



## Teaching Ethical Photography to deepen Global Engineering Competency

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## Abstract

This work in progress examines how engineering students going abroad visualize their experiences through photography and asks how do students learn to see themselves as engineers in a global context? The project is integrated into a first-year global engineering course and builds on published educational assessment research of this program [1, 2, 3]. Through lectures and discussion sections that travel overseas for two weeks after exams, the course seeks to increase students' global engineering competency (GEC), assessed by several instruments including the Global Perspectives Inventory (GPI). In 2019, instructors designed a photo elicitation-reflection as a summative assessment, based on previous arts-informed methods used to explore students' development of STEM identity [4]. We completed a qualitative analysis of a sample (n=24) of these assignments from 2019 to generate baseline data for an ongoing comparative study, informed by the literature on mixed methods and visual research [5, 6, 7]. Preliminary results indicate that students who were not explicitly trained in visual literacy and ethics showed significant gains in several dimensions of global perspective taking, but rarely connected global experiences with their identities as engineers. In spring 2020, an online module was added to train students in this course to take ethical photographs during study abroad.

## Introduction

Global engineering competency (GEC) is a requirement in the increasingly globalized engineering field, as projects are developed across national boundaries and students will be required to work with people from different backgrounds [8, 9]. Although traveling abroad is one of the best ways to develop GEC, only about 5% of students in the U.S. who participate annually in study abroad are studying engineering [10]. International engineering education researchers have conducted studies and developed several instruments to measure global competency for engineers [11, 12, 13]. Researchers have refined measures of intercultural and ethical competence, although several leading instruments, including the Global Perspectives Inventory (GPI) rely on students' self-reported identification with I-statements linked theoretically to dimensions of cognitive, interpersonal and intrapersonal development and meant to assess population-level rather than individual student gains in competence. There are clear gaps between individual students' self-perception of their own global competence and how well they articulate relationships between cultural contexts and technical problem solving and how well they perform on assessments of geographical knowledge and cultural sensitivity. This gulf is evident in the photographs that students take and share to illustrate their experiences abroad, including in the context of formal course assignments.

As social media and students' online presence takes on greater significance for their post-graduation careers, as engineering educators we must also concern ourselves with how students learn to see themselves in a global context. Students increasingly seek out short-term global experiences, with a majority of U.S. students now participating in programs less than 8 weeks in duration [10], a trend that has sparked a corresponding focus in the international education literature. A short-term study abroad experience linked to a global engineering course at our own

institution has become the fastest-growing and largest faculty-led program. Research on the Rising Sophomore Abroad Program (RSAP) has accelerated in the last three years and informed course redesign. Rapid growth and ongoing assessment research has created an opportunity when combined with new course development in the online course management system, so that analytics on new assignments can yield data and, hopefully, insights for better ways to meet learning outcomes and student GEC attainment.

A recent study defined photo-elicitation as a method of teaching critical reflection in graduate engineering students [14], and instructors designed a photo-elicitation assignment for RSAP in 2019. Visual methods can help us understand the student experience and how students learn to identify with engineering practices and articulate the ethical stakes for their work in a global context. Our notion of engineering identity is informed by sociocultural theories of identity as co-produced with social practices, including the ways students reflect on themselves as engineers, *becoming* engineers, and *practicing in a global context* [15]. There is to date little evidence or best practices for teaching visual ethics to engineering students studying abroad, particularly for programs with multiple groups traveling to countries with vastly different cultural characteristics described in intercultural communications studies [16]. Our research begins to fill these gaps in international engineering education literature by analyzing students' photo elicitation-reflection assignments from their short-term study abroad in 2019 and, in 2020 and subsequent years, delivering a new course module on ethical photography for international engineers. By comparing the resulting student reflections as well as eventually examining module analytics, we aim to improve our understanding of how engineering students learn to see themselves as engineers in a global context.

## **Methods**

A qualitative approach was used in this study to answer our research question. We used a case study as the methodological framework to explore how engineering students learn to see themselves as engineers in a global context. Case study research is based on the examination of the context in the real-world setting of the phenomenon in order to have a deep understanding of it by using multiple data sources [17]. The unit of analysis for the case study are individual anonymized students, with data collected from their reflective assignments including photographs and text and a sample established based on survey results for the RSAP course. We made this methodological decision because our goal was to understand students' engineering identity development after a study abroad experience, using different streams of data.

### *Participants*

Participants in this study were Virginia Tech engineering students in the RSAP course. Twenty-four assignments were taken as a sample from over 150 student assignments submitted in spring 2019. Four students from each of six different travel tracks were chosen for this sample. We used student responses from the Global Perspectives Inventory (GPI), a survey administered at three points during the semester to understand how students develop global engineering competencies. We used a purposeful sampling approach [18], based on how respondents' GPI scores changed from week one to after returning from their short-term travel (week 17). We aimed to have a

broad representation of students by sampling based on variation in GPI scores with four ideal types: those who had the largest increase in GPI score; those with the largest decrease; those with the smallest change; and those with the largest variation across the six metrics within their pre-course and post-travel GPI results.

