Engineering Students' Development of Global Engineering Competencies during International Programs

Andrea L. Schuman

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David B. Knight, Chair

Lisa D. McNair

Mohammed Seyam

Michelle Soledad

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(ABSTRACT)

Engineering students need to be prepared to work across cultures to solve complex, global problems. One common way these outcomes are achieved is by enrolling in international programs. The goal of this dissertation is to understand what students experience and what they learn during international engineering programs. I approached this problem using a multi-case study of the following types of programs: 1) a summer international research experience, 2) an engineering semester at a university-owned study abroad center, and 3) an online international collaborative capstone. In each program, students recorded spoken reflections on their real-time thoughts and experiences. The data were supplemented with interviews, observations, surveys, and program documents. I analyzed the data with the framework of Global Engineering Competency, which I defined as a combination of global, technical, and professional competencies. The results indicate that the best way to impart cultural competencies are from long-term immersion in a different culture. To achieve engineering workplace skills, students need hands-on experiential learning, especially with international colleagues. As program leaders design these types of programs, they must consider how the different dimensions of the program point to the intended learning. They should also communicate to enrolling students what to expect.

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(GENERAL AUDIENCE ABSTRACT)

Engineering students need to be prepared to work across cultures to solve complex, global problems. One common way these outcomes are achieved is by enrolling in international programs. The goal of this dissertation is to understand what students experience and what they are learning during international engineering programs. I accessed students' real-time thoughts through their regularly recorded spoken reflections on what they were experiencing and considering during the programs. I analyzed the data with the framework of Global Engineering Competency, which I defined as a combination of global, technical, and professional competencies. The results indicate that the best way to impart cultural competencies are from long-term immersion in a different culture. To achieve engineering workplace skills, students need hands-on experiential learning, especially with international colleagues. As program leaders design these types of programs, they must consider how the different dimensions of the program point to the intended learning. They should also communicate to enrolling students what to expect.

Dedication

For Justin: my partner, greatest support, daily encourager, and favorite person to spend time with. Thank you for believing in me and reminding me of the bigger picture.

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First and foremost, to God be all the glory. This endeavor was only possible through His grace, strength, and provisions.

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Attributions

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Chapter 1

Introduction

My dissertation explores engineering students' learning and experiences in different types of study abroad programs to investigate how the design of programs is associated with a variety of outcomes. The in-depth qualitative reflections provide insights into how students are experiencing the programs and what learning stands out to them. Each case is supplemented with other data, including interviews with students and program leaders, surveys, or documents. The framework for analysis was Global Engineering Competency, defined as the domains of Technical, Professional, Global, and integrated learning. This first chapter is an overview of study abroad programs: their history, justification, adaptation for engineering, and origins of assessment. It also provides the background for the current study, which I outline at the end of the chapter.

1.1 Background of International Programs

1.1.1 Four Arguments for Studying Abroad

Hoffa et al. [59] categorize the justification for studying abroad in both literature and institutions into four categories: curricular, cross-cultural, development, and career enhancement. The curricular justification is that undergraduate education is enhanced by opportunities from studying abroad that are not available at the home campus. The cross-cultural ar-

gument is that the greatest benefit of international programs is the cultural awareness and intercultural skills that students gain from immersion. The development argument is focused on personal instead of professional growth. It can include maturity, confidence, and independence. It may hold more significance for students than institutions [59]. The career enhancement argument is very common in engineering education publications. This category typically can be seen when researchers argue that studying abroad will enhance students' future careers as engineers based on industry needs. For example, Levonisova et al. [74] defined the constructs of global preparedness by consulting with stakeholders in industry and academia to find what they believed students need to succeed in global workplaces. Employers and accrediting agencies view the ability to work cross-culturally as an important professional skill that studying abroad can help students develop [1, 86]. Often authors will mention multiple categories when justifying the importance of these programs. An example from Zaugg et al. [132] is "The intent (of studying abroad) is that students will return with a greater understanding of similarities and differences between cultures, an enhanced educational experience, insights into future employment, new interpersonal networks, and personal growth." This list includes all four arguments. The decisions made in designing study abroad programs can be better understood by observing which frameworks for studying abroad the program leaders cite. The specific purpose of a study abroad program should direct how it is planned, and the links between purpose and program design are further explored in my study.

1.1.2 History of U.S. Study Abroad Programs

The history of study abroad programs at institutions in the United States demonstrates how programs differ as programmatic decisions align with the conceptualization and goals of studying abroad. Defining study abroad programs as international programs run by higher

education institutions that involve an academic credit transfer, the first U.S. programs began in the 1920s [58]. These early programs could be categorized into three types: Junior Year Abroad (JYA), faculty-led, multi-destination study "tours", and summer disciplinary programs. The JYA tends to be a common conceptualization of long-term programs. Students studied a foreign language and culture for the first two years at a university, then enrolled in the institution abroad for their third year. The goals were language and cultural immersion. Students often lived with a host family and took standard courses alongside local students and transferred those credits back. Almost all programs were located in Western Europe, which can be partially attributed to the languages the students studied. This type of program aligns with the cross-cultural justification for studying abroad.

Another type of program that originated around the same time were study tours, which did not have a language-learning requirement. These international experiences prioritized exposing students to a variety of locations and cultures. Students took classes about world issues and conceptualizations of global contexts before the program, with the goal of quickly teaching students about a breadth of places. This type of program is predicated on a belief that all travel is educational [58, 59]. At the end of the program, students would typically complete some type of assignment to demonstrate their learning.

The third type was summer disciplinary programs. Early iterations included a variety of professionally focused programs. Students could take courses, do research, or engage in other disciplinary training. These were characterized by more extracurricular engagement and often sponsored by one university. Since these programs were run outside the academic year and not embedded in the formal curriculum, there is limited surviving documentation [58]. These programs align with the career enhancement justification for studying abroad.

The differences in the purposes of programs can be observed even in these early iterations of study abroad programs. As the types of programs has continued to expand, it is important

to differentiate the wide variety of dimensions of international programs. There is a need to understand and share with students the different outcomes that are associated with different types of programs.

1.1.3 Study Abroad Program Assessment

Demonstrating the value-add of such study abroad programs via assessment dates back as long as the programs themselves because program leaders wanted to ensure to students that they would be receiving a consistently high-quality educational experience [107]. The Institute of International Education was founded in 1919 to mediate between government policies and programs from universities [58]. In 1927, the Institute of International Education created a committee to assess JYA programs. They were able to coordinate between higher education systems in different countries to maintain academic equivalencies and exchange experiences [58]. Comparing grades before and after international programs was a common assessment method through the 1960s, when more well-rounded and intercultural outcomes began to be a focus [107]. However, selection bias of who chooses and is able to study abroad is a consistent difficulty to account for in assessment.

For modern assessment, Salisbury [107] argues that a lack of agreement on the outcomes of international programs has led to tailoring data collection instruments to optimize the evidence of changes whenever they only show mild results. He recommends that future research explore broader outcomes instead of focusing on intercultural gains since cross-cultural experiences are multifaceted and messy. Intercultural competence is a complicated outcome to expect students to develop from a single experience. More foundational learning outcomes could be included, such as openness to new experiences or a more mature sense of self. These expanded outcomes should be aligned with and integrated into broader frameworks of the

outcomes from higher education. Finally, he recommends connecting students' experiences to their learning outcomes so that the findings can be translated to practice [107]. Wong [128] similarly recommends continuing improvement of study abroad assessment tools. Each instrument that is targeted towards specific constructs can only reveal a small portion of what students are gaining from the experience. He asserts that the swing from the assumption of natural growth during a JYA has led to a strictly interventionist approach on the opposite end of the spectrum. The worldviews of social or situated learning could be used to design international programs [128]. Overall, the paper calls for a belief that when students say that they had a "great" experience studying abroad, researchers should believe them, and the ways that programs are assessed should be expanded [128]. My study addressed these concerns by looking for a broad range of outcomes in a variety of program types. The data collection was open-ended, so that salient topics to the students were captured in their reflections.

1.1.4 Learning within Engineering Study Abroad Programs

International experiences have been shown to have short and long term impacts on students, including immediate professional development, increased interest in other cultures and global perspectives, cultural humility, a long-term pursuit of international careers, and more [34, 40, 41, 50, 72, 95]. Quantitative and qualitative comparisons in engineering student study abroad programs have found that the level learning differs across types of programs. The Miville-Guzman Universality-Diversity Scale quantitatively measures openness and appreciation for cultural diversity [81]. When given to students in a pre- and post-test design before and after different types of international experiences, including a short-term program, a global internship, international research, and baseline engineering courses, longer-term (10-12 week) research abroad was found to have the greatest impact on students, although stu-

dents with higher global competencies self-select into more immersive programs [64]. Other studies have compared in-person to virtual international programs. Students completed a survey asking how global experiences contributed to their learning of the 23 aspects of global competency following a global engineering course with international virtual teams, a short-term engineering study abroad program, and a regular engineering course [8]. Students believed that they learned more global competencies when studying abroad than in a global engineering course for 17 of 23 aspects. For the other six, which focused on multicultural teamwork, the outcomes were statistically the same. These results indicated that virtual collaborative programs have different priorities than study abroad programs and can still be successful in achieving scoped outcomes [8]. The previous studies have examined the same specified outcomes to compare the level of learning between programs. My study differed from prior research by approaching the different contexts with the understanding that the types of learning should and will be different, since program design leads to vastly different experiences. Rather than comparing the magnitude of a fixed set of outcomes across each program, my study design allowed student participants to surface what they are learning in the different programs.

The professional development argument for international programs has taken hold in the justifications for engineering study abroad programs and international engineering education research. There is significant literature arguing that global engineering competency is not only valuable for work, but it is becoming increasingly important [37, 97]. Engineering governing bodies are continuing to codify the need for globally competent engineers, which can be observed in the ABET requirement that students be prepared to work interculturally and be mindful of the global impact of their solutions [1]. UNESCO's ongoing call for Global Education asserts the importance of encouraging globally minded attitudes so that graduates can responsibly coordinate international teams and challenges in the era of globalization

[122]. Engineering projects often require international collaboration which leads to a need to work with people who define problems differently [37, 98]. Global problems and goals have a particular need for these collaborations, such as the National Academy of Engineering's "Grand Challenges for Engineering", include topics such as medicine, AI, climate change, and the energy crisis [89]. If engineers can work effectively cross-culturally, these issues will be solved faster and more effectively [37]. Universities are looking to international programs to better achieve these outcomes. They are pushing to raise enrollment in existing study abroad programs and adapting international programs with the goal of achieving these outcomes, but students will only choose to enroll if they see added value in these programs [37].

1.1.5 International Experiences within Engineering Programs

The JYA model of studying abroad is a traditional conceptualization of studying abroad. Significant barriers to enrolling in this type of program for students in all degree programs include finances, personal costs, language, and information access [125]. For engineering students, however, there can be additional obstacles such as the rigidity of an engineering curriculum, lack of an international tradition in engineering education, and incentives to take an internship or co-op instead of going abroad [49, 125]. About 5% of study abroad students are enrolled in engineering majors [60].

In response to the hurdles leading to low enrollment rates, different types of engineering study abroad programs have evolved. The types of engineering study abroad programs are documented in Downey et al.'s [37] conceptualization of the development of a globally competent engineer. The authors categorize different types of study abroad programs as a typology of established methods to achieve global competency criterion. Their typology includes five types of international programs.

First is international enrollment, which is when students directly enroll in a university abroad. The JYA abroad would fall under this category. It is an immersion technique that is often solitary, as opposed to following a cohort model. It does not always involve taking engineering courses and the length, level of immersion, and other factors can vary. The next category is international engineering projects. Any upper-level or capstone project that involves international collaboration falls under this category, meaning that the coworkers, project, or clients can be abroad. A third type of program encompasses international work placement, which is an internship or temporary engineering position abroad. Similar to international enrollment, the student typically has a solitary experience where they are immersed in a workplace instead of within a university environment. The level of immersion can differ depending on whether the company is internationally owned and the level of connection to their international location and coworkers. International field trips are the same as study tours described previously except that they are engineering focused. They are short-term trips organized by a faculty member. The contact with the new culture is more limited, and students travel with a group. Finally, there are integrated class experiences where domestic courses incorporates global learning. There are many ways that global competency can be integrated into an engineering course. It could be through the subject matter, a Collaborative Online International Learning (COIL) experience, or through travel pre- or post-course [37].

Since programmatic decisions explicitly or implicitly align with framing of the purpose of studying abroad, it is logical that the learning outcomes of these programs would differ. In Section 3.2.1, I fully characterize the programs that make up my cases based on this existing literature. Engineering education literature has not fully explored the impact that these design decisions have on students' development while engaging in international programs.

1.2 Overview of Study

The purpose of my study is to compare students' learning and experiences in different types of study abroad programs to learn about how the design of programs is associated with a variety of outcomes. In order to achieve that goal, students in three types of international programs (an international engineering research project, a semester-long international center enrollment, and an integrated capstone class experience) regularly reflected on their learning through spoken reflections. Each case has additional sources of data, including interviews, global competency surveys, and course documentation. Students' reflections on their learning and their experiences in different types of programs were observed and documented through these sources of data.

1.3 Research Questions

1. What do engineering students learn within different international engineering program designs?

2. How do students develop global engineering competency across different international engineering program designs?

1.4 Overview of Framework

The theoretical framework that is used as an overall lens for the existing phenomenon in this research is Kolb's model of experiential learning [27, 70]. Prior literature has described studying abroad as a form of experiential learning that exposes college students to new situations and perspectives and can contribute to the development of global competencies

[99]. Experiential learning takes place when students apply their skills in an authentic context and transform those experiences into knowledge [6, 33]. The students undergo the steps of feeling, reflecting, thinking, and acting. When students are abroad, they are exposed to new situations professionally and personally, where they must access their global competencies to respond appropriately [99]. They may make mistakes, but these learning experiences influence their mental models and skills through reflection [70]. In virtual programs, students are embedded in an online international collaboration where they may encounter a variety of communication and teamwork challenges which also require global competencies to overcome [45]. The environment is a significant part of experiential learning, which includes physical, cultural, institutional, social, and psychological aspects [99]. Studying abroad places students in a completely new environment where their complexity of thinking and ability to accept disagreements are fostered by new, diverse relationships [99]. The act of reflecting encourages students to make sense of their experiences after these significant interactions with a new (physical or virtual) environment and allows me to access students' engagement in this cycle as they study abroad and develop global engineering competencies.

The conceptual framework guiding my study's data analysis is Allert et al.'s framework of the attributes of a global engineering professional [3]. Their defined dimensions of a global engineering professional are Global, Technical, and Professional competencies. I redefined these three dimensions to fully differentiate them, with Allert et al.'s list of skills as the basis [3]. My definitions are included in Figure 1.1. Global competencies require the awareness and skills to work in a cross-cultural environment. Technical competencies are the engineering knowledge needed to complete engineering work. Professional competencies are interpersonal skills that are not specific to cross-cultural interactions. These dimensions take place in a shared context and culminate to "global engineering competencies" [3]. I advanced this framework by defining the integrated dimensions of the framework, as shown in Figure

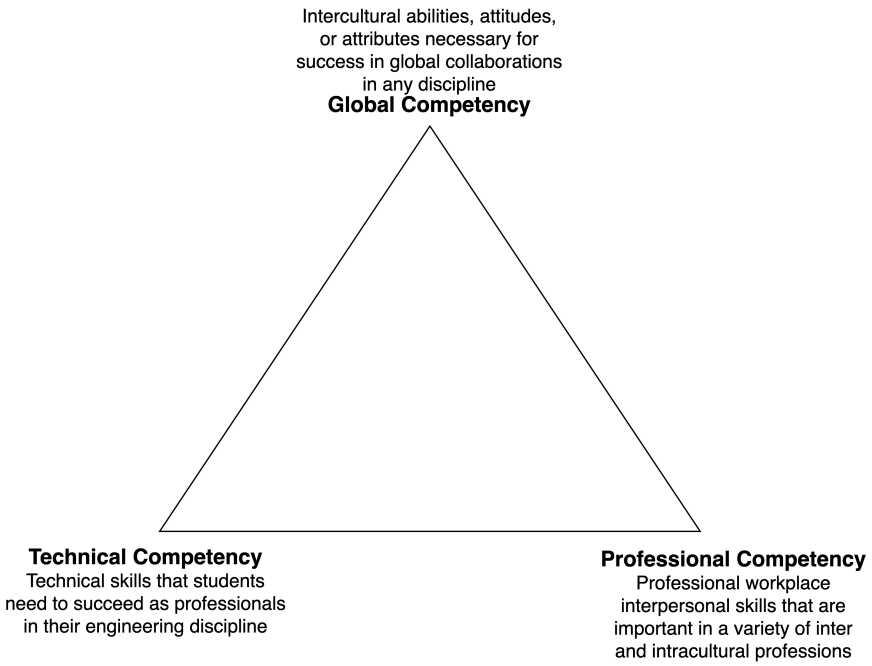

Figure 1.1: Global Engineering Competency based on the framework in Allert et al. [3]

1.2. This framework was applied in this study to unpack students' reflections on their development of global engineering competencies in study abroad programs.

1.5 Implications for Research

The implications for research of this study include new knowledge about how programmatic design decisions and specific student experiences during global programs are associated with different types of learning outcomes and development. This work enables universities to more clearly differentiate the purposes of various international programs so that students can make an informed decision of which one to enroll in. The research methods from this project also provide knowledge of how to assess international programs to increase students'

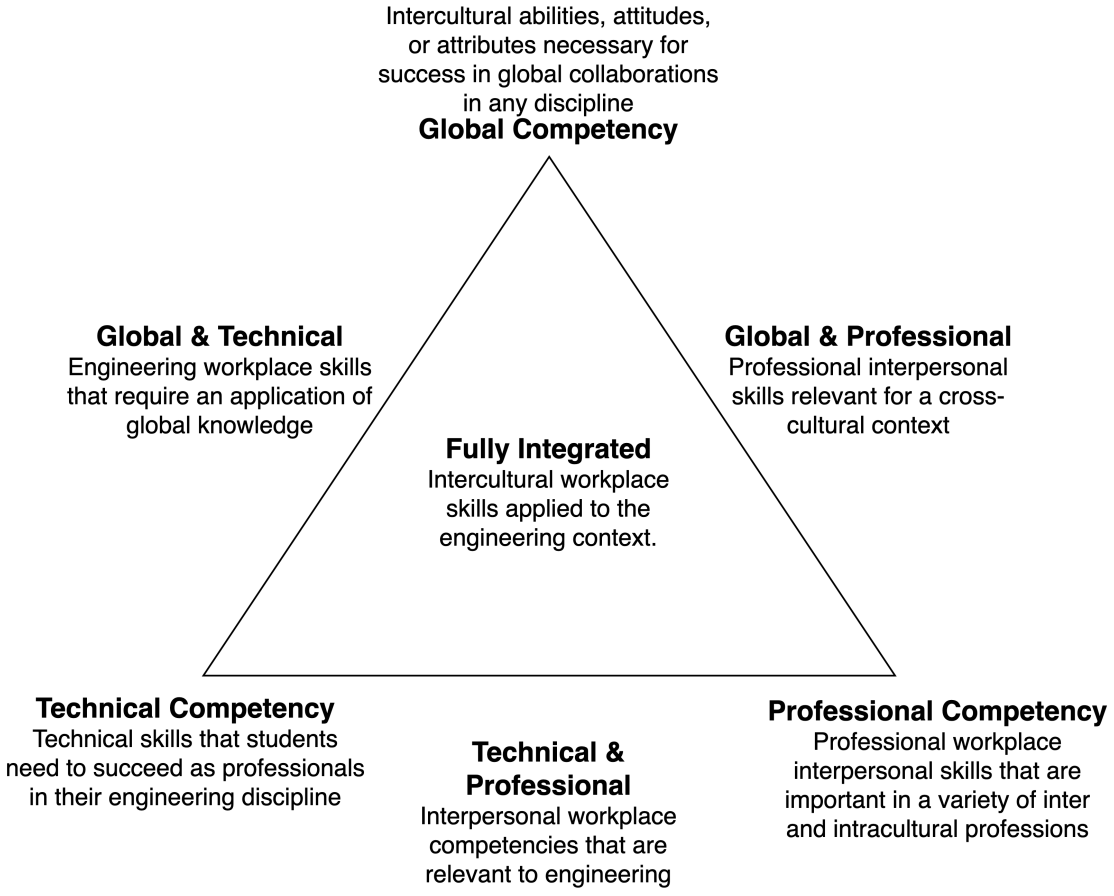

Figure 1.2: Global Engineering Competency with integrated competencies

learning in specific areas that program leaders want to prioritize. I furthered the definition of the theoretical framework by differentiating each integration of competencies, which proved important in revealing advanced international collaboration learning outcomes. This study's approach to collecting reflection data throughout a program as opposed to at the end of the program via recorded, verbal reflections, as opposed to written journaling, is a contribution to the assessment and data collection methods literatures.

1.6 Implications for Practice and Policy

This study supports previous findings of the value of international programs for engineering students, including both predefined and emergent learning outcomes. By clearly defining the purposes and outcomes of international programs, institutions can create and expand their international programs for engineering students. They can also learn about specific impactful experiences that future iterations of the program may emphasize to encourage the development of particular learning outcomes. Aspects of those experiences also may be implemented in domestic programs, such as COILs, in an effort to expand access to opportunities to develop global engineering competencies across more engineering students. In particular, the importance of hands-on international collaborations to impart professional intercultural competencies is underscored by my study. I hope my research will help universities communicate the value of international programs to students and to potential sponsors in new ways as they continue seeking to increase participation. A finding that was illuminated by my framework is that students are connecting their global learning to professional engineering skills when collaborating, which contrasts prior research that indicated that intercultural learning is prioritized instead of engineering skills. Finally, my study can provide an example of how to engage students during global programs in reflection that will improve

their development during the programs. The international study abroad center and COIL settings in particular do not have a large base of previous research, and my study gives a baseline that can be used for future comparisons.

1.7 Glossary and Abbreviations

Collaborative Online International Learning (COIL) COILs are programs where students from multiple countries virtually work and learn together, usually to complete a project.

Critical Incidents Critical Incidents are experiences that students describe as being significant. They are separated from the learning that they bring.

Experiential Learning In this study, experiential learning is defined by students applying their skills in an authentic context and transforming those experiences into knowledge through reflection. Studying abroad is a form of experiential learning for intercultural skills.

Global Competency Global competency is the nondisciplinary ability to cooperate in a cross-cultural environment.

Global Engineering Competency (GEC) GEC encompasses the skills and mindsets that engineers need to successfully collaborate interculturally.

Global Engineering Competency Scale (GECS) The GECS is a self-assessment quantitative survey that includes questions about (1) overall global engineering ability, (2) technical coordination, (3) ethics, standards, and regulations, and (4) engineering cultures [65, 78].

International Programs International programs are any experiences for students that include international components, such as travel in a study abroad program, virtual collab-

orations, or explicit intercultural teaching.

International Research Experiences for Students (IRES)

National Science Foundation (NSF) The NSF funds IRES programs for U.S. students to collaborate on research at a university overseas.

International Study Abroad Center International study abroad centers are campuses or centers abroad owned by a U.S. institution bearing the name of the sending institution in which students from the sending institution study in temporary (not full degree) programs.

Junior Year Abroad (JYA) A JYA program is a direct-enroll immersive study abroad program. It is a traditional conceptualization of studying abroad.

Professional competency Professional competencies are interpersonal skills that are not specific to cross-cultural interactions.

Technical Competency Technical competencies are the engineering knowledge needed to complete engineering work.

Chapter 2

Review of Literature

2.1 Overview

Prior research has assessed the learning that students have from international programs in the short and long-term and found the outcomes to include professional skills, cultural interest and humility, and increased likelihood of continuing international engagement [34, 40, 41, 50, 72, 95]. If it is demonstrated from literature that students need to develop global engineering competencies to be successful in the workforce, how and why students develop competencies through international programs should be examined in programs with students studying both at home and abroad. As outlined in Chapter 1, fundamental programmatic designs vary across programs and can affect students' learning, but additional design elements and interventions also matter, such as preparation before travel, mentorship while abroad, experiential activities, and reflection [117, 124]. My study provides insight into the span of global engineering competencies that students develop in international programs and how outcomes are associated with program design decisions.

Chapter 2 provides a literature review of global engineering competencies and existing research on comparison studies of international programs, including studies about the specific types of international programs featured in this dissertation. The chapter closes by focusing on research projects that implement reflections as a part of experiential learning, which have been used both as a mechanism to spur student learning and for data collection for research

and assessment purposes. In my study, participants' learning was explored through their reflections to gain an understanding of how students' experiences are associated with their learning and answer the research questions:

1. What do engineering students learn within different international engineering program designs?

2. How do students develop global engineering competency across different international engineering program designs?

2.2 Global Engineering Competency

Competency is defined by Lucia and Lepsinger [75] as "a cluster of related knowledge, skills, and attitudes that affects a major part of one's job (a role or responsibility), that correlates with performance on the job, that can be measured against well-accepted standards, and that can be improved via training and development." Their framework for the competency pyramid is that knowledge and skills build on perspectives and are observable through performance [75]. Thus, global competency is the ability to successfully work in an intercultural or multinational workplace, and global engineering competency is being able to work well in a global workplace as an engineer across cultural, technical, and background differences [120]. This framing has been used as the basis for a variety of conceptions of global engineering competency [32, 65]. Davis [32] reviewed the global engineering competency literature and summarized the sets of skills that have been written about as composing the theory. An overview of these results is given in Table 2.1. The *Integrate?* column refers to the level of incorporation between global and engineering competencies in the framework.

Beyond this scope, there have been many other definitions of global competency. A review

Table 2.1: Summaries of global engineering competency frameworks from [32] p. 19

Framework	**Citation**	**Framework Basis**	**Structure**	**Integrate?**
The Globally Competent Engineer	Downey et al. [37]	Historical cultural analysis	Definition: Work with people who define problems differently	High – Implied
Attributes of the Global Engineering Professional	Allert et al. [3]	Experience running global programs	3 dimensions: professional, global, technical	Low – Separate Dimensions
Global Competence for Engineers	Parkinson [98]	Literature review and experience running global programs	13 attributes of global competence, some engineering-specific	Medium – Some Attributes
Engineering Global Preparedness	Ragusa [101]	Existing model of Global Citizenship	4 dimensions, added engineering to each existing dimension	Medium – Some Dimensions
Conceptual Model of Eng. Global Preparedness	Levonisova et al [73]	Delphi study with 18 subject matter experts from industry and academia	4 interconnected categories: global, personal, contextual, global engineering	Low – Separate Dimensions w/arrows
Global Engineering Competency	Jesiek et al. [66]	Analysis of global case studies, interviews, and focus groups with global engineers	3 dimensions: technical coordination, engineering cultures, ethics/standards	High – Explicit Integration

of global engineering competency literature led to the creation of a conceptual model with 23 components [7]. The competencies are grouped under communication, dispositions, world knowledge, teamwork, and engineering-specific aspects [7]. Another skill that scholars from Europe emphasized as the primary goal of global engineering competency is for engineers to have successful teamwork in diverse teams [2]. General global competency frameworks that go beyond engineering are another large subset of the literature [10]. In this study, I use the definition of global engineering competency provided by Allert et al.'s [3] framework of Global Engineering Competency, as seen in Table 2.1. I selected this framework because I think the three dimensions of the conceptualization (professional, global, and technical) encompass the competencies that students can and should learn during international programs. Both engineering and nondisciplinary outcomes are weighed in my coding of students' experiences. This holistic approach helps me thoroughly answer the research question of what students learn in differently planned programs and meets the call from Salisbury to capture non-cultural outcomes in international programs [107]. Allert et al.'s framework is fully defined in Section 2.2.1.

