also included a Portuguese lesson on greeting, food, and safety phrases. The students also had multiple reflections throughout the program. They had a prompted blog post before they arrive in country asking them to discuss what they anticipate the program and their experience in Brazil to be like. They wrote daily blog posts with pictures reflecting on what they did and learned each day. This was a good mindful practice that allowed for consideration on their experiences. Lastly, they wrote a final blog after they arrived home after the program discussing what they learned, what they found to be the most impactful parts of the program, and how they will use what they learned in their future endeavors.

## 5 Results and Discussions

The student responses from OECD PISA global competence questionnaire before and after participating in a 5-week, faculty-led program to Brazil were analyzed to determine changes in perceptions of the 4 dimensions of global competence. The results provide insight into which constructs of global competencies were strengthened in engineering students after participating in the program and how program delivery and execution could have played a role in student competency development. First, the results from the questionnaire for the dimension of global competence 1, the capacity to examine issues and situations of local, global and cultural significance can be found in Table 3.

Dimension 1 showed the biggest increase of all the dimensions with an average of 16% from before and after the program in the content domain of self-efficacy regarding global issues. Specifically, a 25% increase in the question on how easy it would be to explain how economic crises in single countries affect the global economy, 17.7% increase in why some countries suffer more from global climate change than others, and a 17.4% increase in their easiness to explain

why some countries suffer more from global climate change than others. This directly indicates that participating in the program in Brazil, the students perceived to gain awareness, understanding, and evaluate information on global issues.

*Table 3:Student responses and % Increase from before and after the program for dimension 1 of global competence, which is the capacity to examine issues and situations of local, global and cultural significance.*

| Q# | **Content Domains for Dimension 1 of Global Competence** | % Increase |
|---|---|---|
| 1 | Self-efficacy regarding global issues | |
| | Q1.1 Explain how carbon-dioxide emissions affect global climate change | 17.4 |
| | Q1.2 Establish a connection between prices of textiles and working conditions in the countries of production | 15.9 |
| | Q1.3 Discuss the different reasons why people become refugees | 8.2 |
| | Q1.4 Explain why some countries suffer more from global climate change than others | 17.7 |
| | Q1.5 Explain how economic crises in single countries affect the global economy | 24.2 |
| | Q1.6 Discuss the consequences of economic development on the environment | 12.2 |
| 2 | Awareness of global issues | |
| | Q2.1 Climate change and global warming | 9.7 |
| | Q2.2 Causes of poverty | 9.8 |

Dimension 2 of global competence, which looks at the capacity to understand and appreciate different perspectives and world views, had less of an increase from dimension 1, as shown in Table 3. Dimension 2 specifically evaluated the content domains of perspective taking and respect for other cultures. There was a 6.6% increase in looking at a situation and what it would feel life in someone else's place and a 7.4% increase in the question on taking another person's perspective when they are upset with someone. This does show some situational awareness in looking at other people's perspectives. There was minimal increase in respect for other cultures, but the scores before the program were high with an average of 4.74 out of 5. This demonstrates that the students came into the program with this content domain.

*Table 4: Student responses and % increase from before and after the program for dimension 2 of global competence, which is the capacity to understand and appreciate different perspectives and world views.*

| Q# | **Content Domains for Dimension 2 of Global Competence** | % Increase |
|---|---|---|
| 3 | Perspective-taking | |
| | Q3.1 Before criticizing, I try look at the situation from their perspective and imagine how I would feel if I were in their place. | 6.6 |
| | Q3.2 When I'm upset at someone, I try to take the perspective of that person for a while. | 7.4 |
| 4 | Respect for people from other cultural backgrounds | |
| | Q4.1 I respect the values of people from different cultures. | 5.4 |
| | Q4.2 I value the opinions of people from different cultures. | 5.3 |

There was a moderate increase in dimension 3 of global competence, specifically looking at the ability to engage in effective communication with other cultures. There was an 8-10% increase in the ability to adapt to uncertain or uncomfortable situations. Specifically, a 10% increase in the perceived ability to deal with unusual situations is an indication that participating in the program allowed the students to grow and adapt in uncomfortable situations. During this program, none of the students came into the program with a working knowledge of Portuguese. This lead many student to mentioning being uncomfortable interactions at restaurants or grocery stores in their blog posts the first few weeks on the program. These uncertain or uncomfortable situations allow students to learn how to adapt to a new culture and language. In the students' final reflections after the program, they commented on feeling more comfortable going to restaurants and café's as the program went on. Increases were seen in awareness of intercultural communication, which could have been fostered when working on the project with the Brazilian students and company liaisons.