### *Data collection*

Data consisted of a final assignment for the RSAP engineering course at a research university in the U.S. In this course, students take a spring semester course to learn about issues of global engineering, and then travel abroad for two weeks to visit engineering companies and universities. Students are assigned to different tracks around the world. Students signed a consent form to allow the use of their assignments for research purposes and the study secured ethical clearance through IRB. The assignments consisted of a final reflection on the students' study abroad experience, using a photo elicitation-reflection, with students instructed to choose five photographs representing significant or meaningful trip experiences and then describe and reflect on what they learned from these experiences; they were also asked to respond to questions in a mock internship interview scenario. There were two main sources of data for analysis: the pictures the students used and the short written reflections that accompanied the pictures.

### *Data analysis*

Data analysis was conducted by two members of the research team using the thematic analysis approach outlined by Robson and McCartan [19]. Thematic analysis uses individual experiences, interpretations, realities, and discourse as avenues for exploring the group to which the individual belongs [20, 21]. Furthermore, to analyze the photographs, we used an arts-based inquiry approach [6, 7, 22, 23]. Arts-based inquiry is an emerging research methodology that is more based on the formal qualities and aesthetic features of the data, allowing the researchers to extract deeper human perceptions. Similarly, a thematic analysis of the students' descriptions of the pictures provided a means to apprehend how students expressed their engineering identity during the experience relative to a global context.

The sample files were anonymized and entered into a qualitative data analysis software (NVivo 12), where a two-person team coded all entries, compared and refined coding, and analyzed the resulting patterns. The codebook focused on key terms and concepts for engineering identity and global perspectives that students used in their language and images. For global perspectives, we adapted key terms from themes used in the GPI. Because we sought primarily to understand how students learn to see themselves specifically in a global context, we used codes based on geographical setting and visual composition to create a comparative matrix with four elements for data analysis: engineering identity; global perspective; geographical setting; visual composition.

Coders sought to identify places where students write about their identity and terms related to engineering in the context of elements of global perspective, where students demonstrate self-awareness of themselves as engineers and their global context.

### *Limitations*

The study limitations are related to the transferability of the findings. Since the sample represents a small sample, it might not be representative of all the students that participate in study abroad experiences. In addition, results should be considered with caution as the students' experiences represent a specific institution and a specific study abroad program. Other study abroad programs in engineering could use a different approach and their settings and travel locations in particular considerably affect the students' experience. Nevertheless, we consider this work valuable as an initial exploration of how, using visual methods, arts-based approach, we can identify patterns of information that can help us understand the phenomenon of learning global engineering competence.

### *Measures of research quality*

Limitations were mitigated by having a set of procedures to ensure the results were of quality. Firstly, multiple coders met and agreed on analysis suggested in qualitative inquiry [18, 20]. The coders met to discuss the early stages of data analysis. An agreement was reached after having discussions on initial differences in coding to increase the trustworthiness of the results. The confirmability of the results was strengthened further in two ways. The credibility of the findings were further ensured by a third researcher that acted as an external evaluator of the process, ensuring inter-rater reliability; and data analysis was discussed collaboratively and results were deliberated by the three authors.

### *Results*

What do students talk about when they talk about their global engineering short-term study abroad? What pictures do they choose to capture what is most meaningful to them? In short, how do they come to see themselves as engineers in a global context? The majority of the 120 photographs from the sample group show familiar elements of tourism and student travel: plates of exotic food, snapshots of iconic landscapes or monuments, and selfies in front of picturesque mountaintops. This is not to trivialize what is learned by short-term international travel, but to underline a disjuncture between global engineering-specific learning outcomes and the photographs taken and chosen for reflection by students of their most meaningful experiences while abroad.

When students wrote about engineering in conjunction with their photographs, these depicted the built environment and showed students posing in groups during visits to significant infrastructure

(the Sydney Harbor Bridge) and industry sites (such as the Mini factory). Figure 1, a group portrait at a Mini factory in Oxford, United Kingdom was chosen by two separate UK track students in the sample and was a site of reflection on engineering identity for one of them, who wrote, “I hope to become an Industrial/Systems Engineer one day.” The student focused on an incident with how a manager addressed an issue on the assembly line during their visit; apart from identifying the plant’s location, neither student expressed explicit themes associated with global perspectives.



**Figure 1. Student picture at the Mini factory.**

Notably, in their written reflections, we saw almost no correlation of global perspective taking with awareness of engineering identity. Only four times across our sample did reflection on engineering occur in conjunction with explicit reference to global context or global perspectives, based on a matrix comparison of our coding in NVivo 12.