2.2.1 Conceptual Model

The conceptual model that guides how I coded learning outcomes in my study is based on Allert et al.'s [3] framework of Global Engineering Competency. This framework categorizes global engineering professional attributes into global, technical, and professional dimensions, and the definitions are in Figure 2.1. The authors' description of the figure is:

> "The three axes acknowledge a shared context, with the 'professional' axis for the curricular accommodation of teamwork skills and entrepreneurial know-how needed to meet an increased emphasis on design and product development, the

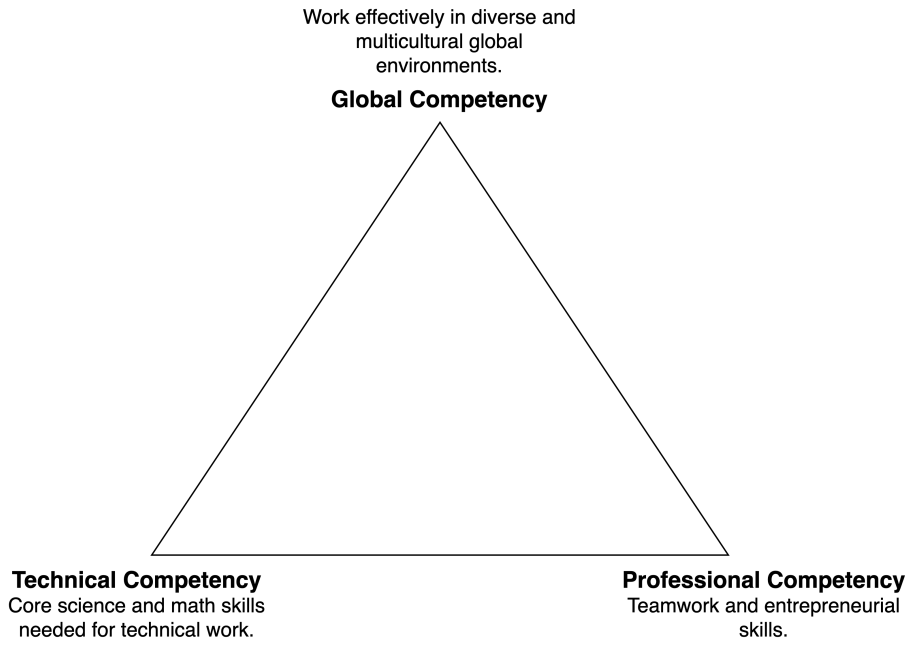

Figure 2.1: Attributes of the Global Engineering Professional from Allert et al. [3]

> 'technical' axis for the continuing core of science and math needed for technical work, and the third dimension of 'global' as the new challenge. The space defined by these three axes is the shared context for the professional work that engineers are actually called upon as they 'apply science' in wider, world markets." p. 3 [3]

The framework originated from data collected in Purdue University's Global Engineering Alliance. Students from a U.S. and German university described their learning through interviews, questionnaires, and focus group discussions [3]. The authors proposed the conceptual mapping of Global Engineering Competency as a basis for the design and assessment of international programs. Additionally, some authors of this paper analyzed early data from the National Science Foundation's International Research and Education in Engineering collaboration grants (which are further described in Section 2.4.1) to find the impacts and best practices for the program and categorized the outcomes into the same three categories: professional, global, and technical impacts [3, 18]. Chang et al.'s [18] definitions were

more specific to an international research program, such as with technical skills including research productivity and robustness in research solutions. They did not define integrated competencies.

I redefined these three dimensions to fully differentiate them, with Allert et al.'s list of skills as the basis [3]. The updated conceptualization can be seen in Figure 2.2. Global competencies would apply in any international field and include skills such as recognizing the sociopolitical impact of work, appreciating cultural differences, and collaborating in diverse teams. Technical competencies are the engineering skills that are taught in curricular classes, such as math, science, problem-solving, and design skills. Professional competencies are interpersonal or collaborative and include leadership, communication, curiosity, and persistence. Though the presence of connecting lines imply the crossover of these skills, other studies noted that this framework did not define the integration of these competencies [25, 32]. To include more complex learning outcomes, I defined global engineering competencies that occur when these categories are integrated, as shown in Figure 2.3. This updated framework allows a variety of different elements of learning to be captured in the analysis, as recommended by Wong [128].

Another project that drew upon this framework was Cook's [25] model of global preparedness that used Allert et al.'s [3] definition of a global engineering professional as a basis, along with Ragusa's [101] conceptualization of Global Engineering Preparedness and Jesiek et al.'s [65] Global Engineering Competency. This study compared survey and interview data from students enrolled in a semester or longer study abroad program, a short-term global engineering or sustainable building three-credit study abroad program, and the Engineers without Borders student organization. The results indicated that students in programs with built-in reflection demonstrated more advanced ability to identify their own growth [25]. My dissertation extends the previous research by focusing on reflection data and examining the

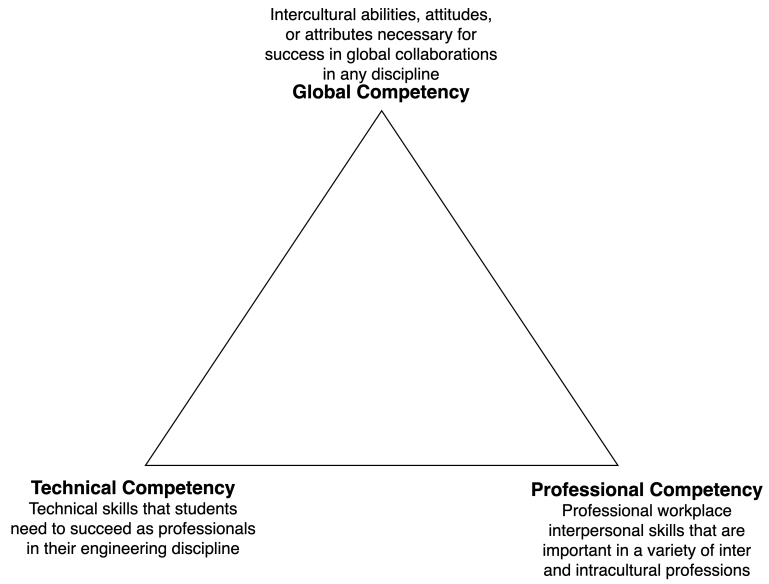

Figure 2.2: Global Engineering Competency with updated definitions

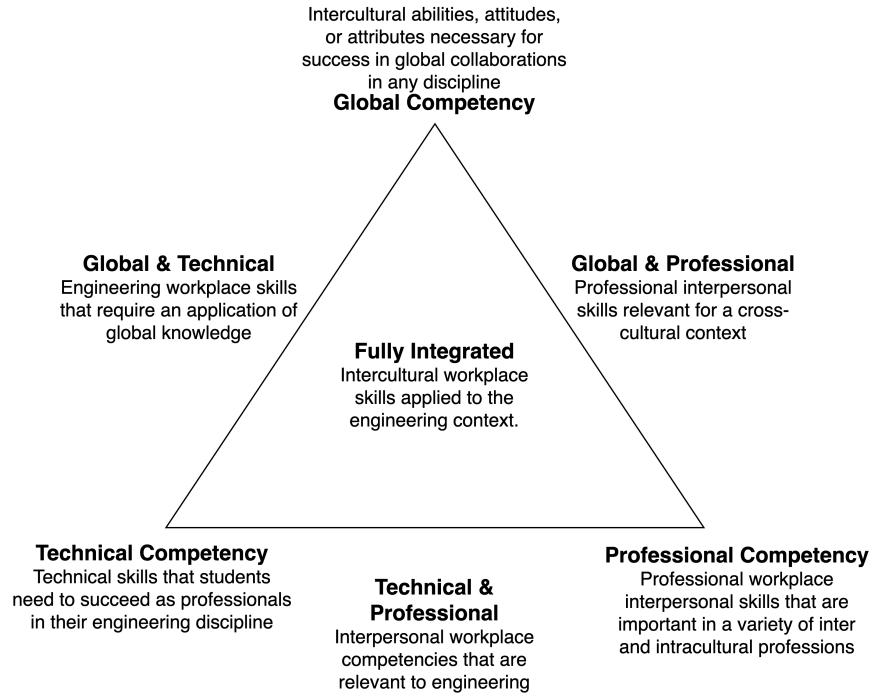

Figure 2.3: Global Engineering Competency with integrated competencies

logistical aspects of each program design in the comparison, and has new emergent themes of each competency type and integration.

2.3 Comparison of Programs

Although researchers have most often investigated a single international program in prior studies, there is also a base of literature comparing international programs, though these studies do not frequently exclusively examine engineering programs. As Hirleman [57] describes, it is important for there to be multiple pathways for students to engage in international programs so that they can choose the one that fits their needs best. My dissertation has multiple cases to illuminate different students' perspectives on their development of global engineering competency. The different programs involve a variety of experiences. This research approach revealed both similarities and differences in students' descriptions of their learning as they experienced the different programs [26].

2.3.1 Characterization of Study Abroad Programs

The range of international programs offered by U.S. institutions is varied. This section reviews groupings of dimensions of study abroad programs, and the literature that has been previously done on these program logistics to establish the program dimensions that have been explored and compared. The programs used as cases in my study are categorized in Section 3.2.1 and Table 3.2 based on the literature reviewed in this section.

Engle and Engle [38] argue that it is the responsibility of institutions to differentiate international programs. They offer both dimensions of comparison and a categorical continuum to broadly classify programs. The aspects of comparison are length of program,

language prerequisites, language of instruction, peer group demographics (local or international), housing, experiential learning, and reflection [38]. Their Levels of Immersion are study tour, short-term study, cross-cultural contact program, cross-cultural encounter program, and cross-cultural immersion program, which is a similar approach to characterizing types of programs as the previously reviewed Downey typology [37]. That prior work does not include evidence on the outcomes of these types of programs but encourages researchers to use this kind of categorization when assessing different types of study abroad programs, which is the space in which my dissertation is situated. Gozik and Oguro [48] explored some of these aspects in their literature review chapter. The program design elements that they focus on and call for future research about are modes of instruction, housing, extra and co-curricular activities, experiential learning, and student support services. Their review of previous research indicated that taking courses alongside local students does not guarantee intercultural gains if the interactions are not meaningful, although the learning from taking courses with only U.S. students was also mixed. Housing is a mixed predictor of language learning since living with a host family is typically immersive, but some host families try to accommodate the study abroad students' beginner language status. Well-trained host families with set expectations can be significantly helpful for the international student. The other types of housing have not been studied as thoroughly [48].

Moore et al. [84] defined a cross-sectional matrix to categorize study abroad programs based on the general program types and mode of program delivery, which is categorized by the organization running the program. The program types they list include study abroad, research abroad, global service learning, and international internships, which they categorize on a scale of classroom-based to community-based immersion. Home institutions, faculty, host institutions, and third-party providers are the institutional categories. These resources are used to define and categorize the programs used as contexts for the current study in

Section 3.2.1 and Table 3.2.

2.3.2 International Programs at Home and Abroad

Prior to comparing programs abroad, I will describe the existing research that compares study abroad programs to international experiences within students' home campus. A large-scale survey with more than 80,000 responses of undergraduate students asked them to report their pre-college and current global, international, and intercultural competencies and compared the outcomes for students who had participated in various global and study abroad programs [116]. Out of these outcomes, the results indicated that studying abroad was only positively associated with intercultural competency development. On-campus international engagement, such as a global courses, lectures, or conferences, was correlated with gains in all three aspects of competencies: global, international, and intercultural competencies. It is possible that the most significant experiences, such as going abroad or enrolling in an international studies major, shows students how little they know, and they thus rate themselves lower than students who do not have that in-person experience abroad [116]. The authors encourage future researchers to compare students' self-perceptions before and after engaging in international courses or programs, since the students in this study were rating their previous knowledge in hindsight.

An example of a comparison of different types of international programs similar to my study was Jesiek et al.'s [64] comparison of a short-term study abroad program, a global internship, international research, and baseline engineering courses. The pre-test results from the Miville-Guzman Universality-Diversity Scale indicated that students who enrolled in global programs had significantly higher scores than the baseline comparison group [64, 81]. The results indicated that more immersive programs corresponding with higher pre-test scores.

Post-program, the students in every international program had significant gains compared to those enrolled in the regular engineering courses. There were also significant differences between each program's outcomes. The long-term research abroad program had the greatest impact on students even though these students already had high scores compared to the other populations [64]. This study demonstrates the importance of considering populations' pre-program global competencies.

Researchers used the Engineering Global Preparedness Index Survey to compare student experiences in an undergraduate research program in the United States and a similar program where students worked in Japan [77, 102]. Analysis after the first and third year of data collection indicated that the students who went to Japan had statistically significant gains in the Engineering Ethics and Humanities subscale [77, 102]. The program in Japan had integrated educational activities beyond the U.S. program [102]. It also required students to complete reflections about cultural differences, which the researchers thought contributed to students' learning.

My study is primarily qualitative, unlike these previous projects. The integration of reflection includes details on students' longitudinal experiences and mindset shifts.

2.3.3 Virtual Programs

One study specifically compared global competency learning between a short-term engineering study abroad program that had a teamwork aspect and a global engineering course which involved virtual international collaboration, though it was not specifically called a Collaborative Online International Learning program (COIL) [8]. There were 11 aspects of global engineering competency that developed similarly during both programs. These were centered around intercultural workplace skills such as teamwork, use of technology, flexibility,

and intercultural communication [8]. The areas where study abroad programs had significant gains and virtual ones did not tended to be related to culture, with some of the most positive gains in being open to cultural differences, an interest in learning about cultures and societies, and understanding the impact of culture on engineering products [8]. This comparison has overlap with the International Collaborations Section (2.3.5). My study contributes to furthering research into the impacts of the medium of collaboration, since once of my cases has a virtual component and is compared to other international cases.

2.3.4 Duration

Duration has been the most common dimension of comparison for study abroad programs [84]. Short-term programs have consistently increased in prevalence since 2005, while mid-length programs have slightly decreased, and year-long programs have fallen to less than 3% of students [61]. Summer programs make up the plurality of study abroad programs, at 49% [61]. Several studies have found that longer programs are associated with more learning [23, 124]. One study used the Intercultural Development Inventory survey, which measures the ability to take on other perspectives and interact appropriately with people who are culturally different, to compare the pre- and post-program results for more than 1,000 students in 61 study abroad programs [54, 124]. The results indicated that semester-long study abroad programs led to the most significant gains in intercultural learning. The students in other duration programs had no or negative changes in their results [124].

More recently, a comparison of a group who did not study abroad to students who studied abroad for various lengths of time was performed when students were graduating [23]. The authors argued that comparing students' learning immediately after their study abroad in programs of different lengths can be misleading because it is expected that students would

learn more during a longer period of time than a short one. To account for this issue, data were collected at the end of students' college experiences to identify the gains students experienced overall during their time in college. Studying abroad for any duration was associated with a positive perspective on their undergraduate experience, other students, and the institution. The semester-long programs were associated with better outcomes in several categories, including empathy, critical thinking, effective teamwork, and diverse perspectives along with behavioral outcomes in class participation and less rote memorization [23]. The students who participated only in short-term programs did not have significant differences in these categories compared to the students who did not study abroad.

However, short-term programs may be the only option for some students because of their cost and curriculum [10]. The findings that short-term programs can have weaker impacts on students' learning leads to the conclusion that there is a need for relevant interventions and reflection. Positive results such as professional development, cultural appreciation, and cultural intelligence have been found in studies that examined short-term experiences without inter-program comparison [20, 36, 79]. My study's comparison of programs of a variety of lengths adds to the international programs literature, which is valuable since the most popular program duration has shortened over time, particularly within engineering. By illuminating the specific experiences that students indicate are impactful for their learning and development, my research can inform specific interventions to be built into short-term programs to maximize their potential impact.

2.3.5 Experiential Learning

Another program element for comparison is the inclusion of collaborative experiential learning projects. A study of engineering students' experiences in service learning, semester-long

study abroad, and short-term programs with and without community projects found that students who had the opportunity for international collaboration identified that they went through the stages of experiential learning, which led to demonstrated global preparedness and technical competency development [24, 70]. This result corroborates the findings of Spenader and Retka [117] who compared students' results on the Intercultural Development Inventory before and after enrolling in different types of semester-long international programs [54]. In this study, the only programs that were associated with statistically significant positive gains were the ones that had service learning projects where the students worked alongside local individuals [117].

Few studies isolate co-curricular learning in a control/experimental group study format. Non-comparative studies have shown indications that cultural offerings expand and synthesize classroom learning in a literature review of global programs. Gozik et al. [48] define research, internships, and service learning as experiential offerings and call for additional comparative studies. It is important for students to be able to articulate what they have gained from these types of programs because employers do not necessarily value these experiences if they do not know what students are learning. There are indications that students have positive technical and global gains from international research [48]. In my study, the IRES and COIL cases involve types of international collaborative projects. The inclusion of these types of experiential learning is a significant point of comparison.

2.3.6 Destination

It is difficult to isolate destination as an aspect of study abroad programs since it often has implications for other programmatic elements. However, the destination does impact the experiences students are having and needs to be considered for this study. One study

examined the differences in two faculty-led study abroad programs in an agriculture department to Costa Rica and Thailand through the lens of transformational learning theory and dissonance [67, 100]. Students' video reflections indicated that they were experiencing intellectual and moral dissonance in both programs, leading to technical learning and an increased desire for sustainable agriculture. Both programs had an additional unique form of dissonance that was not present in the other program. Students in Costa Rica described environmental dissonance related to the environment, climate, geography, and wildlife and made connections to the implications the differences would have in agriculture. In Thailand, students described sociocultural dissonance to the food, religion, and traditions [100]. This study is an example of the value of cross-case comparisons for illuminating unique dimensions of learning.

Destinations have also been used for comparison for Virginia Tech's Rising Sophomore Abroad Program, a semester-long engineering class paired with a short term experience abroad [68]. Students' self-assessment with the Global Perspectives Inventory were compared across different tracks of the program. The Global Perspectives Inventory measures global cognitive, interpersonal, and intrapersonal thinking [13]. The extent of differences between each international track with the United States had implications on student outcomes, along with the History and Architecture of a destination, the presence of a Foreign Language, and the Evidence of Suffering that was visible [34].

Another study by Spenader and Retka [117] compared semester-long study abroad exchanges for students of various disciplines. Students were given the Intercultural Development Inventory before the program began [54, 117]. In the pre-test, the students did not have statistically different results based on location of interest. Students who went to Chile, Guatemala, or South Africa had significant gains post-program [117]. Students who went to Ireland or Spain did not. This finding cannot be disentangled from the facet that Service

Learning was only present in the Chile, Guatemala, and South Africa programs.

Destination also has been used to compare outcomes for an IRES program. Students in summer IRES programs in China and Australia participated in interviews, cultural intelligence assessment, a Global Competency Activity, and a Sojourn Readiness Assessment [35]. The students who worked in China focused more on culture than research in their interviews. The students in Australia discussed all dimensions of research, engineering, personal, and global outcomes more evenly. All students had some cultural learning in the workplace [35]. The destinations that students in this study are traveling to are all in Europe, so it is unlikely that the cultural distance is a significant reason for different outcomes between cases.

2.3.7 Summary of Program Comparisons

It is important to communicate to students what each type of study abroad program can teach them [38]. Studies of single programs' outcomes make up a significant portion of study abroad research [84]. Research designed to measure what students learn from one program is inherently limited because there is no baseline for comparison. There are many aspects of international programs that can be points of comparison. The importance of the specific context leads to a multiple case study being an appropriate methodology for my study. Specifically, past research has indicated that longer, more experiential, in-person programs have the most positive and varied learning outcomes [8, 23, 25]. The contexts chosen for my study are varied across these aspects, and my study answers the calls to build comparative international programs literature [84]. Comparison of international programs is valuable for the improvement of programs [132]. The programs chosen for my study have a variety of interventions, and so finding out which ones may be most relevant for global competency development will help study abroad and domestic programs continue to improve.

2.4 Relevant Program Types

This section is a summary of the background literature relevant to the particular cases chosen for my study: an engineering international research program, an engineering program at an international study abroad center,and a collaborative online international capstone course.

2.4.1 International Research Programs for Students

The National Science Foundation (NSF) began the International Research and Education in Engineering initiative in 2006, through which investigators could send their students to collaborate on their research at a university abroad [18]. This program was originally only supplemental to other NSF-funded grants and had the goals of improving research output and international relationships. It was targeted to engineering grants [90]. In 2010, the program began to additionally emphasize continuous assessment of the collaborations [65]. It has expanded to become the International Research Experiences for Students (IRES) program for science or engineering collaborations [91].

An early publication that investigated what students were learning from an International Research and Education in Engineering program was a mixed methods approach to a program in China [65]. The data collection included interviews, blog posts, and multiple surveys. The results indicated an increase in preparedness to go abroad as well as gains in language, cultural, and global competency. Students discussed cultural sensitivity and knowledge in their interviews. Preparation for the program was emphasized with an in-depth orientation curriculum about the history of engineering in China [65].

More recently, Chapman and Forbes [19] used reflective blog posts to explore students' perceptions of growth during an IRES program in Sweden. The prompts were focused on

challenges the students faced and overcame. The main themes were professional development, personal/cultural experiences, and the importance of mentors. They found that the informal setting of blogging was an effective way to gain insights from the students' challenges in the program [19]. Similar to my study, the researchers emphasized the benefits of longitudinal data collection instead of relying on post-program reflections. My dissertation expands this work by using multiple strands of data and explores the insights from spoken reflection.

Other studies have examined IRES at a programmatic level. IRES collaborations can vary in mentor relationships, orientation programs, housing, extracurricular activities, and more [69]. A comprehensive case study explored nine IRES programs and identified common learning outcomes and best practices. The takeaways emphasized by students were learning about their own career and future goals, new perspectives on personal and professional issues, and cultural learning. A trend was that students who worked in countries with low cultural distances to the United States emphasized factors such as work-life balance differences, whereas students working in a country greater in cultural distance from the United States focused on cultural values and practices [69].

Similar results were found by Davis et al. [31] when they collected the narratives of students' development as researchers in an Australian IRES. Using Person-Environment fit theory to organize analyses, the authors found the following significant experiences across narratives: leadership, how to do research, mentoring, international experiences, future careers, and adaptation. Students commonly used the program to assess research as a potential career path, either positively or negatively [31].

The context for one case in my dissertation is an IRES program taking place in the United Kingdom. This program has been running since 2013 [55]. Mixed methods data have been collected using the Cultural Intelligence Scale and the Global Engineering Competency Activity. The most significant outcomes identified in this prior research were that students

reevaluated what skills are important in a global engineering context, students had an increase in confidence in their research abilities, and they gained more awareness of the areas they needed to improve. The students indicated that they recognized the importance of cultural knowledge in working in an international environment [55]. My study builds on the previous mixed methods work by emphasizing consistent reflection while participating in the IRES program–as opposed to a single data point at the end of a program–and exploring which, how, and why different global engineering competencies develop throughout their program.

2.4.2 International Study Abroad Center

International study abroad centers are a growing type of international program. Wilkins [126] defines them as:

> "An international study abroad center is an entity that is owned by a specific foreign higher education institution, usually for the purpose of providing students from the home campus with a study abroad experience. The center operates under the name of the foreign institution and offers programming and/or credentials that bear the name of the foreign institution. Often, students spend relatively short periods of time at the center (e.g., one semester) and most students gain academic credit." p. 6 [126]

The first international study abroad centers were established in the 1950s [126]. Few universities run engineering programs from these centers. One exception was established by Grove City College, and Clauss et al. [22] explains the main reasons for creating the program included the following: ease of credit transfer, affordability, safety, university reputation, and expanding international opportunities for faculty. Other reasoning includes foreign language

skill development, learning about cultural disciplinary differences, and global perspectives [126].

The published assessment of engineering international center programs is limited. A study of the Grove City program found that the students who studied at the center had a higher improvement in their grades than the students at the home campus [22]. In a post-program survey, students expressed satisfaction with their decision to enroll at the center [22]. There is a need to expand research and assessment to include this type of international program for the engineering context, specifically. My study offers this new perspective within the context of engineering by studying a semester-long engineering program that takes place at a research university's international study abroad center in Switzerland.

2.4.3 Collaborative Online International Learning

Collaborative Online International Learning programs (COILs) are classroom experiences where students from multiple countries collaborate virtually. The complete definition of COILs in literature and for this paper include the elements of: a relatively equal collaboration between two or more classrooms in different countries where students work on a team to complete assignments which are assessed as a part of the student's outcomes [9].

The development of online courses opened the door for international virtual collaborations. An early significant development in the United States' engagement in COILs was when the State University of New York founded their COIL center in 2006 [105]. This program explicitly followed the aspects of COILs, emphasizing the equal partnerships of the universities and intercultural, digital collaboration [83]. These early programs were specifically designed for languages, humanities, and social science curricula [105]. Engineering programs have begun to adopt the COIL model to achieve similar learning outcomes [45, 87].

COILs became a particularly relevant trend in education as their adoption was accelerated during the COVID-19 pandemic when other forms of international work were not possible [9]. In some cases, courses were transitioned from study abroad programs to COILs when travel was canceled [45]. One example of assessment of an engineering project-based COIL involved students from Scotland, Spain, and Venezuela collaborating in a mechanical design class for a project about automotive components [87]. The students were able to overcome common issues in global collaborations, such as different nomenclature for components in global manufacturing and time zone issues. Overall, the survey results indicated that 90% of the students enjoyed interacting with international peers, 93% of students felt they had a better understanding of the topic under study, and 93% were satisfied with the learning experience [87]. The students also described feeling more confident when they would have future international collaborations as mechanical engineers and said that they would use this project as an example when applying to jobs [87].

Other studies of COILs in STEM education have indicated that students gain a new perspective on their own learning by seeing other contexts, improved openness and academic self-efficacy, intercultural competence, and global citizenship [45, 88]. COILs can also show students new aspects of engineering careers by demonstrating that lone engineers in a lab do not advance the field, but collaborative global projects in which communication skills are vital. Their financial accessibility makes them a valuable case for this study to explore the differences of what students learn through a COIL compared to traveling abroad.

2.4.4 Engineering Capstones

In my study, the COIL course also serves as a software engineering capstone, which is a significant experiential learning opportunity prior to the addition of international collabo-

ration. In this section, I briefly review some relevant existing literature on capstone courses that integrate reflection to develop a fuller picture of what students tend to learn from these kinds of capstone experiences.

Capstone courses are designed to teach students the applied skills they will need in the workplace after graduating. Reflection is a fitting learning activity because it moves behaviors from habits to long-term learning [43, 80]. One study examined the range of reflection that occurs in capstone design teams through observations, interviews, and reflective assignment prompts [43]. Although students did not exhibit all the following steps, the full range of student practices include the following:

1. Clarify the problem, including review of emotional states and questioning of assumptions
2. Integrate previous knowledge and experience
3. Make meaning of the situation
4. Develop alternative solutions
5. Reason about the implications of proposed solutions (iterate between solution and implications, testing appropriateness of solution)
6. Decide on final resolution
7. Review what has been learned, generalize to other areas [43]

My study encouraged students to engage in the reflection cycle by having spoken reflections due regularly throughout the course.