The only content domain in which there was a negative development was in question 7 on global mindedness. A decrease of 6.4 percent in the student perception of "I think of myself as a citizen of the world" and an 8.2 percent decrease in the "I can do something about the problems of the world" question. This result may be because they had a naïve perception of the world and considered they knew more about problems of the world and their role than they realized. After participating in the program and having a more robust understanding of global problems and what it may mean to be a citizen of the world, they realized they knew less than they thought going into the program. Interestingly, Schenker found similar results in reviewing global competence results from their short-term study abroad program in which they found a decrease in global awareness in the students who participated in their study. [9]

*Table 5: Student responses and % increase from before and after the program for dimension 3 of global competence, which is the ability to engage in open, appropriate, and effective interactions across cultures.*

| Q# | **Content Domains for Dimension 3 of Global Competence** | % Increase |
|---|---|---|
| 5 | Adaptability - Personal adaptions in behavior in uncertain/ uncomfortable situations | |
| | Q5.1 I can deal with unusual situations. | 10.1 |
| | Q5.2 I can change my behavior to meet the needs of new situations | 9.1 |
| | Q5.3 I am capable of overcoming my difficulties in interacting with people from other cultures. | 8.2 |
| 6 | Awareness of intercultural communication | |
| | Q6.1 I carefully observe their reactions. | 7.0 |
| | Q6.2 I frequently check that we are understanding each other correctly. | 7.6 |
| | Q6.3 I give concrete examples to explain my ideas. | 9.0 |
| 7 | Global mindedness | |
| | Q7.1 I think of myself as a citizen of the world. | -6.4 |
| | Q7.2 I can do something about the problems of the world. | -8.2 |

Students' perceptions on global competencies on the open-ended question "explain your thoughts on the importance for engineers to understanding global issues and other cultures" was

also investigated. Dimensions of global competence were mapped and coded to the open-ended responses and the percent change of the number of occurrences a dimension was mentioned and was calculated, shown in Table 6. The results found that the students discussed the ability to communicate with people of other cultures and to take action towards sustainable development goals significant higher after the program than they did before it began. This shows the value of the collaboration done during the projects with company liaisons and Brazilian university students to students learning global competencies. The projects provided a place for students to communicate with their Brazilian teammates on both sustainable energy topics for the project but also about how their lives after different growing up and being an engineering student in Brazil versus the United States. This cross-cultural learning was led by communication and partnership that the project provided.

*Table 6: Mapped responses to open ended questions to the Dimensions of Global Competence before and after the participation in the program*

| Dimension of Global Competence | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| % Change | 14.3 | -33.3 | 66.7 | 33.3 |

The students were also asked, "Rank what parts of this trip do you think will/did help you learn about global issues and Brazilian culture?" 50% of the students after the program ranked casual activities, such as street markets and walking around city as their number one way that they learned global issues and culture. This shows that students after the program found informal learning experiences valuable to their learning and adapting to the culture. This validates the studies discussing informal learning experiences as having positive impacts on students learning, which is especially true on international and study abroad programs. 38% of the students ranked discussing project with company and Brazilian students as their second choice. This demonstrates that students perceived the discussions and intercultural communication as an important factor in their learning of global issues and Brazilian culture.

## 6 Conclusions

This study found that for research question 1: *"What pedagogical and programmatic strategies can education practitioners develop and implement to foster global competencies in short-term, faculty-led, international programs?"*, that the incorporating a societal need or topical project in a program where the students get to discuss and design solutions for these needs with companies and local peers can enhance students global competencies in self-efficacy of global issues and perspective-taking. While performing these projects, make sure there is discussions about how work and communication will be done as a team. A suggestion would be to use a team charter and team building activities to ensure intercultural communication and a good team foundation before the project begins.

As for research question 2: *"How did the student perception of the 4 domains of global competence change from before and after participating in the global experience?",* the study discovered that the students perceived informal learning opportunities, such as buying produce at open markets and exploring different regions to observe how people live, as the largest contributor to them learning the global competencies. Specifically, these casual cultural activities were found to increase students' adaptability in uncomfortable situations and awareness of

intercultural communication. A recommendation from this research would be to incorporate many casual activities that gets the students to observe and interact with the local community.

The conclusions that can be drawn from this study is that by developing a short-term, global experience for engineering students that incorporates team building, communication, and unstructured learning opportunities, the students can have gains in fostering global competencies. The programmatic implementation of a project with students from the local country and industry helped with cross-cultural communication, understanding, and assessing the needs of that country. This leads to more socially responsible and globally aware engineers and the impacts they can have on a local and global level. Future work would be to implement this survey in other study-abroad programs with different program designs to find which delivery methods could foster better global competency development.


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