Only two students out of twenty-four articulated awareness of engineering in a global context directly, but this occurred not in their reflections on their photographs, but rather in the mock interview portion of the reflection assignment. One wrote, “The most important take away from my RSAP trip is how working with a diverse group of engineers from various countries can offer the necessary perspectives we need as engineers to create the best solution.” The other is worth quoting at length:

Altogether, I think RSAP has equipped me with knowledge, skills, and modes of thinking not conveyed in most engineering classes. It has encouraged me to think carefully on the global context in which engineering is increasingly occurring [sic], and imbued me with a curiosity [sic] for diverse innovation outside that most Americans are familiar with or default to. I believe it’s improved my ability to account for varied perspectives and differing cultures, especially in an engineering context. This will help me and

drive me [to] contribute to any engineering company's operations at a global level.

In other written reflections, global awareness arose in terms of negotiating language barriers, navigating city metro systems, being open to different people, and getting outside comfort zones.

Evidence of reflection on engineering was as common across our sample as curiosity about culture and history in a foreign place, but depth of identification with engineering varied dramatically. A few students wrote frequently about engineering practices or becoming an engineer and related words; thirteen students mentioned engineering less than five times across multiple pages and six students (25% of the sample) did not refer to engineering at all. A student who strongly identified as an engineer, and who had never flown on an airplane or left the U.S., traveled to China. This aerospace engineering student wrote about an image taken from the window of the plane: "I was a little worried before the plane took off from Dulles. What if I hated it? Then what would I do with my life? Would I still want to be an aerospace engineer? All my fears vanished as soon as the plane took off. It was thrilling!"

This quotation also exemplifies the overall tone students took as they reflected on photographs of their experiences abroad: we saw significantly greater curiosity and appreciation of cultural difference than shock or disgust. It was rare to find expressions of feeling threatened by encountering people from different backgrounds. Only one student wrote of feeling "extremely out of place" in Morocco, "because of that I knew I was being judged by those I passed on the street." A few people expressed awareness of specific environmental differences to the places they visited, including the presence of smog or other forms of pollution that caused them discomfort.

Students expressed more assumptions and stereotypical language about China and Chinese culture than the other destination tracks: "I came into the trip thinking of China as one large country and one culture," wrote one student. Another wrote of "all of the horror stories I hear about poor working conditions in China." These students noted how their assumptions or stereotypes were challenged and altered by visiting Chinese cities, interacting with engineers there, or taking public transportation. An example is seen in figure 2.



**Figure 2. Student picture at the Forbidden City in China.**

### **Discussion and Future Work**

The purpose of this work in progress is to report initial findings from an analysis of 2019 data exploring how students learn to see themselves as engineers in a global context. Beyond the scope of this work in progress, the data is a baseline for comparing reflection assignments by students who complete a new visual ethics module in the same course in 2020. That comparison will in turn inform how to help students develop global engineering competency more effectively, including with online modules. We consider our results as an initial understanding of students' perceptions during the trip, and how the study abroad experience made them reflect on the important aspects and takeaway messages from doing this program. Our initial analysis of students' reflections found them to be positive and vocal about the global experience and the novel aspects of traveling internationally, but showing less awareness of how to connect those experiences to engineering, or global engineering practices. Furthermore, few students were able to make clear reflections on how experiencing cultural differences could influence the way they see the world.

The initial results raise several questions for further study:



1. What accounts for the apparent gap between global perspective taking and engineering identity? Why is it that students present first as travelers exploring the world in terms of culture and history rather than as students studying engineering?

When they were asked to choose five photographs that captured meaningful aspects of their trip, they almost never chose photographs of discretely engineering-themed subjects. It is exciting to see the intensity and depth of interest in culture, history, and language differences; it may be grounds for expanding critical literacy training for global engineering courses.

2. How do we characterize the meaning of student empathy as it relates to their development of global engineering competence?

Students expressed explicit empathy for individuals or situations they encountered and expressed language that implied empathy. They are open to people very different from themselves and reported learning about themselves by encountering difference, both elements of empathy that are measured obliquely by several of the themes in the Global Perspectives Index.

3. Is there any significance to learning GEC of the general sentiment or affective content of student reflections?

The overwhelmingly appreciative and positive tone taken toward cultural difference may reflect a classic “U” curve, where students are experiencing a “honeymoon stage” of travel and had not yet encountered negative feelings associated with the much-studied but far from universal experience of “culture shock” [23].

4. Do students learn to see themselves as engineers in a global context more profoundly when they travel a greater cultural distance?

The greater incidence of reflection on assumptions and stereotypes being overturned among students traveling to China agrees with what we might expect from encounters with national cultures relatively more distant from one's home culture [16]. One crude measure of cultural differences between the different RSAP tracks can be made by applying Hofstede's six cultural dimensions and the online “Country Comparison” tool, which suggests that the U.S. differs more greatly across these six dimensions compared to China than to other travel destinations (e.g. Italy and Morocco) in the RSAP program.

The next step of this project will be to implement a hybrid online/in person module teaching visual ethics to students in the 2020 cohort of RSAP. We will then collect data from a repeat photo elicitation/reflection assignment and conduct a comparative analysis in fall 2020 using the qualitative mixed methods described in this work in progress, with a goal to shed light on how best to use visual methods to train global engineering competence.

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