Another study had recent graduates reflect on their capstone experience through qualitative surveys, reflective journals, and interviews during their first three to twelve months of work

[96]. The outcomes that students recognized from their capstone were categorized in managing time and managing knowledge. The capstone experience prepared graduates to learn from new projects, seek out the help they need, manage priorities when completing large tasks, and set long-term goals with a team [96]. The data collection journaling prompts focused on challenges students faced during the projects, which this study's capstone prompts repeat.

The reflection questions and codes for analyzing the capstone data in my current study is primarily based on Lutz and Paretti's study [76]. They performed 50 interviews with capstone students across three institutions. The questions were related to mentorship, preparation for post-graduation work, learning, and challenges. The reflection prompts for the capstone cases in this study can be seen in Appendix B.7. The learning outcomes from capstones were grouped into four emergent themes: (1) Engineering Design Skills; (2) Teamwork and Communication; (3) Self-directed Learning Skills; and (4) Development of an Engineering Identity [76]. Their codebook is used as the basis for coding responses for the capstone cases in my current study, in addition to using the Global Engineering Competency framework. The capstone codes are summarized in Table 3.12. These frameworks are aligned with my study's goals because it provides an established method to understand the COIL capstone, since the program is virtual and immersive study abroad coding frameworks such as the Critical Incident technique will not necessarily apply. For example, Navigating a foreign country and Experiencing a foreign culture would not be relevant. The connections between the GEC results and Capstone codes is described in Table 6.1.

The same Capstone coding framework was used by Ford et al. [39] to analyze weekly reflective journals recorded by recent engineering graduates in their first three months of work. Another study on the same data was published by Gewirtz et al. [44]. The participants were prompted to write about their greatest challenges and what they drew upon to overcome

these obstacles. The a priori codes were the four themes from Lutz and Paretti [76], with Engineering Design replaced by Technical Work. The most significant challenges were self-directed learning and interpersonal communication, and identity development was the lowest percentage of the four main themes. The participants in this study were primarily mechanical engineers, with a smaller portion of engineering science graduates. The authors call for future research to explore disciplinary differences and for capstone courses to encourage more diverse collaborations [39]. While they specifically cite age and experience-level differences, the COIL provides international collaborations and some diversity of expereicnes, since the students have taken different courses.

2.5 Reflection Data

Reflecting allows students to make sense of and synthesize the lessons of experiential learning, particularly in international programs where students need to connect completely new experiences to their existing mental models [70, 127]. Ideally, students' ability to reflect on their own learning and change their minds improves as they advance through an engineering program. Reflection assignments can encourage more advanced levels of reflection [123]. A review of international programs literature where students' learning was assessed through reflection indicates that the approaches tend to be differentiated based on the framework that is used for the study since the framework guides the prompts used and sometimes the medium of reflection. Within these theoretical frameworks, there is variation in the types of programs examined. This section reviews the two predominant frameworks for reflection that have impacted the data collection method for my study: the critical incident technique and critical reflection.

2.5.1 Critical Incident Technique

This section summarizes relevant examples of engineering education research that analyzed students' reflections of study abroad programs or international courses framed through the Critical Incident Technique [14, 71, 130]. The Critical Incident Technique involves asking students to reflect on a specific narrative from their experience that led to significant learning. These reflections can occur regularly during the program or once in hindsight. The analysis method tends to follow a thematic coding approach [14, 130].

Wrobetz et al. [130] had students complete video reflections while enrolled in a study abroad program that included an international internship or research project followed by coursework abroad. This study uses Jesiek et al.'s [65] framework of global engineering. The researchers prompted students to reflect weekly prompted by the Critical Incident Technique and examined the types of experiences in responses and the level of connection between the experience and cultural or engineering learning. The types of experiences were coded emergently, and findings indicated that early experiences were focused on communication and the local environment. As time went on, students made observations about cultural preferences and norms. During the experiential learning activities, students talked about work, education, and regulations. Incidents involving communication were the most connected to engineering. When students noted differences in cultural preferences or governmental differences, they expressed high levels of cultural learning [130]. My dissertation uses the same data collection method while expanding this type of research to new contexts, and codes learning and incidents independently.

Davis [32] compared the critical incidents that students emphasized during interviews about Virginia Tech's Rising Sophomore Abroad Program, an IRES, and in other types of study abroad programs. Personal and cultural experiences were the most commonly cited. The

longer the program duration, the more likely students were to talk about being on their own, iconic experiences, or foreign cultures. The critical incidents cited by students typically occurred during free time instead of planned programming. Shorter experiences more commonly discussed gaining knowledge or awareness [32]. These results led the authors to assert that learning outcomes differ based on the international programs' characteristics. The categories of Critical Incidents from this study are used as a coding framework for the current research, as described in Table 3.11.

An example of integrating the critical incident technique in a program that has similarities to the Rising Sophomore Abroad Program is the proposed plan by Brown et al. [14] in a work-in-progress paper. The program is a critical learning community, defined as instructors co-learning about social justice to educate empowered citizens, in a semester-long international collaborative design course followed by a short-term program. The students were assigned three types of guided journal assignments with the aim of encouraging critical learning. These included two critical incident analysis reflections with the specific goal of students developing critical consciousness. Reflections occurred in the second week and second-to-last weeks of the semester to identify communication difficulties with the international partners and align expectations [14]. This paper was a work-in-progress, so the results were not included.

Purdue University and Tuskegee University run a two-year certification that includes a short-term international component with a daily Critical Incident Assessment group discussion. Students were prompted to explain: 1) Account of the Incident, 2) Initial Responses to the Incident, 3) Issues and Dilemmas Highlighted by the Incident, 4) Learning, 5) Outcomes [71]. The students were surveyed after the program to ask if reflection discussions helped them. The students expressed that if the group dynamics and discussion conditions were favorable, they were able to identify biases, enhance cultural competence, and increase their understanding of sustainability, which was a significant focus of their technical learning [71].

In summary, the Critical Incident technique is well-established in the field of engineering education research. The prompts tended to be similar across program examples, as students were asked to describe a specific narrative of an event that they experienced and what they learned from it. These studies show that the technique can be applied to different types of international programs and students can reflect through diverse media including written reflections, videos, and group discussions. The reflection prompts in my study include critical incident questions to see what types of experiences students cite as being vital to their learning.

2.5.2 Critical Reflection

As discussed in Brown et al.'s [14] publication, critical reflection is a common goal and framework for study abroad literature. Critical reflection is defined as reflection that leads to a shift of a perspective that was previously strongly believed [85]. Students have been tasked to engage in critical reflection in various frequencies, from once at the end of the program all the way to daily [53, 103]. Often students are prompted to reflect on specific aspects of their experience, whether that is company visits or specific aspects of culture [42, 85]. Critical reflection has been used to examine programs of a variety of lengths, from ten days abroad to ten weeks in the summer [85, 103].

Critical reflection can also be used as a pedagogical approach. A faculty-led short-term study abroad program in Belize in an agriculture program required daily and summative journaling, which the authors described as critical reflection journals [103]. The prompts were created with the goal of eliciting critical reflection and included questions such as "What did you see or learn today that challenged or changed your previous thinking? Why did it challenge or change your thinking?" When exhibiting cultural awareness in these reflections, the students

most commonly referenced Relatives and Relations and the Environment. They seemed to gain technical skills and made critical reflections on the agriculture techniques and education they observed in Belize [103].

A short-term teacher education program in Honduras had students engage in critical reflection through journal prompts that asked them to observe cultural differences in the classroom based on their previous experiences [115]. Critical reflection was used as the theoretical framework for thematic coding. The results indicated that upon reflection, students realized pre-existing biases as their observations subverted their expectations [115]. Students also became more aware of their own privilege, increasing their multicultural competencies.

Critical reflection has been used in multiple fields, including foreign language learning, agriculture education, and teacher education. It seems to be typically used as a framework for qualitative analysis. When researchers wrote prompts specifically to encourage critical reflection, the reflection seemed to be more effective [103, 115]. Students challenging their preconceptions is a vital component of experiential learning and critical reflection. When prompting the students in my study to reflect, the questions were purposefully designed for critical reflection by asking what challenged the participants' preconceived notions. I also included questions based on the Critical Incident Technique to access specific stories that were transformational to the participants. The prompts can be seen in Appendix B.

2.6 Reflection Medium

Reflections can be collected through a variety of different forms of media. Videos are an emerging reflection and data collection method in experiential learning, but written reflections remain the most common medium. When individuals access their memories to write them, that process tends to clarify what they learned from the experience [17, 99]. Video

reflections have the added benefit of collecting emotions and nonverbal communication [17]. There are questions of whether students tend to preplan what they will say or are more spontaneous in their reflection while recording a video [17]. From my data collection of spoken reflections, it seems like there are a range of methods of reflection by students. Some had prewritten notes, and others were speaking extemporaneously.

One study had program leaders of a short-term study abroad program record their meetings where they reflected on recent incidents in the program [30]. The meetings can be considered autonomous focus groups and were analyzed through the lens of experiential learning theory. The authors found evidence of the cycle of experiences leading to reflective observations, creating conceptualizations related to the experiences, and active experimentation to see how responding differently affected the students [30]. A benefit of the data collection method that my study has is that the participants process their experiences in real time, without the separation of hindsight.

In a comparison of different media, Chan and Wong [17] examined students' perceptions of video, audio, face-to-face, and written reflections during a short-term experiential learning program with students from universities in Hong Kong. They found that students favored face-to-face and written reflections. Audio and video reflections were new to the students, and many of them found recording them stressful [17]. The positive aspects of the recordings, which correlated with findings of other studies, included that students wanted to rewatch or listen to them in the future, which can encourage further reflection [15, 17]. Research has also shown that video reflection can advance metacognitive reflection further than writing [17]. Overall, future research needs to take into consideration that students may not adapt to video reflection immediately. They may become more comfortable over time. I observed the students' adaptation to the reflection medium throughout the programs in my study, and several students said at the end of the programs that they realized they enjoyed spoken

reflections. I allowed them to choose either audio or video reflection.

2.6.1 Unedited Spoken Reflection

Most pertinent to my study, prior research has asked students to record daily or weekly unedited video reflections to access unfiltered reflections. In a self-described short-term, high-impact experience where students traveled between cities to different nonprofit organizations, the students were prompted to create open-ended and frank reflections on their learning [56]. This study used the framework of experiential learning, and the authors found that video reflections can particularly illuminate embedded learning outcomes of an experience, which they define as affective, emotional, or social learning outcomes as opposed to the disciplinary intended learning outcomes [56, 70]. Through their video reflections, students were able to demonstrate their awareness of the process of coming up with solutions, emotional intelligence, and teamwork, which the researchers analyzed with open coding. The reflections did not have length requirements, and the students submitted videos between three and 29 minutes long, which seems to indicate that students were becoming comfortable with the medium [56]. I noted the length of reflections that students submit for my study in Table 7.1. More frequent reflection may help students overcome the discomfort with being on camera described by Chan and Wong [17].

The agriculture education department at Louisiana State University has done multiple studies on daily video reflections in their short-term study abroad programs [93, 100]. The students are given several topics to reflect on from their day: (1) what they learned, (2) what was different from their experiences in the United States, (3) what was similar, and (4) if anything caused them to feel discomfort [93, 100]. These studies are based on transformative learning theory and examining how the dissonance students experienced led to learning.

The location of the study abroad program affected the type of dissonance experienced [100]. The authors did not explain in detail why they chose video reflections over written ones, instead the prevalence and convenience of smartphones was the primary justification [93]. They also discussed that feedback from instructors can be given rapidly, which is important on short-term programs abroad [93]. The unedited format leads to the benefit of students potentially spending less time on reflection, which could be as short as the video itself depending on how long they prepare before filming. I explained this benefit of the lessened workload to the students in each case as I presented the project to them and invited them to participate in the research.

Wrobetz et al. have used unedited video reflections in multiple studies [129, 130]. One study compared weekly videos of a semester-long program to daily journals, analyzing both based on critical incidents [129]. The journals had various prompts, and the researchers looked through the writings specifically for critical incidents, whereas the prompts for the video were to describe significant learning experiences. The results of the study indicated that students shared more detailed, in-the-moment views of their experiences than either written reflections or interviews and are included in Table 2.2.

The other study invited ten students in Purdue's combined internship and coursework study abroad program to complete weekly video reflections, prompted by the Critical Incident Technique [130]. Students used Indeemo, which is a market research platform, and were prompted to speak for five to eight minutes. They answered two written questions in the caption. The results within the incident and global engineering framework are summarized in Section 2.5.1. The authors recommend that longitudinal video data collection be applied to future programs, as it encourages reflection and gives insight into students' perspectives [130]. My dissertation expands this data collection by introducing new cases, new prompts, audio-only reflections, and different coding frameworks.

The comparison between written and spoken reflections is summarized in Table 2.2.

Table 2.2: Summary of findings about reflection media [17, 93, 129]

Medium	*Benefits*	*Tradeoffs*
Written Reflection	• Students are familiar with the medium • Well-established in literature	• Students can be limited in their reflection by their writing skills • The reflections do not incorporate as much underlying feeling • Students often do not include as much detail
Spoken Reflection	• Includes non-verbal communication • Illuminates embedded learning outcomes • Can be done in-the-moment • May be completed faster	• Could induce anxiety • Requires technology for recording and a level of technological skills

2.7 Conclusions

Although there have been significant advancements since the original calls for research about students' development in international programs, there is still a need for further work [11, 52]. The value of global programs needs to be better understood for them to be more widely adopted by institutions and students. As study abroad programs become more common for engineers, the gains have not been even across institutions. Instead, a few universities that

prioritize international experiences are sending more and more of their engineering students abroad [63]. It is important for other institutions to see a demonstrated benefit to learning from programs abroad as well as from implementing global engineering competencies in their existing curriculum.

We often assume we know what the benefits of education abroad are [92]. These assumptions need to be questioned as the types and programmatic elements of study abroad programs have changed, in particular to accommodate engineering students. As researchers, we need to understand and communicate to students what they will learn from each of these different kinds of programs [38]. My work answers the call for further comparison of experiences and outcomes to identify best practices in study abroad programs [84, 129]. There is a need for in-depth, qualitative investigation of the full range of students' experiences in different types of study abroad programs. Research is often outcomes-based and investigated with pre- and post-trip surveys, not an investigation of students' learning during the program [107]. My research instead examines students' experiences in-depth through qualitative analysis of reflections of what students are learning and experiencing in different types of study abroad programs that have been designed for engineering students. The reflection prompts include the critical incident technique and ask questions to encourage students to engage in critical reflection. I analyzed these descriptions of learning by using the Global Engineering Competency framework. This overall design allowed my study to answer the research questions:

1. What do engineering students learn within different international engineering program designs?

2. How do students develop global engineering competency across different international engineering program designs?

Chapter 3

Methods

My dissertation is a multi-case study that develops specific knowledge grounded in a particular context as opposed to developing generalizable theories [16]. Multi-case studies explore in-depth the experiences of participants in specifically chosen contexts [26, 131]. In this study, each case is a different kind of international program. My study explores individual students' reflections on their learning as units of analysis for each case and addresses the following research questions:

1. What do engineering students learn within different international engineering program designs?

2. How do students develop global engineering competency across different international engineering program designs?

3.1 Positionality and Research Paradigm

This research area and the contexts selected for the study have been informed by my personal experiences. I am passionate about this topic because international experiences have been some of the most influential learning and development opportunities in my education. As an undergraduate engineering student, I spent a semester at the University of Oklahoma's international study abroad center in Arezzo, Italy. This experience was similar to the Inter-

national Center case in my dissertation, where the home institution sends faculty to live and teach engineering courses abroad. After graduation, I worked as an electrical engineering intern with Engineering Ministries International, an organization that offers engineering design work with international non-profit organizations. During this internship, I contributed to a long-term, collaborative project to update the electrical system for a hospital in Gabon. My team visited to review the electrical installation and train the maintenance and medical staff to run and sustain the electrical system. This was a short-term, hands-on experiential learning engineering experience abroad. Through both of these experiences, I developed intercultural and engineering competencies. I became aware of my own cultural assumptions by stepping outside of them into a new context, which enabled me to develop communication skills and flexibility. I learned about how to consider users' and stakeholders' needs in engineering design and teaching. My mentor at Engineering Ministries International was a great example of how to engage in engineering with a global perspective as he actively worked to understand the cultures of Gabon and of our European coworkers to coordinate our multinational technical team and engineer the best solution for the hospital's context. Based on these formative experiences, I decided I wanted to continue to research how engineering students learn technical and global skills.

At Virginia Tech, I have been directly involved with the Rising Sophomore Abroad program, which is a semester-long global engineering course followed by a two-week study tour abroad. I worked as a graduate student track leader in the spring semesters of 2022 and 2023. The two tracks I led were United Kingdom & Ireland and Italy & Germany. I taught the recitation session about the countries we would travel to and went abroad with the undergraduate students. The track leaders work to ensure a safe and helpful learning experience and encourage the students to reflect throughout the program. As a researcher, I have analyzed data from multiple Virginia Tech international programs: IRES [113], the Rising Sophomore Abroad

Program [21, 108], a chemical engineering lab course abroad [111, 112, 114], and faculty-led programs [109, 110]. I also visited Virginia Tech's International Study Abroad Center in Switzerland for a few days and met the staff. I shadowed the (non-engineering) programs that were running at the time with on-site lectures and a visit to a local collaborating institution. Through these experiences, I have observed how the different experiences students are having can affect their learning, which is a motivation for conducting this study. For example, in the chemical engineering lab track to Denmark, the program is four weeks long and the students emphasized the time-management skills they were learning. In an alternate version of the course which was a six-week track to Germany, students had more free time which led to them exploring the area and trying different activities [114]. These different experiences as well as the perspectives I have had as a student, researcher, or instructor in these contexts are valuable for me as a researcher but can also lead to biases based on preconceptions of the programs, which are important to address and mitigate when possible. I engaged in ongoing feedback and coding review, as described in Sections 3.2.4 and 3.3.

Constructivism is the closest paradigm to my current theoretical perspective of knowledge and research. I think that participants and researchers make sense of the context around them in individual ways because of their past experiences [62]. Some sort of consensus across participants in a context may be built around these experiences. I think that participants' values are important and also affect their interpretations of situations since no social study is performed without outside influences [51]. Because of this perspective, I need to take into account my role as a researcher in my work and how my perspective, which is affected by previous experiences, co-constructs the results.

3.2 Case Study Research Design

Case studies examine in-depth lived experiences in a specific context [26, 131]. The phenomenon, or *quintain*, in this research is the development of global engineering competency, and the context of each case is a different kind of engineering international program. A case study is an appropriate methodology for this research because of the close ties between the context and phenomenon and the lack of researcher control on the study [131]. Researchers can examine a single case or multiple cases. Multiple cases are examined with the goal of understanding the phenomenon's variations in different contexts. Each case is selected to explore a variation of iteration of the quintain [118]. I followed a multiple case study design since the goal of this study is to examine cases in-depth and how the quintain is revealed in multiple programs [118]. Each case of this study is an existing international program for undergraduate engineering students. I examined student experiences while they are enrolled in one of these programs as the embedded units of analysis to understand how students develop competencies during different types of engineering international programs. Another important aspect of case study research is collecting multiple sources of data, and in this study multiple forms of primarily qualitative data were collected and analyzed [26]. These data sources are described in Section 3.2.3.

3.2.1 Context

To address the research questions, my study examines three types of international programs as the contexts for the multiple case study: 1) a summer international research experience, 2) a semester-long program at an international study abroad center, and 3) a semester-long collaborative capstone course with online international teams followed by a short-term experience abroad. These cases model a diverse set of program designs that universities

have created in efforts to overcome the difficulties of fitting studying abroad within an engineering curriculum and co-curriculum. This variety enables me to address the study's research questions.

Case 1: Summer international research experience (IRES)

The National Science Foundation funds opportunities for engineering students to engage in research at a university abroad, known as International Research Experiences for Students, or IRES programs [35]. This context is unique because students are gaining research skills in a workplace setting, and the students' travel costs and salaries are externally funded [35]. It is a valuable context to examine what students learn from working in a cross-cultural team in a research experiential learning context abroad. [U.S. institution] has collaborated in an IRES program with the [U.K. institution] since 2013. The students receive training pre-departure and spen six to twelve weeks overseas being co-advised by their sending university faculty mentor and an international collaborator. This study has six participants from the [U.K. institution] IRES program.

Upper-level undergraduate students or graduate students enrolled at [U.S. institution] who are interested in engineering research can apply to this IRES program. Typically, they are working on research with a [U.S. institution] professor who has a collaborator at the [U.K. institution]. Before traveling to [U.K. institution], the students participate in a four-week orientation at [U.S. institution]. They discuss British culture, research methods, technical writing and presenting, and coordinate a mentor-mentee agreement with the international collaborators. The students stayed in on-campus accommodations at [U.K. institution]. They worked on their research for about 40 hours a week. In this case, the disciplines of the projects included materials science, industrial, electrical, and mechanical engineering. I refer to this case as the IRES case.

Case 2: Semester-long program at an international study abroad center

[U.S. institution] purchased an international study abroad center in Switzerland in 1991 that has dormitory space for 60 students, a cafeteria, shared activity spaces, and classrooms. The center hosts multiple degree programs simultaneously, so students can live and socialize with [U.S. institution] students from different disciplines who may not be enrolled in their same courses. The first engineering-focused semester program was run in fall 2023 for Civil Engineering or Construction Engineering and Management major undergraduate students, which is the particular program from which I collected data. Students who were past their second year in Civil Engineering or Construction Engineering and Management were eligible to apply. There were program fees in addition to the normal tuition and fees. Students have the opportunity to apply for scholarships from the global education office to ease the financial burden of participating in the program.

Eight students were enrolled in the three on-site engineering courses along with an introductory Italian language course and optional electives. The engineering courses are 3000-level: Introduction to Structural Engineering, Introduction to Transportation Engineering, and Bridges, Builders, and Society. The core courses are taught by [U.S. institution] faculty who traveled to the International Center. As a part of these courses, the engineering program includes two 9-day experiential field trip portions during which the group traveled to civil engineering sites. Students may also take courses at a Swiss university. [Swiss institution] is a nearby university in Manno, Switzerland that offers a Civil Engineering program in English. The [U.S. institution] professors instruct the lab courses in [Swiss institution] classrooms.

This context is valuable to this study because it is in an emerging research area focused on international study abroad centers. This type of program has been increasingly appealing to U.S. universities because of the academic and financial autonomy it offers in programming

abroad. Although located in another country, the students are primarily learning with and from people from the United States. Relative to the other cases, this case had the longest in-country program duration at 16 weeks. Seven of the eight enrolled students agreed to participate in data collection. I refer to this case as the International Center case.

Case 3: Semester-long collaborative international engineering capstone course followed by a short-term experience abroad

This study had a unique opportunity to collect data from a program that incorporated two types of international programs: a collaborative online capstone (COIL) program and a short-term study abroad program. I collected data from the software engineering capstone course during spring 2024. The students work in a team to deliver a solution to an open-ended software engineering problem. The enrolled students include those from [U.S. institution], [Swiss institution], and two Egyptian institutions. At the end of the COIL section, all the students from the multi-institution collaboration travel to the International Center to collaborate on their capstone project for ten days. As I outline subsequently, I captured students' experiences during the virtual collaboration as well as the in-person components at the International Center.

The software engineering capstone course was available to students in Computer Science, Data-Centric Computing, or Secure Computing majors. In the degree progression, students are recommended to take the course in the final semester before they graduate. 3000-level major courses are prerequisites. Students interested in the COIL section applied through the global education office. The professor selected the 10 admitted students based on their applications, all of whom agreed to participate in the research project. The students who enrolled paid an additional fee for the travel portion of the program. This case is referred to as the COIL case.

Table 3.1: Modes of program delivery, from [84] p. 48

	Modes of Program Delivery			
Program Types	*Home Institution*	*Faculty-Directed*	*Host Institution*	*Third-Party Provider*
Study Abroad	Segment 1	Segment 2	Segment 3	Segment
Research Abroad	Segment 5	Segment 6	Segment 7	Segment 8
Global Service-Learning	Segment 9	Segment 10	Segment 11	Segment 12
International Internships	Segment 13	Segment 14	Segment 15	Segment 16

Summary of case characterizations

The cases in this multi-case study are categorized based on the literature explored Section 2.3.1 in Table 3.2.1. The categories of *Program type* and *Mode of program delivery* come from Moore et al.'s matrix of program types [84], as seen in Table 3.1. Based on this characterization system, I define each of the cases as their Segments. IRES is a host institution research abroad program (Segment 7). The International Center case is home institution-run study abroad (Segment 1). The COIL case is faculty-directed and closest to an international internship during the semester (Segment 14). COIL has a short study abroad led by a faculty member after the semester (Segment 2).

The other case categorizations in Table 3.2 (from *Duration* to *Guided reflection*) are from Engle and Engle's classification [38]. These categories are used to place the current cases in the broader study abroad literature and to compare the impact of these program decisions.

3.2.2 Participants

The purpose of this study is to explore the differences in learning outcomes and student experiences across different types of international programs from the perspectives of the

Table 3.2: Overview of case characterizations [38, 84]

Categorization	**IRES**	**International Center**	**COIL: Online**	**COIL: Abroad**
Program type	Research abroad	Study abroad	COIL	Study tour
Mode of program delivery	Host institution	Home institution	Faculty-directed	Faculty-directed
Duration	Summer (6 weeks)	Semester	Semester	10 days
Entry target-language competence	N/A	Elementary	N/A	N/A
Coursework language	English	English and one target language	English	English
Academic work context	Local research group	Home institution taught	Home institution with online international collaboration	Home institution faculty with international students
Housing	Local dorms	International center dorms and apartments	N/A	International center dorms
Provisions for cultural interactions	Direct contact via research	Occasional lab course contact	Direct contact via capstone project	U.S., Swiss, and Egyptian students enrolled together
Provisions for experiential learning	Engineering research	N/A	Capstone project	Final presentations
Guided reflection	Orientation program, initial and some ongoing	Orientation program, ongoing informal mentorship from program leaders	Cultural contact coursework	Orientation program, ongoing informal mentorship from program leaders

students. The sample of participants in this study are drawn from the students enrolled in each international program described in Section 3.2.1. The study received support from the program leaders to invite their students to participate, and each program leader has agreed to incorporate the data collection plan into their program. I received IRB approval for this embedded design (IRB #s 23-466, 23-738, and 24-029). Even if the reflections and surveys are an expected or graded component of the course or program, it is completely optional for the students to elect to allow their data to be used for research.

For recruitment, I spoke with the students in each program. I visited the IRES orientation in person and explained the purpose of the research and assessment project, the logistics of their participation, and emphasized anonymity. I answered their questions before inviting them to provide their consent for research. During the IRES program, I traveled to the United Kingdom for several weeks in the middle of the program. I had contact information for the students and connected with them by meeting them for lunch. Each student gave me a tour of their lab. The assessment goals for the IRES project included mid- and post-program interviews. I performed the mid-program interviews in person and the final interviews on Zoom. I joined a session of the International Center case's orientation on Zoom and presented the project and invited the students to participate in the research. I visited the software engineering COIL capstone course in person and presented on the purpose of the research project, the logistics of their participation, potential benefits and answered any questions. For each recruitment effort, I read a recruitment script (Appendix A.1) and invited everyone to fill out the consent for research (Appendix A.3).

An overview of the consent for participation rates for each of the programs appear in Table 3.3. As a note, the COIL Capstone only includes the U.S. students in the counts. The international student collaborators are not included in the study because of challenges associated with performing human subjects research with individuals located in different countries (e.g.,

varying IRB and international privacy laws).

Table 3.3: Participants by case

Program	*Total Number of Students*	*Consent to Participate in Research*
IRES Summer 2023	6	6
Int'l Center Fall 2023	8	7
COIL Capstone Spring 2024	10	10

I think the high participation rates can be attributed to the support of the program leaders. In each case, program leaders encouraged their students to participate for the future improvement of the program. The program leaders included the reflections as part of the students' grades in the International Center program and COIL courses. Students still had the option to not allow their reflections to be used for research purposes, but they still had to record and submit the reflections for completion grades. Students' anonymity in each case was emphasized. Additionally, some students in the IRES case in particular consented to participate but contributed minimal data. The pseudonymized individuals' data for the IRES, International Center, and COIL Capstone cases are shown in Tables 3.4, 3.5, and 3.6. The individuals' data contributions are further discussed in Section 3.4.

Table 3.4: IRES students participation' in data collection

Pseudonym	Reflection (R)1	R2	R3	R4	R5	R6	Mid-Interview	Post-Interview
Noah	X	X	X	X	X	X	X	X
Colleen	X	X		X	X	X	X	X
Nathen	X	X	X		X	X	X	X
Arthur	X		X				X	X
Hailey								X
Joey							X	

Table 3.5: International Center students' participation in data collection
Note: L refers to late for reflections that were submitted two weeks after the due date

Pseudonym	Pre-Interview	Reflection (R)1	R2	R3	R4	R5	R6	R7
Ella	X	X	X	X	X	X	X	
Abigail		X	X		X	X		X
Penelope	X				X	X	X	X
Elizabeth		X			X	X	X	X
Sam	X	L	X	L	X	X		X
Conner			X	L	X	X	X	X
Jackson		X	X	X	X	X	X	

Table 3.6: COIL students' participation in data collection

Pseudonym	Reflection (R)1	R2	R3	R4	R5	R6
Selena	X	X	X	X	X	X
Willow	X	X	X	X	X	X
Michael	X	X	X	X		X
Lila	X	X	X	X	X	X
Andrew	X	X	X	X	X	X
Ryan	X	X	X	X	X	X
Joshua	X	X	X		X	X
Benjamin	X	X	X	X	X	X
Alessandra	X	X	X	X	X	X
Zara	X	X	X	X	X	X

Table 3.7: Types of data collected in each case
*Note: * refers to data collection that was incomplete because of low participation rates*

	Types of Data					
Program	*Reflections*	*Student Interviews*	*PI Interviews*	*Program Documents*	*Observations*	*GEC Survey*
IRES	X	X	X	X	X	*
Int'l Center	X	*	X	X		*
COIL Capstone	X		X	X		X
Traditional Capstone	X		X	X		X

3.2.3 Data Collection

Overview

This case study is primarily focused on qualitative research with the spoken reflections as the main data source. Table 3.7 displays the different sources of data that I have collected for each case, and the remainder of this section describes in detail each data source.

Qualitative data: reflections

Qualitative data allow researchers to access participants' perspectives and ascribed meaning within a specific context in much greater detail [26]. To understand in real-time what students are learning from their international experience, participants recorded and submitted videos or audio of spoken reflections throughout their experiences while responding to specific prompts. The questions are designed with the goal of encouraging critical reflection and introducing new ideas.

By collecting data while students are in their program, I have records of how students are making meaning during their program progression, instead of only retrospectively reflecting post-program. Experiences are viewed differently after the changes and learning have

occurred [30, 129]. Longitudinal data illuminate live, in-the moment progressions [19, 130]. Students may reveal their free-flowing stream of consciousness when speaking more than writing. This form of data has the potential to illuminate small changes in perspectives over time, which provides insight into how the students developed global competencies and point to specific elements of the program design that may have enabled or contributed to their learning [75].

The questions in the prompts were initially based on Roberts et al.'s [103] journaling prompts, which are grounded in the frameworks of Globally Integrated Education Activities and critical reflection. These prompts were:

- What were your observations about the culture today?
- Did your perceptions change today? How?
- Which activity from today had the greatest significance to you? Why?
- What did you learn today? How will it affect you professionally?
- What did you see or learn today that challenged or changed your previous thinking? Why did it challenge or change your thinking?
- What do you hope to learn tomorrow?

The first program I collected data for was IRES. I emailed the students the same reflection prompt each week and invited them to select the questions they wanted to answer. The prompt is given below as well as in Appendix B.5. They are a modified version of the previous questions. The second question is loosely based on the Critical Incident Technique. The third and fourth questions are specifically written to inspire Critical Reflection [103].

1. Culture includes aspects of languages, time, space, clothing, food, work, ethics, and technical knowledge.
    - What were your observations about culture this week?
    - Did your perceptions change this week? How?
    - Would what you observed about culture have an impact on engineering in this context?
2. Which activity from this week had the greatest significance to you? Why?
3. What did you see or learn this week that challenged or changed your previous thinking *personally*?
    - Why did it challenge or change your thinking?
4. What did you see or learn this week that challenged or changed your previous thinking *about engineering*?
    - Did it affect your perception of global engineering?
    - Why did it challenge or change your thinking?
5. What do you hope to learn next week?

Since this study was performed longitudinally as different programs take place, I have improved the data collection for each iteration based on students' input. I received feedback in the post-program interviews that changing the prompts for each reflection could invite deeper thinking because with the current questions, students were only answering the questions with which they felt most comfortable. For the International Center program, I created seven reflection prompts sent on a biweekly basis. The instructions were the same each time, and the prompting questions changed. They can be found in Appendix B.6. I added more

specifically designed Critical Incident questions for reflections 3 and 5. For reflection 3, I requested that students share a critical incident from their group travel. The format for the critical incident reflection prompts is:

I would like you all to think about two specific experiences that were meaningful to you during your trip last week (note:a course activity) *where you felt that you learned something important (and this could be any kind of learning, about engineering, culture, travel, yourself, etc.). For each experience, can you explain:*

- What happened?
- How did you respond?
- Why was this experience meaningful to you?
- What did you learn from this experience?

For the capstone courses, I modified the prompts based on the engineering capstone reflection literature so that reflections would be relevant to students in both courses. The protocol was influenced by the Critical Incident techniques and capstone learning outcomes literature, specifically Lutz and Paretti's [76] interviews with capstone students. The questions below are from their prior protocol, and the questions in bold were ones that I adapted and repeated for the current study.

Fall questions:

1. **Could you tell me a little about your project?**
2. Is there one mentor/project advisor that you'd say is your primary mentor/project advisor? Please describe your interactions with that person.

3. Is there anyone else who has served as a mentor/project advisor for you or your team? Please describe those interactions.

4. **How would you describe the strengths or advantages of the other people you have interacted with?**

5. What things have you learned from your mentor/advisor that you think will be most helpful as you move into your career?

6. Was there any kind of mentoring or guidance that you didn't get that you wish you had?

7. Is there anything else you would like me to know about your experiences with mentors or this class as I try to understand "good teaching" in this kind of environment?

Spring

1. **I'd like to start by understanding your project, so can you tell me about your project?**

2. Now I'd like to talk a little more specifically about the faculty mentor(s) you worked with on the project. Who would you say is your primary faculty mentor or advisor on the project? Can you describe your interactions with that person?

3. Are there any other mentors/advisors that you interact with? What are those interactions like?

4. **Now I'd like to step back again and understand a little more about what you believe you've learned from the project. What was your biggest challenge on this project, and how did you deal with that challenge?**

5. **What are the most valuable things you believe you've learned from this project?**

6. **What do you plan on doing when you graduate?**

7. **How do you see the class preparing you for that situation?**

8. Thank you for your time, is there anything else you would like to add that we maybe haven't covered, as I try to understand "good teaching" in this environment?

I did not include the questions about mentorship but instead focused on design, teamwork, and learning. I posted the prompts on the course's website alongside the other assignments. The students completed 5 reflections during the semester with a reflection due every two to three weeks. After the travel portion, students completed the final reflection. The full reflection prompts are in Appendix B.7. A summary of the reflection protocol for each case is in Table 3.8. Since the protocols changed slightly, thorough within-case analysis are crucial for this study, as I subsequently describe.

Table 3.8: Details of reflection by case

Case	**Length of Program**	**Number of Reflections**	**Submission Method**
IRES Long-Term	8 weeks	6	Email
International Center	16 weeks	7	Email
Traditional Capstone	16 weeks	5	Online Form

Qualitative data: student interviews

I interviewed the students in IRES mid-program and post-program as a part of the NSF assessment. The prompts have been used for [U.S. institution] IRES programs for several years. They are used in Davis et al.'s work [35]. The protocols are listed in Appendices B.2

and B.3. Since assessment is part of the grant funding for IRES, the students were highly encouraged to participate in both interviews by program leaders.

I offered optional interviews for the International Center case. Three students participated in the pre-program interview and the protocol is in Appendix B.1. The program leaders did not want to burden the students with the research and did not directly encourage student participation. No students agreed to be interviewed post-program once they were back in the U.S.

I did not invite students to be interviewed for the capstone course because of the workload of the program as students most students took the course near graduation.

Quantitative data

For each case, students were invited to complete the quantitative Global Engineering Competency Scale both before and after their international program [78]. The Global Engineering Competency Scale (GECS) is a self-assessment quantitative survey that measures cognitive and behavioral competencies [78]. The categories of questions are from Jesiek et al.'s [65] GEC framework and are (1) overall global engineering ability, (2) technical coordination, (3) ethics, standards, and regulations, and (4) engineering cultures. Some questions also draw from other global engineering competency surveys [7, 37, 65, 82, 98]. The survey questions are in Appendix Section B.8. The authors worked for content validity by drawing on other existing studies and basing the new items in the theoretical framework, which drew from qualitative research [78]. The confirmatory factor analysis indicated that the dimensions were separate but relatable, which is evidence of discriminant validity [78].

For the IRES and International Center cases, there were issues with low response rates and some straight-lining, which is further discussed in Section 3.4. To correct these issues, for

the COIL Case I added multiple reverse wording questions so that inconsistent responses could be removed. The students received credit in the course for completing the surveys. I discussed with the capstone instructor, and we decided to reword some questions to focus on software engineering specifically, since the disciplines in the course do not have "engineering" in the name (Computer Science, Data-Centric Computing, or Secure Computing). We removed two questions that were not aligned with the course (e.g., cultural differences relating to product design, manufacture, and use). I also added the Metacognitive section of the Cultural Intelligence Survey because it was aligned with the course's learning outcomes, with questions about self-awareness during cross-cultural interactions [4]. For all cases, I asked for demographic information which can be connected to the qualitative data. Survey data for the Capstone Case is be used to understand whether there were observed participant-wide changes in global engineering competency.

Qualitative data: supplementary

I traveled with the IRES students and I felt confident that I thoroughly understood the context, since the students met with me and showed me their research labs. I also have access to an interview with the IRES PI that was collected as a part of an NSF project so I can better understand the program leader's intentions for the program and its logistical aspects.

In comparison, as I was reviewing the International Center students' reflections, it seemed like I was not understanding all the broader context and implications. I decided that a program leader interview would be a helpful supplement. I created the protocol in Appendix B.4 and the graduate student assistant who lived with the students participated. I also interviewed program leaders from the Capstone case, which included the faculty instructor and the same graduate student assistant as the International Center case.

I also have used the publicly available program documents as a resource. [U.S. institution's] Global Education Office has listings for study abroad programs that have academic, financial, and logistical information [46, 47]. I have access to the course documents for the COIL course and referenced these to see the design and cultural topics in the course.

3.2.4 Data Analysis

The first step for the data analysis process was coding the individual reflections to understand the experience of each specific student. Then I examined the students' experiences and learning as a group within a case, while bringing in the other sources of data to triangulate my understanding of the case. This information in aggregate became a case report. Then I draw themes from the case reports to make assertions across cases to address my research questions.

Within-case analysis

Qualitative reflections from each student were analyzed for each case to illuminate how students reflect on their learning. The first round of coding was Attribute Coding, which is used to keep track of essential participant information [106]. The results from the Attribute Coding is previewed in Tables 3.4, 3.5, and 3.6.

The first round of content coding was based on Provisional Coding. This method is recommended when preexisting codes are informing the analysis [106]. When reviewing the data with provisional codes, the codebook can be revised, modified, or expanded to include new codes [106]. In this study, the starting list of codes included the three dimensions of Global Engineering Competency for all cases, the Critical Incident framework for the IRES and International Center cases, and the capstone learning outcomes for the capstone COIL

Table 3.9: A priori codes for Global Engineering Competency [3]

Code	**Attributes from Literature**
Global Competency	work effectively in diverse and multicultural global environments; language; world/global affairs and policies; international relations; global product platforms; economics/outsourcing; socio/political impact on problem definition; global citizenship; appreciate cultural value differences
Technical Competency	engineering fundamentals; science, mathematics, analytical skills; open-ended problem definition and solving; integration of analytical, problem-solving, and design skills
Professional Competency	leadership; teamwork; communication; decision-making; recognize and manage change; synthesize engineering, business, and societal perspectives; multidisciplinary; innovative; strong work ethic; entrepreneurial and intrapreneurial; curious and persistent lifelong learners
Global Engineering Competency	integrating the dimensional attributes

Table 3.10: Defined codebook of Global Engineering Competencies

Code	**Definition**
Technical Competency	Technical research and engineering skills that students need to succeed as researchers in their engineering discipline
Professional Competency	Professional workplace interpersonal skills that are important in a variety of inter and intracultural professions
Global Competency	Intercultural abilities, attitudes, or attributes necessary for success in global collaborations in any discipline
Professional and Technical	Interpersonal workplace competencies that are specifically relevant to engineering
Global and Professional	Professional interpersonal skills specifically relevant for a cross-cultural context
Technical and Global	Engineering workplace skills that require an application of global knowledge, related to the ways that engineering professions, products, and processes differ around the world
Fully Integrated	Intercultural workplace skills specifically applied to engineering work.

Table 3.11: A priori codes for critical incidents [32]

Code	Attributes from Literature
Connecting with people	Connecting with a professor/leader; connecting with another traveler; connecting with a local professional; connecting with local people; developing a close set of friends
Gaining knowledge or awareness	Learning about local history; learning about local current issues; outside perspective on the US; connecting engineering to culture; foreign culture approach to social issues; observing poverty
Experiencing a foreign culture	Running into a cultural difference; working in a foreign culture; experiencing local way of life; experiencing foreign systems (e.g., education or healthcare); gender related experience; experiencing non-touristy part of the country
Navigating a foreign country	Practicing a foreign language Communicating across a language barrier Dealing with unexpected situations Managing travel logistics
Personal growth or awareness	Feeling uncomfortable (culturally, scared, privilege); having assumptions overturned (cultural); personal growth or reflection; taking advantage of opportunities
Being on your own	Being isolated in a foreign environment; navigating on your own; traveling by yourself; getting lost
Iconic experience	Visiting a local site; iconic experience

Table 3.12: A priori codes for capstones [76]

Code	***Attributes from Literature***
Engineering Design	**Planning skills:** problem definition, design requirements, project management. **Execution skills:** handling ambiguity, testing and modeling, learning through doing.
Teamwork and Communication	**Internal team practices:** interpersonal skills, conflict resolution, coordinating information. **External shareholder practices:** professional communication, navigating stakeholder interactions.
Self-Directed Learning	Searching for and using external resources, time management, work ethic, ownership of learning
Engineering Identity	**Understanding the profession:** expectations for work, appreciation for the discipline. **Belonging to the profession:** Thinking like an engineer, integration into community, increased role competence.

case. The global engineering competencies are divided into Global, Technical, Professional, and integrated dimensions and the initial definitions for the codes are described in Table 3.9 [3]. To explore each integration of these three competencies, I expanded the codebook and defined these new codes in Table 3.10.

The Critical Incident codes are listed in Table 3.11, and were applied to the IRES and International Center cases.

The Critical Incidents were unlikely to apply to the COIL case since students were not living abroad, so a more relevant coding framework was chosen to replace it. I created a Capstone codebook based on the emergent themes that Lutz and Paretti [76] found from capstone student interviews. These codes include Engineering Design, Teamwork and Communication, Self-Directed Learning, and Engineering Identity and are defined in Table 3.12. These codes were used to define events that students were experiencing and correlated with the competencies developed in the analysis.

During the first pass through the transcribed data, I coded for one of the Global Engineering Competencies, the existence of a Critical Incident, and the Competency codes. I remained open to emergent codes that are relevant to the research questions about students' learning and growth during international programs, which were categorized under Other Learning.

After completing the first pass, I read through all of the data for a second pass. I confirmed or modified the first round of coding and added descriptors to the Global Engineering Competencies (e.g. "Language learning", "communication", "running experiments") and the specific Critical Incident Codes (Table 3.11) or the Capstone Subcodes (Table 3.12).

For quality measures, I reviewed a subset of coded quotes with another Engineering Education PhD student to ensure that my process remains consistent with my codebook definitions. I reviewed my beginning and final codebook with committee members, and my advisor most

frequently, along with data for which another perspective could be helpful.

For the second round of coding, I drew from Longitudinal Coding methods [106]. In this analysis method, the researcher observes how a participant changes over time. They look for the concepts, skills, or ideas that change over time. The categories for the changes are:

- Increase and emerge
- Cumulative
- Surges, epiphanies, and turning points
- Decrease and cease
- Constant and consistent
- Idiosyncratic
- Missing [106]

This method was appropriate since I am researching how individual students change throughout an international experience. I examined how the topics in their reflections evolve, appear, or disappear and took notes to summarize each participant. I remained focused on the individual students and cases at this point because I should not try to answer the research questions before the cross-case analysis [118]. A summary of the rounds of coding for the reflections and quality checks are in Table 3.13.

The additional data from surveys, program documents, and program leader interviews supplemented the interpretation of students' reflections for understanding each case. I used documents to add to my understanding of the attributes and logistical elements of each case, which were part of my descriptions in Section 3.2.1. The students' interviews, especially

Table 3.13: Summary of plan for coding of reflections

Round of Analysis	**Type of Coding**	**Quality Measures**
Initial data storage	Attribute coding	Securely stored
Round one coding	Provisional coding	Codebook and peer audit, researcher review
Round two coding	Longitudinal coding	Presentation of findings

for the IRES case, are compared to their reflections to further understand what data are or are not gained from reflections. The program leader interviews in the International Center and COIL cases give both the program context and an overall sense of the students' experiences, which are helpful in illuminating potential outliers in the reflections. Alignment or mismatches between program leaders and students are useful for assessment and future programs' development and referenced in the case reports.

The COIL course had almost full participation in the quantitative data analysis, which made it possible to compare the mean responses in each category pre- and post-program.

Questions 3 and 22 are attention check questions that invert the scale. Surveys that gave the same responses for every question including these two were removed from the dataset.

After completing the previous analysis, I wrote case reports for each setting. To write the case reports, I reviewed all of the data sources. I pulled the quotes by their coded Global Engineering Competency and sorted them into descriptive themes for qualitative analysis. The reports serve as the basis for my cross-case analysis.

Cross-case analysis

Once the cases were thoroughly documented with the findings recorded, I executed the cross-case analysis. Before comparing cases, it was important to define the quintain, or phenomenon [26, 118]. In this research, the quintain is learning during engineering interna-

tional programs. Exploring assertions about the quintain was how I answered the research question of how the design of international programs is associated with students' learning, particularly of global engineering competencies.

I used Stake's multiple case study technique for this dissertation [118]. I made assertions about the quintain by examining what the data have in common across cases and what is different. Track I's method (Emphasizing Case Findings) is a good fit for this research because it maintains the specific context for each case [118].

The first step is reviewing each case report and its findings to explore themes related to the quintain. This step was done with my advisor because it is important to receive external input after I explored each case in detail and before transitioning to cross-case examination [118]. I rated how highly each case supports each theme. Then, I reviewed the findings from the relevant case reports and connected them specifically to the themes as evidence. Next, I narrowed down the high importance findings for each theme to see how the context of the case appeared to relate to the finding.

After reorganizing all of the evidence around the themes, I began to make theme-based assertions about the quintain. Through the rest of the process, these assertions could be expanded, deleted, or modified. I reread the findings that lead to each assertion and presented this to a peer. If they agreed that my assertions are well-supported, I wrote and synthesize the assertions. Finally, the synthesized assertions were be reviewed.

In summary, the steps for the cross-case analysis are:

1. Identify themes from case reports
2. Review the utility of the cases to develop these themes
3. Assess the relevance of the findings for each theme

4. Collect the evidence with highest importance for each theme

5. Create tentative assertions

6. Reread the findings that led to each assertion

7. Synthesize the assertions

8. Review and triangulate [118]

3.3 Quality

Reflexivity and openness about my perspective and positionality are important in all of my work, particularly since in qualitative studies the researcher is a lens for the study [26]. I included self-reflection on my reasons for doing this research, as discussed in Section 3.1. I recorded the data collection process to maintain an audit trail during data analysis for transparency [121].

For case studies, it is important to define the cases clearly [131]. In this research, the cases are defined by each different program, which are completely separate contexts. Triangulating data in each of these cases strengthens the conclusion of the research since it is corroborated by multiple sources [104]. The sources for triangulation of the reflections includes interviews with students and program leaders, documents, and observations, as described in Section 3.2.3.

When I analyzed the data, it was important to collect and present conflicting evidence and to include direct quotes and data so that readers can draw their own conclusions [131]. I used external auditing of my qualitative data analysis from engineering education researchers. As

described in Section 3.2.4, my codebook, difficult data, longitudinal summaries of participants, and case reports were reviewed.

The results include detailed contextual description since that is a vital component of case study research [121]. The further each case is explained, the more informed the reader can be about the findings [26]. To collect more detailed data, I read available documentation and collaborated with the instructors and program leaders who are most closely involved in each context since they provide valuable insights and could identify aspects I may have overlooked. The in-depth data in this study have strong theoretical constructs and were selected purposefully to answer the research questions, allowing rigorous qualitative research [121]. For the quantitative measures, a strict causal relationship is not claimed. Instead, this study is about exploring the relationship between students' learning and these types of experiences. Cross-case analysis informs the reader about relative differences so that they can make their own decisions about the transferability of the findings [26].

I submitted my research plan to the Institutional Review Board and it was deemed to be Not Research. All participants filled out the consent form in Appendix A.3. I do not believe there is harm to the participants from engaging in this research. I fully anonymized the participants and I made it clear to them that I would do so [121].

3.4 Limitations

There are several limitations associated with this research design that should be taken under consideration when interpreting findings. In this section, I describe some of the limitations and my efforts to mitigate those limitations when possible.

Although I explored collecting data from multiple universities, the cases where program

leaders were willing to commit to the data collection and encourage students' participation were all based at one U.S. university. The trade-offs of this design decision are that the results are most transferable to universities similar to [U.S. institution]: well-resourced research universities with large engineering enrollments. There is a benefit to the cross-case analysis because all of the students have had relatively similar experiences in their undergraduate engineering programs prior to enrolling in the international program, as opposed to needing to consider a variety of educational experiences in the analysis.

Students in study abroad programs do not represent a university's entire population [32]. Students who chose to enroll in these programs made a time and financial commitment. Additionally, there are differences in the student populations in each case even though they are all [U.S. institution] students. The different types of programs appeal to different populations because of their lengths, activities, and costs. Each program also is focused on different engineering disciplines, which should be considered a caveat in interpreting findings.

Spoken reflections are a worthwhile emerging data collection method, but there may be limits to what the students share if they have significant discomfort with the spoken medium. Prior research has shown that some students are less skilled at writing and struggle with written reflections [17]. For that reason, I believe this study is a valuable addition to the reflection literature because some students who were uncomfortable with written reflection may be more comfortable speaking, opening up my findings to more students and outcomes. In my data collection, I observed that some students are opposed to the spoken reflections. In Table 3.4, it can be seen that two IRES students did not submit any reflections. The table for the International Center program (Table 3.5) shows that some students did not do the first reflections but consistently recorded them later in the semester. This shift may indicate that there is a mental barrier to trying the spoken reflections, but once students make an attempt, they adapted to the process. In the COIL case, the participation rate in reflections

were extremely high and only two reflections were missed across 10 participants, as seen in Table 3.6.

Students' level of participation in the data collection was considered as I analyzed their individual data. The participants in the IRES case were the least likely to continue to the end of data collection, as shown in Table 3.4. This program had the least incentives for students to complete the reflections because there was no grade involved. It is also possible that the prompt being the same for each reflection made participation less interesting to students, so I adapted the protocol for subsequent programs. In the International Center case, more students participated over time, as seen in Table 3.5. Before the fourth reflection, the program leaders reminded students that they were graded for completion, and all students reflected on time. For the final two reflections, five of seven students turned in each reflection. Multiple students noted in their final reflections that they were happy to have the reflections or they more comfortable doing them by that point in the program, which is discusssed in more detail in Section 8.3.2. Only two students in the COIL course missed a reflection submission, as seen in Table 3.6. Participation in reflections was given a completion grade. Tracking each students' demographics, participation, and submission date can be considered Attribute Coding [106]. I took into account each students' participation rate when analyzing the data from them.

Since the programs are different lengths, the frequency of reflection varies from weekly to once every three weeks, as seen in Table 3.8. The amount of time between reflections may affect what students remember and what is top of mind during their reflection. If students are reflecting as they speak instead of thinking about what they want to say before recording, they may emphasize events that occurred more recently. In the International Center case, there was a unique problem of late reflections. Sometimes students recorded and submitted reflections back-to-back to receive course credit. This variation will be important to note

in the analysis and has been recorded in Table 3.5. Since I analyzed individual students' longitudinal progression, their reflection time frames were considered.

I emphasized to the students multiple times in the introduction to the research that their responses would be anonymized for all research. I also explained that the program leaders will never hear their reflections, and only anonymous feedback may be shared with program leaders. This step was done to reduce social desirability bias of the students sharing what they thought would make their program leaders happy. A benefit of the self-recording process is that I am not present for the students' reflections, so my reactions and physical presence did not have an impact on what the students shared [121]. I also explained for the International Center and Capstone participants that the reflections are only graded for completion and that I was not looking for any particular answers in their reflections. Students at the International Center consistently submitted reflections that were longer than six minutes, and some reflections were more than ten minutes long. Students in the COIL course typically submitted reflections between 4 and 8 minutes long. These statistics are detailed in Table 7.1.

As a longitudinal study, the prompts for reflection evolved between each case. These changes were specified in Section 3.2.3. The data sources were not identical for each case, as shown in Table 3.7. The data collection in each case varied based on the program leaders' preferences and convenience. The original plan was to use the GEC survey data for all cases. For the IRES program, I sent out the survey to all of the students, and three of the eight participants answered it. When analyzing one of the responses, I was not confident that the student was reading the questions because they put the same answer for each question, or straight-lined. The International Center students were not incentivized to complete the pre-program survey, and I think that I made a mistake of overburdening them by combining multiple surveys. As a correction, I kept the survey for the capstone case focused on the GECS for the current

study and added multiple reverse wording questions so that inconsistent responses could be removed. The students received credit in the courses for completing the surveys. The survey is still a small sample size, which will limit the claims that can be made. As a result of these data collection differences, each case was examined on its own to gain as much understanding as possible before attempting any cross-case comparisons, as described in Section 3.2.4.

Overall, my research is closely connected to its context, which is a requirement for case studies. It is not an experimental design and the students were not randomly assigned to each case. I need to take into account that they may have outside influences or life events that affect their reflections during the program. I include as much detail as possible with my findings so that their potential transferability can be understood by the reader. The following Chapters 4 - 6 are the resulting case reports. Each chapter is an individual case report.

Chapter 4

Case Report: International Research

4.1 Overview

This chapter is the case report for the International Research Experiences for Students (IRES) case. It begins with an overview of the current case with a summary of the data sources, Figures 4.1 - 4.3, and a narrative of the overall experiences, critical incidents, and competencies in the case, created by integrating all data sources. Summaries of each participant and code in the case follow. The next sections describe each competency in detail, grouped by theme and supported by direct quotes.

4.2 Summary of Experiences

4.2.1 Data Sources

This chapter is a case report that draws from the interviews and reflections of six students who participated in the U.K. IRES program in 2023. I visited the site and conducted the mid-program interviews in person with students. My observations from casual conversations informed my interpretation of the results as I gained a holistic perspective on students' experiences. I also toured the labs that students were working in and observed some of their research projects firsthand.

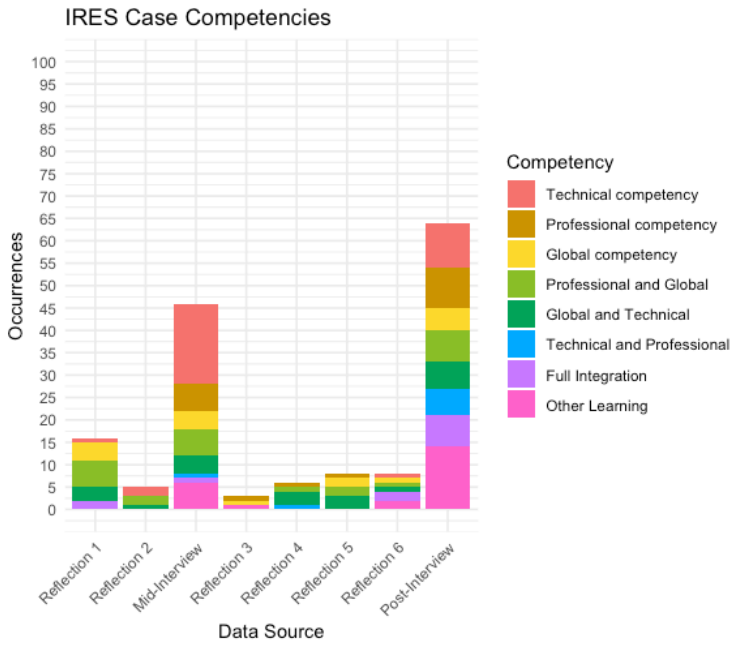

Figure 4.1: IRES case competencies

4.2.2 Case Visualizations

The visualizations of this case include a summary plot of the coded competencies over time (Figure 4.1), the coded critical incidents over time (Figure 4.2), and Figure 4.3 is a diagram of the themes by code in the form of the theoretical framework visualization, Figure 1.2.

4.2.3 Narrative Summary

This section is a narrative summary of the learning and experiences in the IRES case. IRES includes a four-week workshop series at [U.S. institution] before the students travel to the United Kingdom. The workshop included a cultural overview, setting a plan with the research advisors, and guidance on literature review, which was a research competency for the program. This emphasis in the workshop paid off, since the undergraduate students cited literature review as a significant new skill.

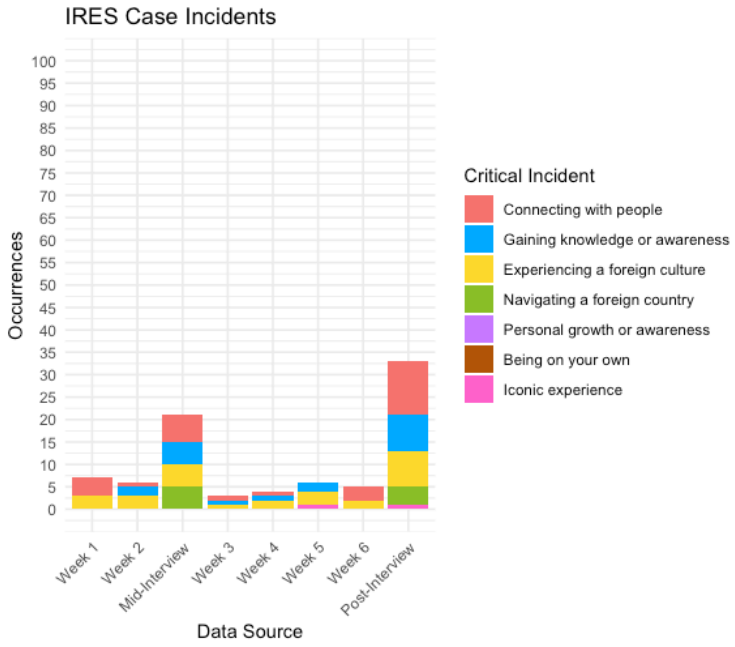

Figure 4.2: IRES case incidents

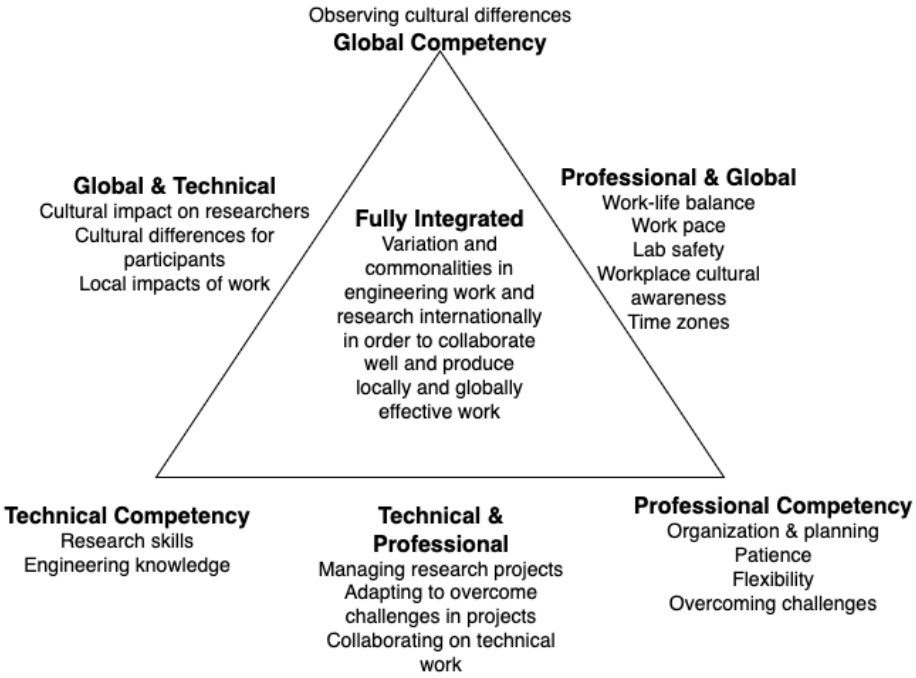

Figure 4.3: IRES GEC diagram

After the United States portion of the program, students moved to the United Kingdom and quickly furnished their apartments before they started working on their research for forty hours per week. The portion in the United Kingdom was a six-week program. The experience of logistically and socially adapting after moving abroad gave students the confidence that they could repeat that process when they start new jobs in the future. It also provided them the opportunity to try out a new lifestyle and discover what they like and want to apply to their lives at home, such as hobbies and methods of socialization. Multiple students noted that they experienced culture shock more in the professional environment than during personal time because of the overall language and cultural similarities between the United States and the United Kingdom. Later in the program, students stopped experiencing significant culture shock unless they consciously put themselves in a new situation. Small differences could still stand out when their expectations were subverted. As I subsequently describe, the limited appearances of Global competency in the second-half reflections and presence of integrated Professional and Global competencies can be seen in Figure 4.1.

Once students started collaborating in the United Kingdom, IRES provided students with a new context in which they could apply their research skills. In contrast to their prior research experiences, the IRES program was a primarily self-contained six-week project where the students collaborated with a new, international team and gained new mentoring relationships.

Undergraduate and graduate students benefited from the research experience in different ways. Once they arrived in the United Kingdom, the undergraduate students participated in the planning, executing, and analyzing of a research project for the first time. They learned how engineering research is designed and executed. For graduate students, the accelerated timeline and independence was unique because they had to perform lab testing that might typically be done by undergraduates and finish an entire project in six weeks.

IRES participants expressed a variety of opinions on which parts of engineering differ culturally and which are the same. The aspects that were discussed as being different included engineering processes, lab safety, technology, and a small amount of discussion about the impact technology has on society. A few students said that looking at the same research from a different cultural lens can lead to helpful new perspectives. Students valued input from individuals with different cultural backgrounds when they were planning their research projects. They gained insights into how to design their projects to benefit different kinds of stakeholders and practiced collaborating in a cross-cultural workplace, which developed integrated Global and Technical and integrated Professional and Global competencies, as seen in Figure 4.1.

Professional cultural differences were surfaced from the in-depth relationships they formed at work, which frequently appeared as the Connecting with People Critical Incident code, as seen in Figure 4.2. One student made the point that even if they observe a new aspect of British culture, they cannot apply that assumption universally because a culture is not a monolith, which is an advanced cultural insight. The professional differences typically included work-life balance, differences in communication, and priority of safety. Additional workplace competencies included workplace communication as students collaborated with people who are non-native English speakers. They developed cultural self-awareness of their own communication styles. Lab safety was discussed by several students. They observed differences in the training and implementation of safety procedures with their [U.K. institution] advisors compared to their home university. This connected to their overall understanding that engineering work varies around the world.

Projects that required intercultural communication demonstrated to some students the danger of making cultural assumptions. They were able to compare the cultural lessons they were told during the pre-travel workshop to the cultural differences that they experienced

firsthand. One example is they were told that small talk during research should be minimized compared to the United States. By observing a [U.K. university] graduate student's interactions with a research participant, one IRES student discovered that during the study was not an appropriate time for small talk, but post-study they did chat casually.

Mentorship was a common theme for all students and those relationships aided them in the transition to the United Kingdom, helped them to perform the research in scientifically and culturally appropriate ways, and guided them in career planning. For two students working on the same project, a standout workplace moment was their research advisor recommending a pivot in their research that required they redo part of their work. They felt short-term stress but when they looked at the project in hindsight, they recognized that they developed flexibility and resilience in research from this incident and both students were grateful for it by the end of the program.

Multiple students learned about coworkers' and mentors' nonlinear career paths. These stories were comforting to the students as they learned that they did not need to have their whole future mapped out. They gained insight into their own preferences for their future careers from IRES, which could include pursuing graduate school or work in industry and working or studying abroad. Almost all students hoped to continue the research collaborations into the future and were inspired by other examples of international work.

4.2.4 Student Summaries

Table 4.1 includes an overview of the participants in the IRES case. Following is a summary of each participant's engagement level in data collection and their key incidents and learning. Details of each students' reflections and experiences can be found in Appendix C.1.

Colleen is an undergraduate student working with Nathen on a Human Factors project in

Table 4.1: Overview of IRES students

Pseudonym	Department	Degree	Gender
Colleen	Industrial and Systems Engr.	Undergraduate	F
Noah	Materials Science	Undergraduate	M
Hailey	Materials Science	PhD	F
Nathen	Industrial and Systems Engr.	Undergraduate	M
Ned	Engr. Mechanics	MS	M
Arthur	Chemical Engr.	PhD	M

ISE. She participated in the reflections at a high rate and only missed Reflection 3, as can be seen in Table 3.4. She discussed every competency from the codebook at some point in the program. Colleen's frequency of professional competency was lower compared to some peers. During her project, she learned about how to run a research study, the impact of culture on how to relate to participants, and had to pivot the technology her and Nathen were using based on the advice of a mentor. She traveled on her own around the United Kingdom during the program and to Denmark post-program. Overall, she primarily found some surface level differences in the cultures early in the program but later expressed global competencies that were integrated with technical, such as an awareness of the danger of making cultural assumptions in engineering and that there is diversity within U.K. culture that needs to be taken into account in engineering work. Her most common critical incident was Experiencing a Foreign Culture as she observed cultural differences professionally and extracurricularly.

Nathan is an undergraduate ISE student who was working with Colleen on a human factors project. He shared more competencies during interviews than in his reflections and said he would prefer the reflections to be written rather than recorded. In his research group, he advanced his skills as a researcher by learning about communication, overcoming challenges, and the technical ability to run research trials. Nathen said that pivoting the research design was an incident that stood out from the program and encouraged him to be flexible.

He primarily talked about connecting with other IRES students and had additional critical incidents of Gaining Knowledge or Awareness and Experiencing a Foreign Culture.

Noah is an undergraduate student who majored in Materials Science but was participating in an Electrical Engineering research group. He participated in every reflection and interview. Noah frequently spoke about Connecting with People and emphasized the relationships that he had formed in his research group. He enjoyed the camaraderie at the office and spending time with coworkers in the evening. He also observed that there are frequent research collaborations between universities. Noah spoke about differences in work-life balance and setting boundaries with work. His technical skill development included Electrical Engineering domain knowledge. While Noah said that he hadn't gained a significantly different perspective on his work and was staying on the same path at the end of the program, he later described a variety of differences in his work style post-program. He also said he learned how to be a researcher who spent more time planning and wanted to deepen his relationships in the United States based on his experiences abroad.

Hailey is a graduate student transitioning from Physics to Engineering. She only participated in the final interview and said that her learning disability was a barrier to submitting the reflections. Her interview included every competency except Global and Technical integrated. She discussed technical skill development and understanding of the field of engineering, advancing cultural awareness in the workplace, and was encouraged by her advisor to travel and create a work-life balance. She had experience in a previous IRES but said that this program still advanced her global and professional competencies.

Joey is an M.S. in Engineering Mechanics student. He only participated in the mid-semester interview, during which I visited his lab. Joey primarily worked alone, except for meetings with his advisor. He liked that the lab equipment was reliable and it helped him advance his experiments. The work experience helped him apply his technical skills to a new lab, which

was a typical 40-hour work week job. He said that he had not found the cultural differences significant and most of his free time was spent with IRES peers. Joey also said that he does not like to spend time reflecting.

Arthur is a PhD student in Chemical Engineering. He completed both interviews and two reflections. During the reflections, he did not share any critical incidents. Arthur is an international student at [U.S. university] and enjoyed the opportunity to learn about the cultural differences in workplaces and research. Since he is further in his academic career, the aspects of working on an abbreviated research project alone, living in the dorms, and spending his time with undergraduate students stood out to him. For the technical work, he returned to fundamentals and expressed a desire to continue the research with his U.K. advisor joining his committee. During the mid-semester interview, he said that IRES should be advertised only to undergraduate students. At the end of the program however, he was glad he did IRES and was considering returning next year.

4.2.5 Summary of Codes and Subcodes

Technical competency: Research and engineering based, students learned specific skills they used in their projects. More frequently elicited during the two interviews than the reflections.

Professional competency: Did not appear until mid-interview but had a significant presence in both interviews. Much more common for undergraduate students than graduate students. Significant skills included planning, patience, flexibility, pace, career paths, collaborating, and overcoming challenges.

Global competency: Primarily observing cultural differences, similar throughout program.

Technical and Professional: Uncommon until the final interview when they talked specif-

ically about managing their research projects.

Global and Technical: This code was spread throughout the program as students saw how the [U.K. institution] workplace differed from what they were used to and culture impacted engineering, processes, lab safety, technology, and research.

Professional and Global: Common in the first half, a little less in the second portion, except in their final interviews. Work-life balance as a cultural difference was the most common code along with intercultural communication and approaches to collaboration.

Integration of Technical, Professional, and Global: When asked to define global engineering, the students did a good job integrating all three aspects and their responses were the most thorough at the end of the program. The students described designing culturally appropriate and internationally collaborative research work.

Other Learning: Appeared most often in interviews, especially at the end of the program. Learning that did not fit into the previous categories included future career paths, openness, new professional connections, and motivation in engineering.

4.3 Individual Competencies

Students demonstrated Technical, Professional, and Global competencies throughout the program. As can be seen in Figure 4.4, the number of competencies was higher in interviews than reflections, which can be attributed to both the higher participation rate in the interviews (5 out of 6 for both interviews and typically of 3 out of 6 for each reflection) and the questions asked. Students were prompted to answer questions about how their thinking had changed recently in the Reflections, but follow-up questions were included in the semi-structured interview, as can be observed in Appendix A. In addition, the interviews were

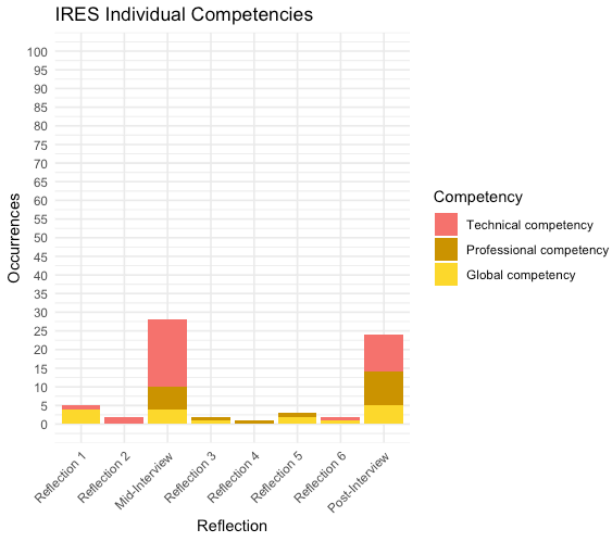

Figure 4.4: IRES individual competencies

about 20 minutes long whereas the reflections were typically less than 5 minutes long

The following sections include a summary of students' discussions of each competency that they developed. The quotes that were coded with each competency were grouped into themes.

4.3.1 Technical Competency

Technical competencies mentioned in the data included: research, engineering, and lab skills. Students were working on new or continuing engineering research projects from their home institution.

Research

Some students were new to engineering research projects. This was an opportunity for them to be exposed to several aspects of the research process. Nathen and Noah talked about learning how to get the information they needed from a literature review.

> A literature review, forcing myself to actually sit down and read [publications], helped me be more focused and learned how to read articles more efficiently instead of reading the whole thing. I got to where to read for most information in the quickest manner or data collection wise. *Nathen, Post-Interview, Technical*

> We [spent] a lot of time just talking about how to read papers and how to break it down and how to use reference managers. That's been super helpful for me to organize my thoughts and be able to dissect papers and take the useful things from them without getting overwhelmed by the sheer volume of papers that are out there. *Noah, Mid-Interview, Technical*

Nathen also talked about becoming more experienced in completing IRB protocols and other aspects of data collection:

> I think I've developed skills in making IRBs. Before, when I first made the IRB, I thought it took months to complete the process, but now we're getting used to it, and it's getting much easier to write them. Making surveys has been much easier, and since I have a general idea of how research works, making the general research protocols and the scripts, the research design has been getting better. *Nathen, Mid-Interview, Technical*

Colleen said that she gained awareness of the research field and how to set up a study:

> I've learned a lot of setting up human subjects and research for autonomous vehicles. I haven't done that before, so the different types of considerations regarding the level of autonomy that a car has, and then the existing body of knowledge of the best practices, and what types of data people collect, and why

> they collect it, and what they compare it to, I didn't know any of that before starting. And then also getting introduced to new research ideas, which I may or may not have been exposed to at [U.S. university]. We're doing a think-aloud protocol for our study... I'm excited to actually implement it, and then do analysis of that data to just have experience because that's a common research technique that I haven't used before. *Colleen, Mid-Interview, Technical*

Colleen also specifically mentioned data collection methods such as think-aloud protocols. Nathen was working on the same project, and he found surveys that would be helpful in the future.

> We learned other ways of asking surveys. We had no idea there were many surveys that correlate to transportation research. Those surveys I think will become very useful in the future in my other research. *Nathen, Mid-Interview, Technical*

Arthur was a graduate student, and he found the advising helpful in developing research competencies. The experience of completing a project quickly reminded him of research fundamentals:

> [My advisor] helped me a lot [in] not only the experiments, but the fundamentals of the project and [to] look at this project differently from just doing some kind of measurements or experiments and then the data analysis. He cares a lot more about the fundamentals of the research. *Arthur, Mid-Interview, Technical*

> As a fourth-year PhD student, I've been doing research for a while. So I knew the basics and how to conduct research. I know how to plan it, how to conduct

> different experiments... [IRES] didn't really significantly change my opinion or my idea about conducting and doing research. One difference was that in PhD, we have longer deadlines. For example, a year or a year and a half, that's very normal. But in case of IRES program, we had such a short time to conduct every experiment that we had in our mind. And that was a big challenge. And I learned a lot in terms of planning and just doing what needs to be done. *Arthur, Post-Interview, Technical*

Students worked on a self-contained research project that would have transferable skills for their future work. Newer students learned how to run engineering research with methods they were unfamiliar with. The program included mentorship from the faculty abroad to advance their technical research skills.

Engineering

Hailey and Noah were transitioning to new disciplines in their studies. Hailey was coming from a physics background and moving into engineering, and Noah was transitioning from materials science to electrical engineering. During IRES, they were mentored by faculty in the new discipline and gained hands-on experience in completing a relevant project. Noah's engineering competency development included electrical engineering awareness and interdisciplinary connections:

> I would just like to get a better understanding of... electrical engineering, because I'm more materials science. And it's great, because I feel like [the research group] doesn't have any really materials science people, so I feel like I can provide [expertise] in terms of reliability, where honestly I didn't think I was going to be

> able to contribute as much, but it seems to be a really good back and forth of communication and learning. *Noah, Reflection 1, Technical*

> New skills [are] definitely the PCB design, [PCB software], taking under consideration just electrical considerations and just things in design I never would have really thought about before because for me it was a very mechanical structure… The whole reason I came here is for that. So I can kind of understand the electrical considerations I have to take into account. *Noah, Mid-Interview, Technical*

Hailey learned about finite element analysis and modeling from lessons and hands-on projects:

> Because my background is physics and not engineering, there were certain topics of engineering that had to do with solid mechanics that had to do with my research and that I never took a course on. So [my advisor] also took the time to do a couple of technical lectures on that material. *Hailey, Post-Interview, Technical*

IRES provided an opportunity to accelerate the process of pivoting disciplines through experiential learning in engineering research in a workplace setting. Noah and Hailey were introduced to new technical methods and knowledge and immediately applied it in a hands-on setting which helped them to be confident in their choice and abilities of the new field.

Lab equipment

Ned and Arthur specifically discussed the high-quality lab equipment to which they had access during IRES. Their experiments benefited from the improved equipment:

> In the [U.S. lab], most of the time I'm trying to fix a broken machine so that I can do my own work. But here I'm able to just run with the work I want to do. Maybe a test doesn't work out quite like I'd hope. So I try and figure out what happened there. But everything seems to be working pretty smoothly, which is a little unusual. But it does make it a lot more realistic to get a full-scale project done in six weeks rather than a year or so. *Joey, Mid-Interview, Technical*

> In terms of the research skills, so this new armature that they have here, it's a little bit different from what I used to work with at [U.S. institution]. So it's more sensitive, it's more accurate and the software is very different. So it was a new challenge to learn it and I had to learn it very quickly. *Arthur, Mid-Interview, Technical*

Students initially had to become familiar with how to use the new equipment. This equipment helped them to focus on the underlying cause of their specific results instead of spending time troubleshooting the lab equipment.

4.3.2 Professional Competency

Professional cultural differences were surfaced from the in-depth relationships the IRES participants formed at work . The professional differences typically included work-life balance, differences in communication, and priority of safety.

Students discussed learning specific professional competencies. Noah, Hailey, and Arthur talked about being more organized and diligent after spending time planning. For example, they noted:

> [The skills of a good researcher are] being diligent about your process and more

> of the planning phase. Making sure you have everything set up correctly, so when you do start executing on those plans, everything's figured out beforehand. While previously I spent a lot less time planning and then therefore I failed a lot more and was stuck. So I think just the planning, preparation part of the research, I learned a lot there, and it taught me how to be a better researcher. *Noah, Post-Interview, Professional*

> I have a very nonlinear work path, I'll do things in bursts here and there and things like that. So there are ways [the IRES seminar planning sessions] could be stressful and a little frustrating, but it also could be helpful because it was to help you. This is to help you focus and get organized. And even if you don't necessarily follow everything on this list and check it all off, this helps keep in mind if this is how much time I have, these are the things I want to accomplish. *Hailey, Post-Interview, Professional*

> I learned a lot in terms of planning and just doing what needs to be done. That was a plus. I learned a lot from that aspect of the IRES program. *Arthur, Post-Interview, Professional*

Nathen discussed several professional competencies. These included patience, approaching challenges calmly, and adaptability:

> I think you definitely have to be patient, and you should definitely use your resources such as advisors, professors and your colleagues that are in the lab, grad students have been very helpful. *Nathen, Mid-Interview, Professional*

> I learned that I thought I was pretty good dealing with problems when we face challenges, but definitely some[times], I wasn't sure how to deal with them and

> I just got frustrated. But with the help of coworkers or Mary who I was working with, I was able to solve them better, more efficiently too. So I realized that I should work on those traits more. And calm down and think slowly instead of just being emotional about the challenges. *Nathen, Post-Interview, Professional*

> [I developed the skill of] being able to adapt faster. I think I was good at adapting, but this experience help[ed me] get an insight of what things to focus on and what things to adapt to quickly in order to make the process better overall. *Nathen, Post-Interview, Professional*

Noah talked about flexibility within research to solve the problems that are important and connected that to being open to life changes:

> One thing I did kind of get an understanding of is as a researcher, you have a lot of flexibility into going after the problems you want to solve or find interesting. And that's what really surprised me, because I thought when you do get into research, you have to be very narrow-minded on your field of focus. What I've realized is a lot of people, they pick up interests or they see changing problems in the world and their environment that they want to solve. *Noah, Mid-Interview, Professional*

IRES had a workplace setting, and students contributed to their research group as a full-time job. They had the opportunity to develop professional competencies such as organization, patience, and flexibility in research.

4.3.3 Global Competency

Meeting people during free time or during work led to several incidents of new cultural awareness. They were typically subtle incidents, but Joey and Noah found that people communicated differently. For example:

> The thing that I thought was actually kind of funny was [that] we hear so much that [British people] use different words for certain things. But I think just because there's actually been so much interaction before, most people over here even know what I'm talking about. A lot of restaurants actually will say fries is the example that I just found funny. So the whole learning curve for a new culture wasn't as steep as I expected, actually. *Joey, Mid-Interview, Global*

> Everyone's been really nice. Not as many people say "good morning" here, walking over. I think people tend to keep to themselves until you get into your actual place of work, but that was just a small observation. *Noah, Reflection 1, Global*

Colleen had a significant experience in which she connected the pre-travel lessons on cultural communication to what she observed in the program:

> I came in with the perspective that British people and people from the U.K. are not at the same type of small-talk friendly as Americans are... We were in the car with a [U.K. institution] PhD student because he was the one driving. So observing him and his interactions, it really was striking a balance of when the study was happening, we were silent... But then on the way back, once the study had concluded, we were able to have some small talk, and it disrupted

> my expectation that people were really against small talk, because there was definitely plenty of it. *Colleen, Post-Interview, Global*

Nathen also compared the pre-travel modules to what he learned during the travel portion and found that he had a misconception about sharing elevators:

> In one of the [IRES] modules they talked about we should walk on the left side, but [British people] don't really do that, they just walk wherever. And when [the modules] also said when you get into the elevator, if there's a person already occupied, then you shouldn't get into elevator/lift. But we've only had one person that said that's true, and everyone else said, "what are you talking about? I've never heard that before." *Nathen, Mid-Interview, Global*

Noah observed the differences between the multiculturalism in the United Kingdom and compared it to the melting pot philosophy in the United States.

> [My favorite things are] the work life and the people and the cultural diversity. Where in the US, I think there's already a lot of [diversity], but it's all melted together, where here, not that it's still separated in a way, but all the culture is still very prominent. And that's really great because you get to talk to people with different life philosophies and different day-to-day operations. *Noah, Mid-Interview, Global*

Nathen discussed observing multiple examples of environmentally friendly transportation:

> For the question of culture, U.K.'s effort on reducing carbon footprint waste is very admirable. I knew this but it's impressive how much the tram and bus

> systems are designed so that it forces people to use either public transit or walk. Also I recently ordered [food delivery], and they deliver the food fairly quickly when the delivery man biked. *Nathen, Reflection 3, Global*

Finally, Colleen summarized overall that living in a new culture taught her deeper lessons than a theoretical lesson:

> I think it's important that part of this program was international. I think nowadays, with technology, people could make the argument that why would you actually need to physically go somewhere to do this type of collaboration? But I think it is very important... There's so many things that you wouldn't even consider to be differences that come up after living in a culture. Even a culture that's as similar as the U.K., it's really important to be able to have that experience. *Colleen, Reflection 6, Global*

Overall, students found that the experience of living in the new culture was less different than they expected based on their preconceived notions formed after the cultural workshops. The differences that they did observe introduced them to new ideas, and students appreciated the opportunity to advance their cultural competencies.

4.4 Integrated Competencies

All combinations of integrated competencies were present in the data, as can be seen in Figure 4.5. Integrated Professional and Global and integrated Global and Technical competencies appeared throughout the program. Integrated Technical and Professional and fully integrated competencies rose in the post-program interview. Compared to the individual

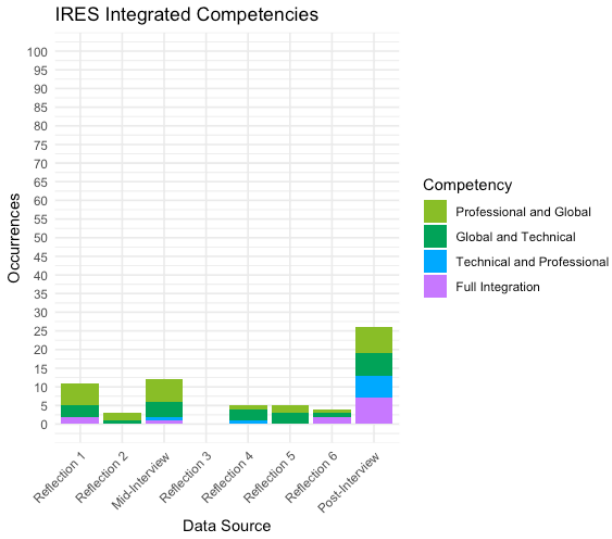

Figure 4.5: IRES integrated competencies

competencies, the number of integrated competencies is more evenly distributed throughout the program. This may be because of the fact that students who reflected consistently throughout the program displayed integrated competencies more frequently. As a result, the interviews with a higher participation rate contain more of the individual competencies.

The following sections include a summary of students' reflections on each of the integrated competencies, grouped by code and then emergent themes.

4.4.1 Professional and Global Competency

While there were some initial cultural observations, students had more cultural competency development as the program progressed in the professional environment than during personal time, possibly because of the overall language and cultural similarities between the United States and the United Kingdom. This led to consistent development of integrated Professional and Global competencies, which the program leader also saw as one of the most significant areas of growth:

> I have really seen students changed by their participation in the program. Some of them have had [a prior] international experience, many of them have not. And so the experience of going overseas and having to learn how to collaborate in a different environment, I've seen the students really grow as far as the skill sets that they have. When we've done assessment with those students, their comments have really centered around feeling a lot more comfortable with working in an international environment. *PI Interview*

The experiences in this program required students to adapt to international workplace collaborations.

Work-life balance

This study indicates that work-life balance is a significant competency developed during IRES because of the frequency it was discussed by students enrolled in the program. Noah in particular mentioned the difference frequently:

> The work-life balance definitely is a little better here as well. Everyone's kind of 9:00 to 5:00, more or less... I do feel in a much better headspace stepping back from the problems, having the whole afternoon off and really getting to dive back into it the next day with a clear mind. Whereas at [the U.S. university], I don't know how helpful all those extra hours I'm putting in are. *Noah, Reflection 2, Professional and Global*

> Life is different in a way. The work-life balance I think is much better… I talked to some people here, and they want to stay past 5:00, but they know if they do, they're going to get bogged down. And so they go home, they get back, and

> they're able to take a break and take that step back. It allows them to be more productive the next day. *Noah, Mid-Interview, Professional and Global*

Hailey had learned this from a previous IRES, and the lesson was repeated in IRES:

> This was something that I learned when I was in Germany [for a previous IRES] as well, which is that America is a very work-focused culture and pretty much everywhere else, almost without exception, there needs to be a healthy work-life balance. *Hailey, Post-Interview, Professional and Global*

Students felt that the work-life balance was more of a priority in the United Kingdom, and they wanted to use the awareness that it is a cultural value to implement more balance into their future work.

Workplace cultural awareness

Hailey discussed in the final interview that she was surprised to see cultural differences and gain cultural awareness. She said that she needed to observe the culture firsthand to truly understand it, instead of learning theoretically. She described the importance of cultural awareness in communication when collaborating internationally:

> I remember [the IRES program leaders] did a cultural overview and were telling us, these are some ways that [work] is different. And they were saying meetings in America will start off very business-like to the point, but in Britain, they want to chat first and have a conversation. And that was definitely something that I noticed with meetings with [my advisor]... I was surprised to see that there were differences. Just in how people communicate and approach solving problems.

> Even though they warned us of that, I guess I did not believe it. Seeing that even with a country that's very similar to American culture, you have to take that cultural filter into account when working with somebody. *Hailey, Post-Interview, Professional and Global*

> [This experience] helps me keep in mind all the things that I do, and how I communicate, and how I can adjust those to communicate with other people better. So I do feel like [this experience] would be helpful because the more exposed you are to different cultures and how they work, the more you realize how much of what you do is coming from your cultural background and how much of it you can adjust to work with people better. *Hailey, Post-Interview, Professional and Global*

Noah observed a higher importance placed on collaboration socially and professionally when he was abroad:

> And I think the social aspect, again, is much greater here. There is a real emphasis on going out to people you haven't talked to yet, getting their expertise on a problem you might have. Where at [U.S. university], I'm definitely much more reserved on going to people with my problems... it's not really, I think, seen as bothering here. More just we're all working toward a similar goal, where I feel like in the U.S. it's maybe a little more individualistic. *Noah, Reflection 2, Professional and Global*

Noah discussed an observation about second-language learning in Reflection 5, which he additionally connected back to engineering.

> Most of [my colleagues] speak one language or a native language, and then English, and it is really valuable to see the impact that can have. And when we were going around and traveling throughout around [the local area], there's so many different people you can talk to because they went out their way and learned English, and a lot of us feel motivated now to keep learning the second languages we might have started in middle school, high school... I think the people are surprised when Americans speak a second language, but it's almost that breaking bread mentality, which is showing appreciation for their culture by learning their language. *Noah, Reflection 5, Global, Professional and Global*

Other impacts of culture on professional environments included communication styles, collaborating, and speaking a second language. All of these observations helped students to become aware of their own assumptions and prepared them for future intercultural work.

Lab safety

Ned and Colleen connected cultural values to the way that rules about lab safety are implemented. He found that the rules were applied strictly in the United Kingdom, whereas the United States' approach was more contextual.

> In the U.S., we have the [safety] trainings where it's one training for every specific thing that could come up. So a different ladder versus fire safety, and they're all different. Here, it was just one massive training... The priorities they have in the U.S. seems to be a lot more case by case for a lot of things. I never actually had to wear a lab coat in the U.S... There might be wet chemicals in the lab. But as long as I wasn't near it, it wasn't a big deal. But here, I'm supposed to have

> [the lab coat] on any time I'm in here. So just the way people focus on specific aspects of the work. *Joey, Mid-Interview, Professional and Global*

> So, in the U.K. it seems to be a lot more unified, kind of like the safety approach. There seems to be a greater presence of safety personnel and safety checklists. And [safety equipment] is free, which is kind of wild because it's not free in the U.S... the safety culture [is] more involved in the U.K. at every step of the research process. *Colleen, Reflection 4, Global and Technical*

Two students found that even the priorities in and approach to lab safety could be impacted by cultural differences.

Time zones

Ned and Arthur touched on learning to adapt to different time zones. This included contacting their collaborators in the United Kingdom before traveling and switching technology to the United Kingdom time zone.

> I think the actual harder part was remembering while I was still in [the United States], how to accommodate the time zones, making sure everything I sent was early in the morning, so that it was still maybe mid-afternoon here... But once I got here, a lot of things ran nice and smoothly. *Joey, Mid-Interview, Professional and Global*

> One thing that still has problems is the different time zones. So I still get some emails in different time zones, and I'm trying to figure it out how to change it to the U.K. time zone. *Arthur, Reflection 1, Professional and Global*

Although only a small portion of the research work was done remotely from the United States, the experience gave students awareness of the importance of crossing time zones when collaborating internationally.

4.4.2 Global and Technical Competency

Students were able to learn about the impact of culture on multiple dimensions of engineering research as they interacted cross-culturally in the workplace.

Researcher perspectives

Students observed cultural differences between themselves and their colleagues. Nathen said that before IRES, he thought that all researchers would be the same. He observed differences in the approach to research that he attributed to culture:

> Before the program, I thought all the researchers were the same, but from working with the [research group at the U.K. institution], it definitely changed my views on how they approach things and their method of making the research design and things like that. So I assume that all the other countries have their own different way of doing things. So I'm curious how other countries might approach things differently. *Nathen, Post-Interview, Global and Technical*

Arthur said that both technical differences such as units and overall perspectives could vary by culture.

> In the simplest way, the units they are working with are different. So they are doing SI units and here we have another metric unit. So that's the simplest thing

> that [I] can think of. But people have different opinions based on the culture and the environment that they have grown in. That adds a lot to me to see research objectives from different points of view. *Arthur, Post-Interview, Global and Technical*

Colleen expanded this observation to include differences in institutional processes:

> There's a major cultural difference in the ethics review process when you're dealing with human subjects. So, in [U.K. institution], we got approved in about a day, and honestly we're still figuring out the [U.S. university's ethics review]. So that has been really frustrating, and I'm curious as to why that is a major cultural difference. *Colleen, Reflection 4, Global and Technical*

The culture of their coworkers had an impact on overall approaches to research, units, and oversight processes. This competency development came from interacting with research groups at work.

Participant perspectives

Colleen and Nathen's project was in human factors and had people as participants for their study. Colleen said that cultural differences showed up in their data collection.

> For the area of study that I'm doing, since it's human factors and we're investigating how people interact with technology in vehicles, specifically autonomous vehicles, any type of cultural difference is important to know. Because we're observing people interact, their cultural norms dictate how they interact with things, as well as any type of human subjects testing requires really careful

> consideration with how you set up and prompt participants to avoid any bias. *Colleen, Reflection 1, Global and Technical*

Near the end of the program, Colleen said that she would prioritize recruiting international participants in future research to increase her transferability of findings:

> We got the chance to do research studies with both people from the U.S. and the U.K. this week… it made me think that maybe it would be a lot easier to incorporate international participants, especially in remote research studies... It can make your research more robust because you have a more diverse population. So maybe there's more generalizability to your research. But I do think it would be difficult to do with the language barrier or significant cultural difference. *Colleen, Reflection 5, Global and Technical*

Running research trials with local participants increased awareness of the cultural assumptions made in human factors studies. Colleen said that including international participants would make their research more robust and was a priority for her future work.

Impact of projects

The final dimension described by the students was attempting to understand a local culture to prepare for the impact of engineering projects on local communities. Arthur was aware of the importance of understanding the impact of engineering but said that he could not prioritize it in his current project.

> Engineering is directly related to people. For example, this kind of experiment that I'm doing, this is in a confined lab, but if you think about it in a more general

> way, it will directly impact people that are working with you or living with you. So, in that way, every project comes with a commitment and responsibility… before this, I was just focusing on the project, and I was not aware of the impact of the project that I'm doing on other people and on society. *Arthur, Mid-Interview, Global and Technical*

Noah said early in the program that it is important to be mindful of the global impact of engineering projects, but he found that researchers in both countries kept the impact in mind.

> I'm not too sure how the engineering discipline differs across borders. For power electronics, you're improving electrical systems, renewable energies, transportation to create a cleaner flow and I think that's a pretty worldly perspective and I don't think that's really changed at [U.K. institution] or [U.S. institution]. *Noah, Reflection 2, Global and Technical*

Colleen met a diverse group of students during her post-project travels. She took away a lesson on seeking out other perspectives when working on engineering projects:

> I got the opportunity to make friends with people in the hostel that I was staying with, which included people from a whole bunch of different countries all around the world… It did make me reflect on global engineering. That was the part that really made me think it's so important to, it's impossible to consider all perspectives, not that you shouldn't try, but it's impossible to really know everything about every culture you might be interacting with or your engineering might be interacting with. So it's really important to be prepared to be flexible and ask those questions. *Colleen, Post-Interview, Technical and Global*

It is valuable to take into account the perspectives of local communities as global engineers, even though other cultures cannot be completely understood. Students gained awareness of this skill from their IRES project and from meeting other travelers during free time.

4.4.3 Technical and Professional Competency

Students learned some integrated technical and professional competencies when running research projects. The competencies varied. Arthur was a graduate student and was used to having assistance from undergraduate students. He practiced completing research projects independently during the program:

> Our research group here at [U.S. institution], we are 10 or 9 PhD students plus 2, 3 masters and some undergrad students. And I think that think of the works are being done in a team. Everybody is doing a piece of that. But in [U.K. institution], I was all on my own. So that was new to me, for example, [at the U.S. institution], if we want to run a lot of experiments, we definitely participate the undergrads to help us with running all those experiments. But at the [U.K. institution], I was all on my own. And that was the difference. I was doing 0 to 100, everything on my own. *Arthur, Post-Interview, Technical and Professional*

Hailey saw the importance of theoretical and practical research in engineering projects:

> [IRES] helped me understand engineering and how [engineers] approach research. And how much more interwoven theory and experiment are, because they had a whole big lab, but they're applying the things. So in [my previous discipline of] physics, there's normally a big separation between theory and experiment, they don't usually tend to work together. Even within the same department they'll be

> working on totally different things, and so someone tends to do either one or the other. Seeing that [in the] engineering lab, it was the same people that are doing simulations but then going down and building things. *Hailey, Post-Interview, Technical and Professional*

Noah participated in a collaboration where he and another student exchanged knowledge, showing collaboration and technical learning. He said:

> I'm working with someone else at [U.K. institution] that is doing similar simulations with the newer software, so it has some newer capabilities that I couldn't have done before. So I'm showing her the ropes of simulations, what to look out for, and she's showing me how to use this new tool. *Noah, Reflection 4, Technical and Professional*

Managing research projects gave students the opportunity to practice Technical and Professional competencies, such as running the fundamentals of research projects, the theoretical basis of projects, and collaboration.

Adapting to challenges

For two students working on the same project, a standout workplace moment was their research advisor recommending a pivot in their research that required they redo part of their work. They felt short-term stress, but when they looked at the project in hindsight, they recognized that they developed flexibility and resilience in research from this incident and both students were grateful for it by the end of the program. Nathen's perspective was:

> The first time we all went out to do our first trial study with [our advisor], Colleen, and I, we were using [one] headset, and we realized that all the work

> we've done so far has basically been useless because it was not working. And [our advisor was] commenting on what to change. So we were stressed at the time. But then he also recommended us to start a trial using [a different] headset, and we tried it, and we found that it was way better. So we had hope. And I think that the most memorable memory I have: fixing that issue and finding out that we actually didn't waste time. We were just in the process of learning, and now we can apply the learning to [the different headset] and make the design much better for us to collect data. *Nathen, Post-Interview, Critical Incident*

Colleen described about the same incident:

> The important thing that I learned from that experience was how important it is to be flexible and not be too attached. Because I had put a lot of work into the [headset] we had originally brought, and so my instinct was to try to make that work as much as possible, even though there was a chance that the other way would work better. So that was a really important thing, the sunk cost fallacy. Just because you put a lot of work into something doesn't mean that there's not a better option that you should at least try. *Colleen, Post-Interview, Technical and Professional*

Colleen discussed adapting during research projects so that the original goals could be met, even if there were setbacks.

> Another lesson or new perspective on research would be that you are not going to end up where you started, if that makes sense. You have the plan, you look into it, you do pilot studies, you do experimental runs, and stuff like that, and decide different questions better for asking... going through that process, now

> I actually understand it and would go into future projects maybe a little more flexible. *Colleen, Mid-Interview, Technical and Professional*

At the end of the program, she said that she learned the specific skills involved in research and how to manage the project with the right mindset

> I learned some concrete things that I already mentioned, like [programming software] and setting up a human subjects research trial, all the things that go into that, including just having a script or a protocol ready, and having all the things prepared and how to recruit participants, that process and lessons learned from that. But then I think I also learned more about research in general. How to manage your expectations around that and keep to a schedule when things are so unpredictable, was one of the biggest things that I learned. So keeping the eye on the end goal. And making sure, even if there were setbacks, that we were making decisions and compromises and stuff so that we would actually finish on time and get valuable information. *Colleen, Post-Interview, Technical and Professional*

Nathen and Colleen gained experience in pivoting when a project is not working, based on the advice of their advisor. They decided to use a new technology. Even though they had to redo some of their previous work, it was important for their project to move forward.

4.4.4 Full Integration

Four of the six IRES program students demonstrated a fully integrated global engineering competency. The first reference was in Colleen's initial reflection. She said that in U.K.

culture, the engineering design process involves describing all of the potential choices to an engineering problem instead of rushing to a solution:

> I think [culture] also has a different impact on professional culture and that also impacts the type of work we're doing within engineering… I do notice a distinct difference in readiness to make decisions right there on the spot as opposed to be like, "Let's circle back around to this." And we talked about that in our cultural modules before we came here, so that was expected. It's not too different, but it is something that we talked about that I [didn't] think I would really encounter. I thought that was maybe more of a stereotype, but it was true… I did actually appreciate the idea of laying out all of the options, doing the future research, and not choosing a favorite or choosing a decision right then and there. I think that's more beneficial to the engineering process, so people don't get stuck in their ideas just because they came up with that idea before they have all the information. *Colleen, Reflection 1, Integration*

In the mid-program interview, Arthur observed the similarities in technical goals but the different viewpoints that come from culture.

> It's always good to know different researchers, because knowledge is worldwide. So people are working on same areas all around the world, and all those scientists and researchers, they have their own point of view that could be very different. And working with people here, I learned that they look at the same subject from different point of views. And that was interesting to me that you can do the same things, follow the same procedure, but have a different mindset and different point of view. *Arthur, Mid-Interview, Integration*

In the post-program interview, Colleen also said that there were global commonalities in research areas. She said that in the future, she would want to continue to collaborate internationally to have better and more innovative research.

> [IRES] made me realize that obviously everyone's researching these areas, but there is a lot more overlap than you would expect. And it would be cool to continue going forward as a researcher, taking that into account and really trying to reach out to people and talk to people instead of just being like, "I'm going to research this," and then have an output that might be redundant in the worst case, or not as impactful, if there wasn't that opportunity to talk with people in different universities or different parts of the world... A little more of an international and collaborative approach to research was a bit of a shift in my perspective. *Colleen, Post-Interview, Integration*

Colleen made an additional point that even if someone observes a new aspect of British culture, they cannot apply that assumption universally because a culture is not a monolith. This is an advanced cultural insight that she connected to human factors research:

> Some of the traveling that I did while on the IRES program, like weekend trips and right after the IRES program, helped me realize that there's a lot of diversity of thought and expectation and culture, even especially when you look at small everyday things. And at work, which is what the ISE program focuses on, just workplace human factors. There's just so much diversity on a day-to-day basis to take into consideration, and so many things you don't know [that] you don't know. *Colleen, Post-Interview, Integration*

In Section 4.4.2 and Noah's second reflection, he had thought that the goals of engineering

research are generally the same. In his final interview, however, Noah demonstrated knowledge of different cultures' usage of the same technologies. This connected to the design process and open-mindedness.

> I don't think the engineering, at least where I was, I don't think the culture has really shifted the practice of the skills or anything like that in engineering. But the work life is definitely preferable and definitely something I'm going to try to bring back to the United States. *Noah, Reflection 6, Professional and Global*

> I think the different cultures also come with different considerations of design. And it's hard to see in power electronics, but the overall objectives of what they want to build for, I think was inherent in designs. Some people from China wanted to make the power electronics for electric vehicle inverters, while some people from Greece wanted to focus more on the wind turbine technology. And we would optimize our [outputs] and we'd start to think about the integration even though we were before that step. So I just think the different cultures maybe saw its way into the design aspect a little more than I thought. But also just having an open mindset and understand that people work differently from different places has been a privilege. *Noah, Post-Interview, Integration*

Hailey was familiar with global collaborations in the field of physics, but this was her first exposure to engineering fields. She was the only student to mention the legal differences with intellectual property and said that she was happy to see that the field had international connections.

> It seems like in engineering, there's a lot more legality issues of like patents and intellectual property. So I was surprised to see that again, there's international

> collaborations and academia and companies are working together. *Hailey, Post-Interview, Integration*

Students were able to reflect on their experiences working cross-culturally on projects during IRES to define varied integrated global engineering competencies that incorporated all three dimensions.

4.5 Other Learning

Additional significant learning outcomes included students' descriptions of adapting quickly to a new environment, building interpersonal relationships, and gaining clarity on their future career interests.

Transition to a new environment

Students moved to the United Kingdom and quickly become settled before they started working forty hours per week during their six-week program. Arthur talked about the difficulty of settling into a new dorm quickly.

> Cooking is challenging here. We didn't know what [were] are going to face when we got here. The kind of dorm that you're staying [in], what kind of equipment they will provide us with. We didn't have any kind of kitchen utensil. So that was our first challenge, we had to buy a lot of stuff. *Arthur, Mid-Interview, Other Learning*

The experience of logistically and socially adapting to the environment gave students the confidence that they could repeat that process when they move or join a new project in the

future.

> I'm hoping to be able to grow in the confidence that I could go to a new location or an international location and figure out the transportation, or independent travel, and things like that, which already IRES has helped me grow personally in that area, that I feel less intimidated to try all new things… I think personally uprooting and going to a new location for five weeks is really good to try a whole bunch of new things really quickly. *Colleen, Mid-Interview, Other Learning*

As Colleen discussed at the end of the previous quote, the new environment provided students with the opportunity to try out a new lifestyle and discover what they like and want to apply to their lives at home. Noah wanted to replicate the socialization he had with his colleagues in [U.K. institution]:

> I felt like I really got to know the people [in the U.K. institution] on a pretty good level. And I think in the U.S., I think when you hang out with people, it's more just like you get some drinks, you go out. But [in the United Kingdom] it was like you get some drinks, I felt like we had some really engaging talk... [Post-program], I'm trying to do other activities that maybe we wouldn't have done before that I found myself doing a lot more. And it was very fulfilling activities. *Noah, Post-Interview, Critical Incident, Other Learning*

The process of adapting to a new environment quickly was viewed by students as a valuable and transferable skill.

Relationships

The relationships that students built with their colleagues and peers were valuable for them to take away from the program. Nathen said that he hoped to continue to publish from the project:

> Participating in this internship was an invaluable experience, and it motivated me to work harder. I hope to see the faculty members again, whether it be online or in person when working on the publishing paper and maybe showcasing this study together at a conference. *Nathen, Reflection 6, Other Learning*

When asked about his favorite part of the experience, Noah said it was his relationships:

> Mostly just the people. Just all the different people. Everyone's really nice and outgoing because I think there's just a lot of people coming in and out, especially in my [office]. So everyone's very used to being social and introducing people, I'd say just like the social aspect of the work environment has been my favorite part. *Noah, Reflection 2, Critical Incident*

Ned said that the networking within and beyond his lab was important, along with the transfer of skills:

> Professionally, I've always really strongly believed in the idea of networking and just having a lot of connections. So I'm definitely getting to know a lot of people here between the professor I'm working with, [and] I'm going to be working with a few professors and technicians at the other lab that I'm going to have to go to later this week. And these are connections that I can keep with me and make

> sure that just building a general network is always a good thing to do. In terms of the workload, it's something else to throw in my resume at a certain point as well. Being able to say that I came over here and was able to transfer skills to do a whole new project in a span of six weeks. *Joey, Mid-Interview, Other Learning*

All students were interested in continuing their projects and work relationships with their supervisors, which the program leader said has been successful in the past:

> They're getting publications out of [IRES] as well. I've also noticed that the students who go tend to be the glue between the faculty members [in both countries]. So because the faculty members are both responsible for mentoring that student to whatever they've decided the final product is going to be, whether that's a conference paper or dissertation research or feeding into gathering data for a larger project. They are in a sense forced to communicate with one another pretty regularly because they have a student working between them. And so I think it's been really instrumental to growing the collaboration between our universities in a larger sense. *PI Interview*

Career paths

Multiple students learned about coworkers' and mentors' nonlinear career paths. Arthur had his previous assumptions overturned by meeting an alumnus of his lab:

> One of the former PhD students from [my advisor's] lab was here, and he was actually visiting the lab and talking with his previous advisor. And that was interesting to me because he's no longer into what he got his PhD for. Rather

> than that, he's into politics and that was very interesting. I've never seen people with a PhD in engineering change his direction that significantly. *Arthur, Reflection 3, Other Learning*

These stories were comforting to the students as they learned that did not need to have their whole future mapped out. Noah talked about how different students ended up in his lab:

> A lot of [people] ended up at that lab through different ways. Some of them knew right out of high school they were going to do power electronics research or something in electrical engineering. And a lot of other people, they just came in through different avenues. So it was really nice to see that there's still a lot of time for me to figure what I want to do out, and where I want to go. *Noah, Post-Interview, Other Learning*

Students observed that the choices they make in their current professional development does not have to dictate their path forever, and many people make changes throughout their lives.

Future careers

The students gained insight into their own preferences for their future careers from IRES, which could include pursuing graduate school or work in industry and working or studying abroad.

> This might not be what the IRES program wants to hear, but it really solidified my idea that I want to go into industry as opposed to staying in school for a PhD. Not that it wasn't a great experience research-wise, but it made me realize the parts that I really liked of the research experience was the actual creation

> of a product and getting people's feedback and doing it really quickly. *Colleen, Post-Interview, Other Learning*

> [IRES] fortified my love for research and academia. And I think that was really important for me to get an understanding of that I don't just love it at [the U.S. university], but I also love it at this other university where it's a completely different work culture… professionally and personally I'd like to continue in my degree abroad... I think I'm going to apply for my Italian citizenship, since my dad's an Italian citizen. *Noah, Post-Interview, Other Learning*

> I was initially contemplating between pursuing Master's [degree] or PhD, and I think the IRES program made me lean more towards PhD more confidently. Now that I have a better idea of what I want to do as my research in the future and having connections that aligns with my interests. *Nathen, Post-Interview, Other Learning*

> At first, the outcome of this project, we thought that would be only a research article. But now we are thinking about expanding it to one of my chapters in my preliminary exam or in my defense. And if that happens, it will actually significantly change my plan for future for this year and for my graduation. *Arthur, Post-Interview, Other Learning*

Hailey said that her overall motivation in the field had increased after the IRES experience

> I was having trouble feeling like I fit in and like I understand engineering and knowing what I want to do, because it's been such a big career change. And [IRES] definitely made me more motivated to get more into engineering and just stick to that track. *Hailey, Post-Interview, Other Learning*

Students pivoted or gained confidence in their choices for next steps, whether that was entering industry, pursuing a PhD, or moving abroad.

Chapter 5

Case Report: International Study Abroad Center

5.1 Overview

This chapter is the report for the International Study Abroad Center case. The contents include a summary of the case, including the data sources used in the analysis, visualizations to show the competencies and critical incidents coded along with a thematic overview (Figures 5.1 - 5.3), and a narrative overview of the competencies and incidents that are present in the case. There is a summary of each student and a high-level overview of each competency, followed by a detailed analysis of each competency. The analyses are grouped by themes that emerged from the quotes coded with each competency and supporting quotes are included.

5.2 Summary of Experiences

5.2.1 Data Sources

This case report draws from the interviews and reflections from seven Civil Engineering students enrolled at the International Center in Fall, 2023. I invited the students to participate

Figure 5.1: International Center case competencies

in pre- and post-program interviews. I interviewed three students pre-program and asked questions based on the protocol in Appendix B.1. No students agreed to be interviewed post-program. I also interviewed the Executive Director of the International Center as well as the civil engineering graduate assistant for the program.

5.2.2 Case Visualizations

The visualizations of this case include a summary plot of the coded competencies over time (Figure 5.1), the coded critical incidents over time (Figure 5.2), and a diagram of the themes by code (Figure 5.3). Table 5.1 includes the participants in the international study abroad center case.

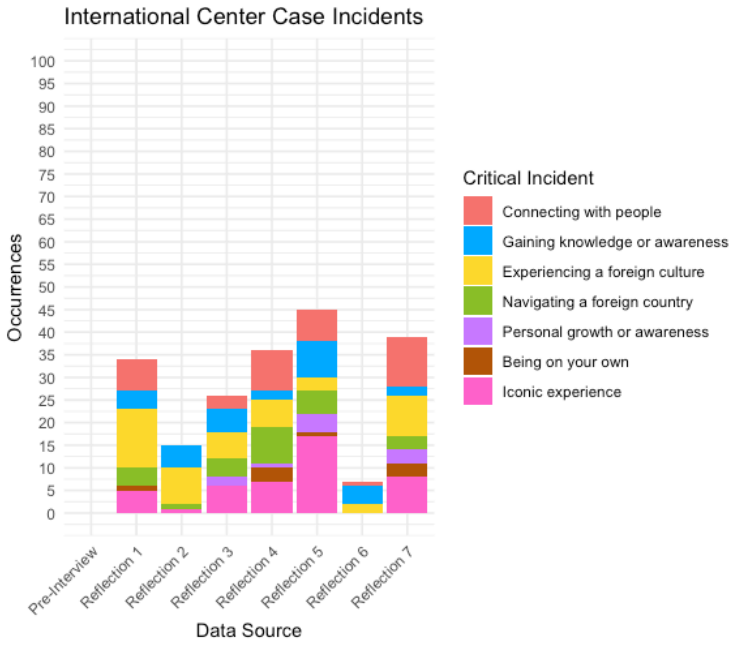

Figure 5.2: International Center case incidents

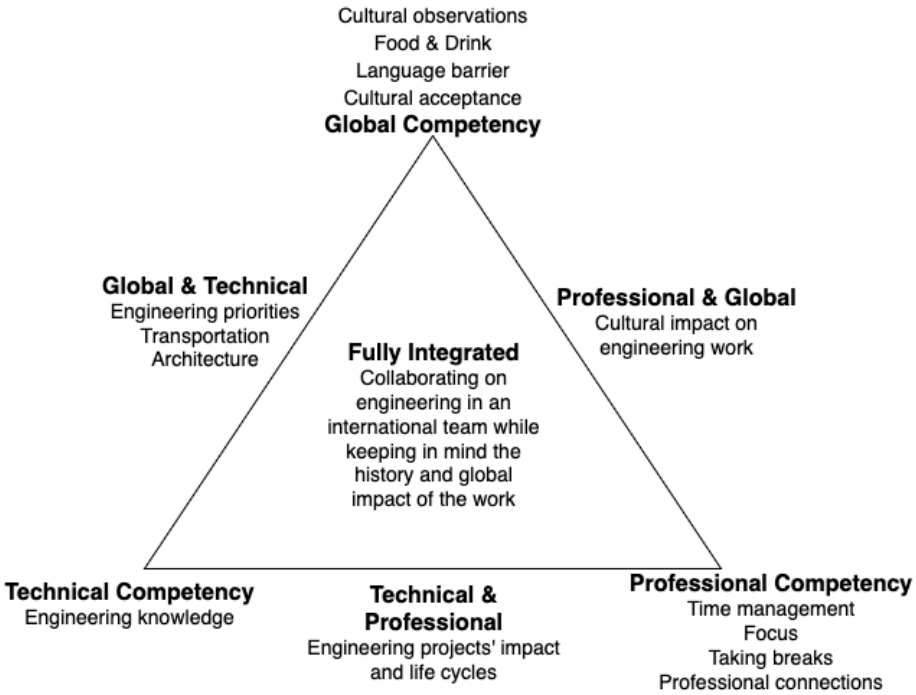

Figure 5.3: International Center GEC diagram

5.2.3 Narrative Summary

This section is a narrative summary of the learning and experiences in the International Center case. Eight students spent a semester at the U.S. university-owned international study abroad center, and seven of the eight consented to take part in this research study. For this program, the students were 3rd-5th year students in Civil Engineering. The program leader stated that most students who come to the center are either from a wealthy area and are well-traveled, or are from a rural area and the international experience will be completely new to them. This observation was true in the current case. For one student, it was her first time leaving the country. Many of the other students had traveled abroad extensively. A couple of students discussed that even though they may have traveled before, it was a new experience to meet people with different backgrounds at the Center and beyond. They said they were coming from a self-described "bubble" at home and in their college town. They saw the semester abroad as an opportunity to move beyond their limited previous experiences and meet new types of people.

The participants were enrolled in the three on-site engineering courses along with an introductory Italian language course and optional electives. Students infrequently discussed purely technical learning. They took lab courses that were similar to those available in the United States, specifically Introduction to Structural Engineering and Introduction to Transportation Engineering at a Swiss university, which gave students the opportunity to keep on track to graduate on time. They also took a course that was the history of bridge building and a comparative examination of civil engineering between countries. These experiences revealed differences in the education systems and the engineering discipline in the United States and in Europe.

The civil engineering courses incorporated some relevant cultural aspects. The faculty

showed the students example bridges in Switzerland and elsewhere in Europe on multi-day excursions. These experiences were frequently associated with Global and Technical integrated competency. Some examples of this were the impact of engineering, how it differs by culture, and historic engineering projects.

Another predominant lesson was from examples in class which showed the students that Swiss bridge design prioritizes the aesthetic and environmental aspects, instead of the speed and economic influences in the United States. The observed differences in design priorities was cited by five students. Some students said that they wanted to adopt a more international perspective in their future career as engineers.

Logistically and socially, the International Center is a very different experience than being at the U.S. Institution. The classes are much smaller, which allowed the students to receive more personalized attention from and build relationships with the faculty. Students appreciated this opportunity and for some, it translated to an improvement in grades.

The relationships among the students fluctuated. They were living with and taking classes alongside a small group all semester, which led to bonding as well as conflict. They shared when there had been disagreements during travel or with feeling left out. Despite conflicts, the students who had difficult experiences still valued the positive relationships they built with other engineering students during the semester.

The students spent many weekends traveling on their own. Typically, six or seven of the eight students would be out of town on a given weekend. They visited different areas of Europe, and one student also visited Morocco. The importance of personal travel to the students was shown in its significant presence in students' reflections.

The goals of the program from program leaders' perspectives are cultural openness and competency. These outcomes were connected with students' reflections on their personal

travel experiences, which frequently included Connecting with People as a critical incident. Students met local residents and other tourists during their trips and most of these interactions were positive. This taught the students global awareness about other cultures and self-awareness of U.S. culture. Another competency developed was communicating with a language barrier or practicing a second language.

Initial global observations by students were about general cultural differences and expanding their understanding. The students were abroad long enough to develop but not necessarily hold on to negative impressions of other cultures. Some negative incidents were shared of other disruptive tourists, but these were for different countries in isolated incidents. No one repeatedly persisted with negative cultural stereotypes throughout the semester.

Some of these cultural differences were connected to broader societal understanding. Traveling on the train gave students' insight into countries' priorities that were connected to engineering. Train strikes were also a new experience.

Students also gained travel skills from overcoming challenges. When asked for the biggest challenges they faced during the semester, some students cited travel issues. Overcoming the challenges contributed to students' learning about travel or personal growth and flexibility.

Students had to learn how to balance their work responsibilities with desire to travel, which is an applicable professional competency. Students had the chance to try out different lifestyle choices than they had previously by prioritizing rest and understanding more of the European life pace and approach to work.

The location of the international center is a very small town. Most businesses are closed on Sunday and the population is mostly older people and families. This was a culture shock to students as they adapted to the quiet area and the beautiful setting. Similar to their experiences during personal travel, communicating in town could be a challenging

experience. Students were able to learn about the local lifestyle.

The change in lifestyle was also difficult for the students. As shown in literature, there is a honeymoon period of cultural adjustment that can become difficult over time. Sometimes during the semester, students grew tired of the small study abroad center and lack of places to study. A few students had moments where they really missed their friends and comfort of the familiarities of home. In the end, the same students said that it was worthwhile to have the unique experience abroad.

A critical incident that was uniquely present in this case is Personal Growth or Awareness. These led to self-awareness or maturity. Some examples included openness to new experiences section. There were examples of students identifying how they had changed during the semester, saying that they had gained maturity, leadership, awareness, confidence, and independence.

5.2.4 Student Summaries

This section contains an overview of the participants in the International Center case (Table 5.1) and a summary of each participant's engagement in data collection, experiences, and learning. More details on each participant's data can be found in Appendix C.2.

Ella is a fourth-year student in Civil Engineering who grew up in a self-identified "bubble" of a wealthy area. She participated in every reflection except the final one, as can be seen in Table 3.5. Ella enrolled in the European food course in addition to the engineering courses. In the foods class, she observed cultural differences in eating habits. Her reflections included a variety of Critical Incidents and competencies, with a particular focus on Global, Global and Technical, and fully integrated competency. In relation to engineering, she discussed the integration of global ideas, the significance of professional aspects, and

Table 5.1: Overview of International Center students
**NA indicates that the student did not release their demographic information for research purposes*

Pseudonym	**Year in Program**	**Gender**
Ella	4	F
Elizabeth	4	F
Sam	3	M
Abigail	NA*	F
Penelope	3	F
Conner	NA*	M
Jackson	5	M

longevity of projects. Throughout the semester, Ella said that she was stepping outside her comfort zone by traveling and trying new things. She practiced time management in her coursework, perseverance, and maturity when facing travel difficulties, and the value of taking things slowly and connecting with others from her cultural experiences and external personal difficulties.

Elizabeth is a fourth-year Civil Engineering student who was born in Europe and had traveled abroad, though she was raised in the United States. She completed four reflections during the semester. Elizabeth was challenged by the small classroom setting, which had the upside of making it easier to connect with the professor but made it difficult to find time to be alone and focus on work. Elizabeth was in the European foods course with Ella, and she discussed that she met local restaurateurs and students through the course and learned about cultural priorities and differences in education. She said that the semester abroad had taught her about living on her own and that she is easygoing. In engineering, she learned about cultural differences in professionalism and standards. She would be interested in working abroad someday.

Sam is a third-year Civil Engineering student, and he participated in every reflection except one. He had previous experience studying abroad and traveling internationally with his

family. Sam strongly preferred the small-classroom setting at the International Center to the large classes at domestic campus of [U.S. institution]. He formed a relationship with the faculty and saw improvements with his grades. He shared several anecdotes of connecting with people when traveling during his free time, which was a frequent source of global competency development. Sam said that he grew personally by becoming more confident, developing problem-solving abilities, and demonstrating leadership with his peers.

Abigail completed five of the seven reflections. Her responses had notably more focus on incidents than competencies, and the majority of her competency development was coded as Other Learning. Through the bridges course, she learned about Swiss priorities in engineering and professional differences. She described struggling with homesickness in the fourth reflection, as she was tired of the unfamiliarity and missing home. Abigail said that finding a work-life balance was difficult. Her favorite parts of the semester were interacting with people in and outside the International Center, which is corroborated by her frequent Connecting with People incident code. She said that she plans to continue living in the United States after she graduates since adapting to a new context was a big stertch.

Penelope is a third-year student in Civil Engineering. She participated in reflections four through seven. She was the only student who said that the program would be her first time abroad. In the second half of the semester, Penelope described enjoying her travel experiences and having some difficulty keeping up with her schoolwork. She enjoyed gaining cultural awareness, learning about the history of other countries, and observing infrastructure differences. At the end of the semester, she said that she had experienced some homesickness and difficulties with communication. She enjoyed seeing the bridges in Europe and had gained an increased interest in a career in structures, with openness to living abroad someday.

Conner participated in every reflection except the first one. He specifically discussed sustainability in engineering and public transportation. His reflections frequently included

discussions of personal growth, including difficulties focusing, self-awareness, maturing, and overcoming challenges. Conner wanted to take on the observed cultural value of taking life slowly. As an engineer, he wanted to be creative in his future work and problem-solving, and had an increased interest in bridge architecture after the program. He hoped to continue traveling in the future.

Jackson is a fifth-year student in civil engineering. He participated in every reflection except the final one. His reflections had significantly more focus on Critical Incidents than competencies. He said that his upbringing was in a more homogeneous area, and his college life was focused on fraternity involvement. While studying abroad, Jackson said his favorite part of the program was meeting new people through the program and during travel. He took many trips and described what he experienced, and travel difficulties were his biggest challenge during the program. He had some homesickness when his friends met up for homecoming, but said that studying abroad was worth it.

5.2.5 Summary of Codes and Subcodes

Technical competency: There were limited examples of individual technical competencies being developed, but the ones present were related to engineering as a field and how to physically understand load.

Professional competency: Professional competencies included time management, focusing when working, taking breaks, and forming professional relationships as students balanced coursework with travel.

Global competency: Global and cultural competencies were primarily developed through observations of different cultures' values and priorities. Eating and drinking in a different culture was also frequently mentioned. Some students transitioned to cultural acceptance.

Professional and Global: A few students talked about collaborating cross-culturally and keeping local needs in mind when designing solutions.

Global and Technical: Global and Technical integrated learning was frequent as students observed differences in priorities in structural design and learned from their courses about European bridges, architecture, and engineering.

Technical and Professional: Two students discussed Technical and Professional competency related to teamwork and output in engineering.

Integration of Technical, Professional, and Global: Several students were able to define global engineering with all three competencies, and they said that the program contributed to their global engineering skills.

Other Learning: There were several themes of other learning including travel skills, future plans, and a significant aspect of personal growth and maturity during the program.

5.3 Individual Competencies

This section contains a summary of the individual competencies that students discussed during the semester at the International Center. Global competencies were the most common and consistent, followed by Technical and Professional competencies, as seen in Figure 5.4. The themes of the data coded as Technical, Professional, or Global competency are described with supporting evidence in the following sections.

Figure 5.4: International Center individual competencies

5.3.1 Technical Competency

At the International Center, the students took Civil Engineering courses that incorporated some local elements. Only Ella and Elizabeth discussed taking away purely technical competency. Ella stated that the course content specifically taught her more about the history of the field and how that influences engineering work. For example:

> Over the last week-ish we have learned about a few more structural engineers that have been relevant to history and things like that… I've realized how much people influence each other from not only one generation to the next, like mentors and things like that, but just building off of each other's work and constantly taking what somebody else has and working to improve upon it and put your own spin on it and things like that. Constantly bettering the profession and yourself and using new technology to your advantage and taking somebody's original idea from wherever it might have come from and making it personal to you and also using the new technology to make it better. *Ella, Reflection 2, Technical*

Elizabeth learned from one of the faculty about having a physical understanding of load.

> I would say now a global engineer is someone who can think physically. Like [our professor] says that a lot in class, now, she's like "Think about the problem physically and actually try to envision the problem"… In class, [the professor] told us that one kip [imperial unit of load] is like four big linebackers. So that's like a way we can envision the actual load. *Elizabeth, Reflection 6, Technical*

Later in the same reflection, Elizabeth talked about gaining a better understanding of the interactions between technical disciplines in construction.

> [Engineering] a broad field, but it's not as broad as it seems. So for example, a lot of engineers' work intertwines with each other. So you have structural engineers, [and] for a bridge, they also need to work with geotechnical engineers to do the foundations and then also transportation engineers for roadway design. *Elizabeth, Reflection 6, Technical*

There were very few technical competencies that could be observed in the students' reflections from the program. Those present were related to engineering knowledge and understanding the field overall.

5.3.2 Professional Competency

Students discussed professional competencies in association with their coursework at the International Center. The aspects that students learned about included time management, improving focus, collaboration, taking breaks, and discovering their own preferences for work.

Time management

Travel and experiences competed with schoolwork responsibilities for students' time. They learned when to prioritize each and how to balance their time. Elizabeth said mid-program that balancing each was a challenge but her time management competencies had improved.

> This semester has been really fun [and] a big learning curve to adjust to traveling and schoolwork at the same time, and how to balance that. But I think I've been able to better manage my time. *Elizabeth, Reflection 4, Professional*

Conner said that he was tempted to spend too much time on extracurricular activities, but he had implemented a system of self-discipline.

> Another challenge is my time management skills, because I distract myself from other important things... I honestly need to help and advice on that. Kind of just discipline. Discipline myself, making sure school is going well and then using the rewards as motivation to do the important stuff not the other way around.*Conner, Reflection 4, Professional*

Ella anticipated the difficulty of this challenge in her first reflection. She did not want to impact future opportunities by failing classes, but she also recognized the value of the opportunity to study abroad.

> I worked really hard for my GPA and I really don't want it to tank just because of the semester. But at what cost, what experiences, what friendships, what opportunities, am I missing out on if I focus solely on school? But if I don't focus on school, will my grades suffer that bad, and am I okay with that? And

> the answer is no, not really, I'm not okay with that, but I've also been pushing myself really hard to achieve extremely well academically, and I feel like I just need to loosen the reins on myself a little bit, and hopefully I'll be able to relax my expectations of myself while I'm here. *Ella, Reflection 1, Professional*

Ella discussed this topic again mid-semester and found that she had balanced her time, even though it sometimes required sacrifice.

> I think one of [the challenges] would be time management. I had to set aside two whole days and not travel for a weekend until I could study for the tests and make our formula sheets and stuff like that. So time management and focusing on school and prioritizing school also making time for fun and travel and friends and things like that has been a challenge for the entirety of the semester but I think I'm kind of getting the hang of it. *Ella, Reflection 4, Professional*

Part of the challenge came from the ebb and flow of intensity during the program. Abigail also described managing her time when everything was due at once.

> I think the biggest challenges were when, so we would have weeks where there wasn't really that much of a workload. And then this week, for example, we just came back from a long break [and] we have a paper due, two presentations, an exam, three lab reports, and then two assignments. And that is just such a big challenge to balance getting enough sleep and eating enough and taking care of my body and mental health and making sure that I'm prepared to go home in a week. *Abigail, Reflection 7, Professional*

Time management was an indirect experiential learning outcome from the program, as students balanced their schoolwork throughout the semester with a desire to take time off and

travel throughout Europe.

Focus

Students discussed improving their ability to focus as a competency that was similar to time management. Some specifically improved their ability to focus when working on schoolwork. In the first reflection, Sam said that he found the environment at the International Center easier to focus at than at his home campus.

> It definitely is a difference adapting to this new environment for a semester. I actually found I've done a better job keeping up with my work. Maybe it's because I'm taking one course less than I normally am. But I also feel like I'm able to focus more and get work done a little bit easier. *Sam, Reflection 1, Professional*

Connor said that he learned that focusing could be difficult for him, but he was making a conscious effort to improve.

> What I've learned about myself is that I kind of just like get distracted really easily, so I want to be able to increase my focus in all things, whether it be schoolwork or conversations or looking at stuff. Just paying better attention to things and keeping my focus for longer, that's a goal of mine. *Conner, Reflection 5, Professional*

Penelope discussed that she has trouble focusing on schoolwork at her home campus and that her structure for motivating herself was different at the International Center.

> Another challenge I face is being able to focus on schoolwork. I've had a hard time doing that sometimes, because there's kind of a feeling you have to travel every weekend… I've decided to do a lot more work during the week, which is kind of hard because I don't have a ton of free time during the week, but it definitely is worth it because then I'm able to go do what I want to do on the weekends. It's a tradeoff. But that's something that's been interesting because I do have a hard time focusing on doing schoolwork in [the United States] but it's a whole different thing here because there's just so many things you could be doing, and seeing, and traveling to. *Penelope, Reflection 4, Professional*

Elizabeth was used to studying in a specific environment and had to find a way to get her work done while being surrounded by peers at the International Center, in addition to asking more questions to the professor.

> The biggest challenge was adjusting to schoolwork while being abroad. Back in [the United States], I'll be able to go to my classes, see my friends on campus, and then find any random empty classroom on campus and do my work there. But here, because it's 60 of us and we're all really close together in the basically the same building, it's hard to find a place to study that's quiet... I adapted to that, finally. I'm able to get work done with my friends and my classmates around. And then also by going to office hours more, I can get through the homework quicker. *Elizabeth, Reflection 7, Professional*

By putting themselves in a new academic environment, students learned about their own preferences for work and practiced focusing, even when there were other distractions.

Taking breaks

Since their schoolwork and travel had high intensity, some students said that they learned to take breaks during each. Penelope liked physically stepping away from her work to rest her mind and create separation:

> I think one thing is I do really like [is] going on walks… I work here all day, so it kind of feels like I never get a break. But when I go outside, I can separate myself from work that helps to clear my mind to actually be able to sit down and focus when I come back. *Penelope, Reflection 6, Professional*

Ella learned that she needed to take breaks from traveling instead of pushing herself too hard.

> I also know and noticed about myself personally that traveling non-stop for 10-ish days is really tiring and I think it made me value my relaxation time a little bit more than I have previously, because I'm the kind of person who sometimes feels guilty for not doing something and not working and not being productive 24-7... But it also is really draining to be going 24-7 and that relaxation time is so valuable. I need that time to decompress and to not do and it is extremely important. *Ella, Reflection 5, Professional*

Some students learned that should balance their work with the necessary rest. Some of this learning was associated with the local culture and for others it was the high intensity of traveling.

Professional connections

The small classes and close-knit environment led to some relevant competency development. Elizabeth anticipated increased collaboration between her peers and more connections to the instructor:

> In our classes, it's only eight of us. So we have more opportunities to ask questions and further understand a topic versus if you're in class in [the U.S. university that] has like 60 students. You can ask a question, but the professor still trying to move the lecture on so they can finish on time and complete what they need to complete. But here we have more individualized access to the professor. So we're able to ask questions and get to know each other more. I think that would greatly improve our collaboration for the lab class, since we have that time now outside of class to get to know each other. I think that'll improve our collaboration skills. *Elizabeth, Reflection 1, Professional*

Sam appreciated the experience of being in a small class and also discussed asking more questions. The result was improved grades.

> I like the small classroom experience, only eight students. I feel like I asked a ton more questions. And I went to office hours the first time here. I feel like that's because having an interpersonal connection with the professor and interacting frequently with them helps... And I think this is my best semester grade-wise as well, which is awesome. *Sam, Reflection 7, Professional*

The smaller learning environment at the international center was associated with professional connections among the students and instructor.

5.3.3 Global Competency

Students spent significant time traveling and learned about different cultures through their classwork and free time. Their learning was primarily through comparisons and observations of cultural differences. In addition, students reported some cultural openness and improvement in cross-cultural communication.

Cultural observations

A prominent competency was learning about different cultures. The International Center is near the border between Switzerland and Italy. Sam talked about learning about the differences between the two cultures from class and added a comparison to Germany from his personal trip.

> One lesson [the professor] provided us was that the Italian transportation was not as reliable as the Swiss, who are much more particular... And I noticed that the Swiss are very on time and all that, whereas the Italians are a little more not as on time. *Sam, Reflection 2, Global*

> We went through Switzerland and Germany, and personally I went to the Netherlands, and it was interesting to see the different cultures. In Switzerland, they were very particular about everything's on time. Everything was perfect. In Germany, they were very specific as well, but they weren't as meticulous on time. There was a lot more train delays in Germany than I found in Switzerland, for example. It was also difficult to navigate trains in Germany. *Sam, Reflection 3, Global*

Two students, Conner and Abigail, talked about cultural differences that they observed during their travels to different countries.

> In Barcelona, everybody was pretty friendly. The trains are heavily utilized all the time. Subway was really great. And they stay out late. They also eat dinner super late, like 10 p.m. And I thought that was funny... I just love seeing how differently everything is from how we do it. Because it's not like crazy. It's not different in a way that causes major differences. *Conner, Reflection 3, Global*

> Everyone [in Denmark] seems to be so friendly and so welcoming and like helpful... There was a little old woman sitting on a bench, but she was like sitting in the middle, so there wasn't really any room for me to sit down. So I was just standing there with my backpack on, and she moved over and was like oh do you want to sit, and then we just sat there, and we chatted a little and that was a really cool experience. Yeah, and just walking through Copenhagen, I feel like it's so evident how much they put emphasis on quality of life, and you wouldn't think that that's such a shocking thing to experience, but it feels good when the world is fun, and it feels really good when society wants you to smile and have a great life, and it's not like you have to work really hard to have that life. *Abigail, Reflection 7, Global*

Penelope did not say what she specifically learned but that she enjoyed becoming familiar with Moroccan culture during her trip and getting outside of Europe.

> Going to Morocco was really incredible, and I just thought that that was such a cool experience because even being in Europe, the culture is different, and it definitely is that it is new, but I think in Morocco it was so starkly different...

> [I] feel like, oh, there are so many different groups of people out there that think differently and grow up differently and live their lives differently. *Penelope, Reflection 7, Global*

Connecting with people was a frequent critical incident during travel. Elizabeth learned about Italian culture from sharing that it was her birthday during a trip:

> When we arrived, the hotel manager, I told him it was my birthday coming up and he was so happy for me because he was talking about how important life is and living life and enjoying life. And he saw that we're young travelers. So he was really excited for us and I think in the Italian culture, they really celebrate life, and they enjoy living in every moment and having moments for family time and his work time, and they were able to separate it pretty well. So I got to experience that separation of life and work, but celebrating the life part. *Elizabeth, Reflection 5, Global*

Students made observations about culture and said that they were becoming more aware of culture differences throughout the program as they lived in Switzerland and traveled.

Food

Food was an aspect of culture that was discussed by multiple students. Students observed the time taken to eat slowly and build community over meals in Europe. Ella and Elizabeth took a course about European food and their assignments and external observations led to some competency development. During the first reflection, Ella talked about slowing down to eat in order to build community:

> It might possibly be because I'm in a European food class, but I pay a lot of attention to the fact that they really do value the time where they are eating and the time that they spend eating around a lot of people... they organize the tables so that people sit together, and it looks like a dining room table instead of this small little table where you have to put the to-go box of food on and just shovel it into your mouth and get going. They really value the time that you spend to just like decompress and have it be the time where you enjoy food and people. *Ella, Reflection 1, Global*

At the end of the semester, Ella, made a similar comment and said that she hoped to bring these practices with her in the future.

> I definitely think that I've learned to, as cheesy as it is, to stop and smell the roses. People in Europe put a lot of importance on having time to just sit and have a cup of coffee with some friends and talk and relax, and I think that I've been very much going, going, going since high school, and I haven't really taken the time to slow down and just enjoy a cup of coffee or a nice meal with friends and just sit and talk. So I think I'm going to try and do more of that next semester if I can. *Ella, Reflection 6, Global*

Elizabeth interviewed a restaurateur for the European food course and learned about her experiences:

> It was just a cool experience because I've never interviewed a food person, a person in gastronomy, the study of food. So I thought that was so cool. And now she runs the restaurant with her cousin. So it was interesting to see how highly food is regarded in her family and their culture. The food there is actually really

> good, and they serve really high quality food at low prices. *Elizabeth, Reflection 5, Global*

Near the end of the semester, Elizabeth made a similar comment to Ella about wanting to eat with community.

> Usually [at home], I would eat my meals and watch a TV show or something. But since I've been here, since everyone eats at the same meal time, I've been able to eat with other people and take a break from the screens. So I like to keep that, not watch TV as much when I'm eating and focus on like what I'm eating… In the US, we take that for granted, we only really think of food as fuel. It is fuel, but it should also be a community event. It's something daily that's enjoyable. So I think I'm going to try to incorporate that when I get back to [the United States]. *Elizabeth Reflection 6, Global*

Early in the semester, Conner had a specific critical incident at the International Center that taught him about a cultural difference in food, but he stated that his opinions would not change.

> I ran off with my dinner to go to Lugano on the boat. And the chefs in the cafeteria, I was like "Oh my gosh, I'm gonna have to go. Can I take this to go?" And I was gonna put it in a napkin. And then the [chef] was like "No, no, I'll give you foil." And then he gave me foil and while I was waiting for that foil, another chef watched me start eating some potatoes with my hand because I was just in a rush and I was super hungry.
>
> And I think for Americans, food is more like just nutrients. And meanwhile, for Italians, it's something to be enjoyed. And I think that's great because it's

> always a time for connecting with other people and also enjoying food. But I also think food is just like a source of nutrients and it's a form of survival. And I'm not gonna change the way or what I eat... So that challenged my way of thinking. But I didn't back down from a challenge, never. *Conner, Reflection 2, Global*

However, by the end of the semester, he said that he wanted to adopt the more relaxed pace of life from Italy, although he has kept his perspective on meal time.

> Everybody's a lot more relaxed here. Not such a, I gotta fill out my time with as much useful stuff as possible. And it's more like, enjoy the moment that you're in... one thing that Italians do a lot is really think of their food as flavor time and relax time and take a lot of time to eat and chat with friends. And for me, while I do love delicious food and I love restaurants, I know that it's nutrients to my body at the end of the day. And that's why I feel like I can eat anything for the sake of getting the nutrients. And also I like even doing other things while I'm eating as well. *Conner, Reflection 6, Global*

Jackson discussed differences in what people eat in Switzerland compared to the United States:

> Another thing that I miss about home is just like having protein in my diet. And it's just hard to do that here because I think just meat in Switzerland is super expensive. *Jackson, Reflection 6, Global*

Food stood out to students as significantly different in Europe compared to the United States. They found that Europeans prioritize eating together, eating slowly, having high quality food, and choose different foods than they were used to.

Alcohol

Students also compared the approach to drinking alcohol between the United States and Europe. Jackson and Ella said that drinking is in moderation in Europe

> One thing I have noticed while being abroad is the nightlife in many countries is very similar in Europe... I think compared to America, it's just not as heavy of a drinking culture. It's more people go out to dance versus like dead belligerently drunk here. *Jackson, Reflection 4, Global*

Ella said that the restraint is because of the cultural normalization of alcohol.

> I feel like in Europe, they place more impact and more importance on having drinking be a social experience and not doing it to get drunk, not doing it in excess, not doing it as a way to like numb your feelings or things like that, which is something that I think Americans do a lot of. But as a way to simply interact with other people and share common experiences and have time to just talk. Like I was talking to [a center employee] and she said, people are going to sit at a table for three, four hours for dinner. So having three, four glasses of wine over the course of that three, four hours, right, is not uncommon. But because it's over such a long period of time, it's not as detrimental or as like impactful to a person's sobriety... I feel like that is a really good example about how people in Europe consider their time and also interact with alcohol as a society and as a culture. *Ella, Reflection 2, Global*

Students spent time at bars and found that Europeans seemed to drink alcohol less excessively than they had observed in the United States.

Language barrier

Students occasionally learned from communicating across a language barrier. Elizabeth found communicating in Germany to be more difficult than communicating in Italy.

> The language barrier would be not a huge challenge, but it's a slight challenge, because I don't really know a lot of Italian, but I am learning it. So I am able to navigate a little bit, and I'm learning as I go. But I would say the most challenging was when we went to Germany. I don't really speak much German. So I think Italians are more, in my experience, have been more willing to work with you via the language barrier than when I went to Germany. It wasn't as easy to navigate, but it was okay, because [of] Google Translate.*Elizabeth, Reflection 4, Global*

Sam was in Switzerland and had to find a common language with a waiter so he practiced his French. He observed that English is usually good enough, which can make Americans complacent.

> The place we went for dinner, the waiter asked if we spoke any German. And we were like, no, [we speak] English... And I said French, because I took a little French in high school. So I know at least basics, basic conversational skills and that. So I ordered our meal in French. And that was kind of a fun experience. But that also put into perspective to me, like. The U.S. does not do a good job of teaching other languages because we're a little bit spoiled with English being kind of the global language. *Sam, Reflection 7, Global*

Second languages are commonly considered a global competency, and students had some

opportunities to practice a language they know. If they did not speak the local language, students had to adapt to using translation apps and communicating in other ways.

Cultural acceptance

It was important for some students to approach the cultural differences with openness and adaptability. The programs graduate assistant said that openness to new cultures was one of the main goals of the program.

> And the biggest value is the global perspective that they gain, I think. Living in Europe is very different from living in the U.S. I think the culture shocks that they experienced here were things they would have never thought about if it wasn't for living in a different country. And I think going back... they're more open to people from international countries because they know what it feels like to be some place that isn't your own. *GA Interview*

Sam said in the first reflection that he was prepared to be surprised so he was able to handle it.

> I don't think I've experienced a whole lot of culture shock per se. I mean, I definitely feel like I've adapted pretty well. I would say I'm pretty conscious of that as well. So I feel like some of my peers aren't necessarily as conscious as I might be. It definitely is a difference, like, adopting to this new environment for a semester. *Sam, Reflection 1, Professional*

Conner also said that he approached the environment with an open mind since he was coming in as an outsider.

> It's kind of like nothing's challenging [my notions about culture] because I'm very open to accepting it, you know? I kind of just see it, and it goes by because I'm the one that's challenging their culture because I'm in their space. So like I'm trying to go with the flow. *Conner, Reflection 2, Global*

Penelope tied several competencies together in her observations about history and culture during travel, which taught her to be aware of and open to other cultures' lifestyles

> I think experiencing other cultures is important, but experiencing things that are not necessarily as obvious as going to a new city and eating food and talking to the people, but going and learning and trying to absorb how things used to be I think is a really cool thing to do. This program has had a big effect on me. I've really enjoyed it. I mean, I feel like I've been able to see a lot of things, kind of expand my horizons. I think I've become a lot more, I don't really know how to describe it, but like cultured, I guess, but like I just understand a lot more about how other people live and like differences between where we are and then like other places in Europe and just all over the world.*Penelope, Reflection 5, Global*

Students came into the experience prepared to be surprised and have to adapt to the new lifestyle. Penelope was a student who had not traveled abroad before, and she said that she had expanded her horizons and become overall culturally aware, beyond surface-level observations.

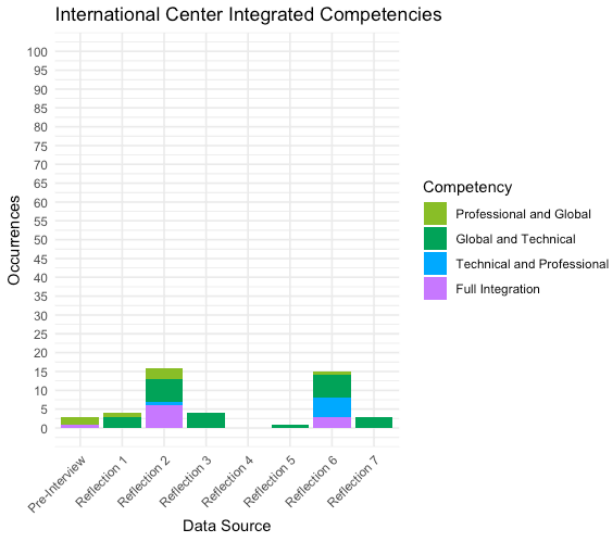

Figure 5.5: International Center integrated competencies

5.4 Integrated Competencies

The presence of integrated competencies can be observed in Figure 5.5. Integrated Professional and Global and integrated Technical and Professional competencies were infrequent. Integrated Global and Technical competency had some appearances throughout the program. Detailed descriptions of the integrated competencies, including Full Integration, follow with relevant quotes.

5.4.1 Professional and Global Competency

Three students defined global engineering by integrated professional and cultural competencies. Conner talked about the impact of engineering, and Elizabeth talked about cultural openness during workplace collaborations.

> A global engineer to me is someone that looks at engineering on a global scale [and] thinks how it'll impact the world in the short and the long term. Global

> engineers are sustainable because that's thinking in the long term. Global engineers want to solve problems for people in places of all wealth classes. *Conner, Reflection 2, Professional and Global*

> I would say a global engineer is a person who has open mind and is capable of adapting to change. Because when you're collaborating with different people, like different nationalities, ethnicities, etc. You have to be able to adapt to change and be able to be flexible and accommodate each other. *Elizabeth, Reflection 6, Professional and Global*

Abigail defined a global engineer as someone who engineers for the local community and connected her definition to an experience that she had in class learning about bridges.

> A global engineer is someone who is flexible and is empathetic and able to identify the needs of a region and the people they are serving in that region. Something that I think is super interesting about Switzerland is that they are more than happy to completely shut down a very integral piece of transportation… I think it's really cool that they put the safety and durability of the piece of infrastructure that they're performing on at the highest level. More important than the wants of the people, they put the needs of the people first. *Abigail, Reflection 2, Professional and Global*

Students integrated Professional and Global competency when they talked about the importance of taking into account sustainability and entire communities as an engineer. They also discussed global collaborations and how culture can impact project planning.

5.4.2 Global and Technical Competency

Global and Technical integrated competency was a more frequent code than purely Technical or any of the other integrations. Engineering observations and coursework were associated with competency development in this area.

Bridges course

The faculty showed the students example bridges in Switzerland and on multi-day excursions. The graduate assistant described how these experiences were designed to encourage learning.

> I think the bridges course was very beneficial to have here because we had field trips to different bridges, and so they could kind of see how they were built what the suspension was, the history, and they had to research different bridge builders, and then we went to go see the bridges those bridge builders built. So they could see things that they researched in action. I think it stuck with them a lot more than if they had just done it for a class presentation. *GA Interview*

A predominant lesson in the bridge engineering history course was comparing societal priorities in civil engineering. Students observed that aesthetic unity and environmental impact were valued in Switzerland. The observed differences in design priorities were cited by five students. First, Ella talked about the aesthetic nature of designs that are tied to culture

> I've noticed that some of the engineers in Europe and throughout history, especially the ones that we've been focusing on, really take time and effort into making their structures aesthetically pleasing and accommodating to the existing environment in which the building is going to be… Whereas I think in the

> United States, we just tear down and bulldoze. At least that was a big part of our history. We're trying to do so less now. *Ella, Reflection 2, Global and Technical*

Conner said that the priorities were lightweight structures that aligned with the local environment, and he wanted to take these lessons forward in his career.

> And what I learned was that Swiss engineering values lightweight structures, but also structures that don't take away from the exterior nature, like the surroundings of the bridge. So the bridge is just trying not to be there as much as possible, just do its job and let nature look amazing. And they do that with this really lightweight engineering... It was meaningful to me because I don't want my engineering to be just lowest cost, most efficient, all that. I want it to be a staple piece, something that stands out and also does its job very well. *Conner, Reflection 3, Global and Technical*

Jackson similarly discussed the importance of aesthetic design and said that in the United States, money is more of a priority.

> Looking at a lot of the bridges that we've seen so far on different field trips, I would say that a lot of the engineering design that goes into these structures is more about its aesthetic and simplicity versus say, something in America [designed] to be built quickly and more cost-effective... I think that speaks to a lot of the values in the same way how it's not as much of something money-wise versus something that people can use and how it'll impact the community. *Jackson, Reflection 2, Global and Technical*

Penelope talked about the importance of cultural awareness when designing and making sure that the aesthetic did not negatively impact the local environment.

> I think that a global engineer is somebody that understands how infrastructure impacts people from different places… I think that it's important to realize other cultures and how other people use things and design and account for that when working on a public project that will be used by a lot of different people... Bridges and the structures here are so beautiful, they're so seamlessly integrated into the nature of Switzerland… I never really thought about that and the impact of putting a structure up and what that can do to the environment around it.*Penelope, Reflection 6, Global and Technical*

The cultural impact on engineering design included changing the priorities for the final product. Students were told about these differences by the professor and got to observe them firsthand during course excursions in their engineering classes.

Transportation

Transportation systems were discussed several times by students related to their travel and coursework. Most comparisons were negative towards the United States, but Sam said that the newer builds in the United States allowed for easier walking.

> It shows that with a different culture, they're going to engineer stuff differently to fit their culture and fit their needs better… for example, the town, the roads are very narrow and there's hardly any sidewalks, and it's kind of hard to tell where to walk and where not to walk. And all that, where I feel like in the USA, it's very given where a sidewalk is going to be. And towns aren't as dense as

> these are. Now granted, these are built many, many, many years before anything in the USA was. *Sam, Reflection 1, Global and Technical*

Conner talked about the improved sustainability of transportation methods in Europe compared to the United States

> Riding this train in Switzerland and the trains here in general, for the most part, any and all people can take it. And it's just as good of an option as driving a car, if not better... But the reason that this train and transportation engineering in Europe is more global engineering than what we have in America is because like it's efficient and people use it, and it's not expensive, and it's sustainable. *Conner, Reflection 2, Global and Technical*

Ella discussed the compromises that have to be made between affordability and reliability, and that this idea should be considered when thinking of the United States as a case:

> One of the biggest differences that I noticed is like public transportation that [is] just truly public and free versus public transportation that is purchased. The quality is affected, 100% you get what you pay for kind of thing. And I just thought that was something that is worth thinking about in terms of transportation engineering in America. *Ella, Reflection 3, Global and Technical*

Observed differences in transportation included pedestrian friendliness, sustainability, and affordability. During coursework and travel, students observed that there were different global ways to approach these tradeoffs.

Architecture

By observing different ways that civil engineering could be done, students see new possibilities of how to approach engineering, which is an integrated Technical and Global competency. The graduate assistant spoke about the new perspectives students gained, with transportation and construction as specific examples:

> I think just understanding that things can be done in different ways and it can still lead to a successful outcome. And seeing that Europe has a really good rail transit system, [and asking] why can't it be applied in the U.S.? Europe has really old buildings, why do buildings here last longer? ... How can we make things that we build last longer and be more functional? *GA Interview*

Cities around Europe had examples of civil and architectural engineering that were educational for students. During her travels, Penelope noted the overall differences in infrastructure and investment in beautifying cities:

> The way that they use infrastructure here is so different. It's cool to see something that is sort of mundane, like a bridge or a road or a building, a lot of things here are designed differently... I went to Budapest this past week for Thanksgiving and that was really cool to see all of the architecture there. They had a building there and I think it was probably the most beautiful thing I've seen ever. That was incredible to see that they had [spent] so much time and I'm sure money building that, and it's just beautiful. *Penelope, Reflection 7, Global and Technical*

Conner discussed multiple aspects of the professor-led trip to Rome. He learned about historic building methods for longevity and was inspired by the impact.

> When we got [to Rome] and I see the right out of the train station and [the Colosseum is] just larger than life... It was such old engineering but the materials and the structural ways that they did things made it last so long even now and I learned a lot about it from [the professor]... It just has such a strong influence and it's lasted so long that it could be a role model piece for any civil engineer. *Conner, Reflection 5, Global and Technical*

Architectural differences were particularly impactful for this group of students since they are all majoring in Civil Engineering and related fields. The trips were an opportunity to observe cultural differences in architectural choices.

Education

Elizabeth had two Global and Technical competencies that were not shared by other students. She learned about the education system in Europe compared to the United States:

> So we got to go to [the Swiss university's] labs and just shadow and do our labs there watch the demonstrations and talk about how the demonstrations that they're doing are different in Switzerland versus the rest of the European Union, but they're also different from the American way of doing labs and testing procedures. *Elizabeth, Reflection 7, Global and Technical*

She observed that the engineering field's differences by country can start be observed in higher education.

Engineering standards

Elizabeth also stated that she learned about engineering standards.

> It's been so interesting learning how engineering like how the standards differ from my country to country like Switzerland versus the US. *Elizabeth, Reflection 7, Global and Technical*

Understanding the global differences in engineering standards are an important aspect of global engineering that students can learn while in international programs.

5.4.3 Technical and Professional Competency

Two students said that they learned an integrated Technical and Professional competency. Sam said that he learned that it is important to create engineering projects that have a positive impact. This observation was similar to other quotes that were coded as Global and Technical or Fully Integrated, but Sam's response focused on teamwork and did not specify international or intercultural communities.

> I've realized that engineering is more than just working on a project. It's making sure that it benefits the community in full and that everybody working on the project [is] working in a good sense and working well together. And it's not just "let's get this project done so we can make money". It's getting this project done so it benefits the community. *Sam, Reflection 2, Technical and Professional*

Ella spoke about an learning experience that included multiple Technical and Professional competencies (i.e., engineering disasters, stakeholders, and project life cycles).

> We learned a lot about the history of engineering and how it brought into focus the unfortunate reality that a lot of what we learn as engineers through failures… I've always known that there was a whole bunch of different parts of engineering

> that weren't just the technical side of it, there's the political side of it, there's the environmental, there's a whole bunch of different aspects of being an engineer. And this semester put into focus for me how small the technical part of it, it's very important and it's very necessary, but the technical aspect of engineering is relatively small compared to all of the other aspects... it changed my idea of the timeline and the scale of time that engineering has functions on. 40 years is considered new or early in the world of engineering technology and new methods. *Ella, Reflection 6, Technical and Professional*

Technical and Professional competencies included an awareness of what is required to manage engineering projects well, including taking into account the impact of the work, balancing technical with interpersonal aspects, and keeping up with new standards and technologies.

5.4.4 Full Integration

Several students demonstrated an understanding of how global engineers should integrate all three competency areas.

Global engineering

The students were asked in the pre-program interview, Reflection 2, and Reflection 6 how they would define a global engineer. The students had a strong understanding of global engineering in Reflection 2 and four of the students gave a definition that integrated Global, Technical, and Professional competencies. Sam and Jackson gave definitions in Reflection 2 that integrated all three competencies. Neither of them gave a definition in Reflection 6.

> I'd define a global engineer as someone who takes into account the values of the

> cultures of the communities around the world and their practices of engineering, and also one that attributes the design elements that are recognized globally as well. *Jackson, Reflection 2, Integration*

> I would define [a global engineer] as someone who works with other cultures in mind while designing projects, while also being able to work with many groups and teams with various backgrounds. So that means being able to go abroad and work successfully and do a good job working with different companies or different teams from a different country where there may be a language barrier or an idea difference and being able to work with them well enough to come to a group decision that benefits everyone. *Sam, Reflection 2, Integration*

Three students answered the prompt both in the pre-program interview or Reflection 2 and in Reflection 6, and their perceptions can be compared early and late in the program. Conner defined global engineers with technical and cultural integration the first time. His first definition was brief and focused on sustainability and impact. His later reflection emphasized the importance of context in technical decisions and incorporated professional competency in the form of including broad perspectives and problem-solving. His final definition integrated all three aspects:

> A global engineer to me is someone that looks at engineering on a global scale, thinks how it'll impact the world in the short and the long term. Global engineers are sustainable because that's thinking in the long term. Global engineers want to solve problems for people in places of all wealth classes and stuff. *Conner, Reflection 2, Professional and Global*

> A global engineer is someone who understands that solutions to problems can be looked at by people from all over the globe at any given moment. So it's all about

> using your knowledge of the world and taking that into account when you have to solve a problem... At first, I thought that once someone thinks of a good way to do something, then you can replicate that. But around here, it's like every task is seen as a brand-new way to step out of the box. And I think I want to take that with me as well, and look at every problem as a new problem to solve. And it affected my perception of global engineering, just because there's no one perfect way to solve a problem. There's all sorts of different ways and they all have their own little benefits and drawbacks. *Conner, Reflection 6, Integrated*

Penelope gave an answer in the initial interview and Reflection 6. Her first answer related to intercultural professional competencies. Her second definition was technical and cultural as she discussed the global impact of engineering work but not professional collaborations.

> [A global engineer is] someone that can work with people of different cultures, all the different cultures around the world, because everyone's so different and has different backgrounds and different society, norms, and ideas of everything. Just someone that can adapt to that and work with many different people. *Penelope, Pre-Interview, Professional and Global*

> I think that a global engineer is somebody that understands how infrastructure impacts people from different places. I think the way that infrastructure impacts people here [in Switzerland] is very different than like in the U.S... I think that it's important to realize other cultures and how other people use things and design and account for that when working on a public project that will be used by a lot of different people. *Penelope, Reflection 6, Global and Technical*

Ella is the only participant who responded to the question all three times. In the interview she talked about cultural open-mindedness and focusing on impact. Her second definition

similarly emphasized incorporating international ideas while adding impact and environmentalism. Her final definition specified that engineers should incorporate technology and procedures from around the world to create the best solution.

> I think a global engineer is somebody who is very open-minded to all of the different approaches, different countries, and different professions. Someone who isn't set in the American way of doing things and is open to learning from and applying international ideas and perspectives to American engineering [and] is also willing to take American ideas and perspectives and bring them to the international locations, depending on which one would be more beneficial to the community in which the engineering project is based. *Ella, Pre-Interview, Professional and Global*

> I personally would define a global engineer as somebody who takes ideas and inspiration from all over the world. But they don't just stick to the new concepts and new ideas being like brought up in their country… Also, I think a global engineer is somebody who really takes time to consider the global impact of their work, what is this going to do not only for the world but also what is this going to do environmentally, how is it going to impact society and politics and every aspect of our day-to-day lives. *Ella, Reflection 2, Integration*

> I think a global engineer is somebody who knows where things came from and knows how to not just focus on the technology and the procedures that are used in their part of the world but to look beyond that and into the global practice and how everything works together and how they can incorporate things, from methods and technologies and materials from different places around the world to create something that fits the needs of whatever they're working on. So having

> a broader view and not just being narrow-minded to their specific location and technology. *Ella, Reflection 6, Integration*

Several of the students integrated all three competencies in their definition of a global engineer, which shows an awareness of the dimensions that engineering work incorporates.

5.5 Other Learning

Other learning was a frequent code for the International Study Abroad Center case, with themes including future plans, travel ability, and personal growth.

5.5.1 Future Plans

Students clarified their future plans from the study abroad program. This was most often related to traveling, learning new languages, or living abroad, but Penelope said that she additionally had an increased interest in structural engineering.

> I've gotten definitely more of an interest in structures and pursuing a career in that, which has been really interesting to learn and travel through classes and figure that part out. Also I really, really enjoyed Vienna... I think that I could definitely see myself being okay living abroad, which is something that I didn't really think about before. *Penelope, Reflection 7, Other Learning*

Conner said that he wanted to travel more internationally and he was confident that he could do it.

> I definitely wish I could have learned some other languages, but I need to put a lot of time into that, which I didn't have this semester. This experience definitely impacted my plans for the future because I definitely want to come back to Europe and also see the rest of the world... I've proven to be able to handle myself in foreign lands. *Conner, Reflection 7, Other Learning*

Having new experiences helped students to decide what they wanted to continue to incorporate into their lives in the future.

5.5.2 Travel ability

Students had different learning experiences from spending significant time traveling. Elizabeth described being able to read the train timetable as a learning process.

> We've been traveling a lot, so I've been able to better navigate the trains. It's been really helpful because at first I was like unsure of how to read what platform we're on, but now it's easier to read and navigate and know what train to get on. *Elizabeth, Reflection 4, Other Learning*

Elizabeth also said that she was open to new experiences when traveling recognized that many experiences were new for her travel companions.

> I learned that I'm really like easy going when traveling… if you want to do it, I'll do it. I don't matter. I think I've changed because I have a more open mind to things. *Elizabeth Reflection 5, Other Learning*

Problem solving and overcoming challenges were frequent learning experiences during travels, which was noted by the program director:

> You can navigate different situations. I like to say you should be comfortable feeling uncomfortable, so that you should be able to say, okay, I'm going to go here. What if I miss the train? Can I manage that? *Director Interview*

Jackson and Penelope said mid-semester that navigating transportation was some of their biggest challenges. They learned how to adapt to the situations.

> It definitely took a while to get used to the trains in Switzerland and Italy. The trains in Germany were very tricky. And the airports definitely are a little different here. I think it's almost a little annoying because each airport has different rules of going through TSA. *Jackson Reflection 4, Other Learning*

> I've had a lot of challenges with transportation since I've been here. There's been a lot of times when things are canceled [or] I don't make the right train [or] I can't find the train… I've dealt with it by problem-solving and figuring out what I need to do to get to the right place. It's definitely very stressful and it's something that I've adapted to and I think it makes traveling a lot easier when you realize, OK, this might happen, but everything's going to be OK and you can figure it out. *Penelope, Reflection 4, Other Learning*

Sam had an incident where his group was separated on the trains, but they were able to solve the problem.

> On our way to Munich, we were getting off the train for our transfer. The door didn't open. One of our group had gotten off the train, and the three of the rest of us didn't get off the train. So we go to another stop an hour away. It was a big learning experience. Having to navigate, being separated, and working our way to stay calm. Figure out a solution. *Sam, Reflection 3, Other Learning*

Sam referenced another transportation mix-up in Paris at the end of the semester and said that the priority was staying calm. He planned to transfer these lessons to other situations in life.

> When we went to Paris, our train to the airport shut down in Mendrisio, which was literally two stops from [where we are living]. And we ended up having to get a taxi, which was cost an arm and a leg. But we managed. And that's kind of the moral of all these stories. We managed and we were able to stay calm and just deal with it. And that's a big lesson I learned… I feel like that definitely helped me in the problem-solving aspect of life. You just got to stick with it and figure it out and deal with it, which is a very beneficial thing of this experience. *Sam, Reflection 7, Other Learning*

Talking about travel was a significant portion of the reflections, and multiple aspects of becoming better travelers was present.

5.5.3 Personal growth

A critical incident that was uniquely present in this case is Personal Growth or Awareness. These led to self-awareness or maturity. Conner said that he learned from a trip to Barcelona about prioritizing fulfilling experiences.

> In Barcelona, in the subway one time, I just did a panoramic [photo]. And every single person that was in there was in a couple. And they were really lovey-dovey. All of them were just in each other's faces, holding hands, self-hands, kissing. And I was like, Barcelona is the city of lovers. And I think it makes sense just because they kind of value what you do with your free time over what money

> you make or something like that. And honestly, I've been learning more and more that most fulfilling experiences are the ones where you connect with other humans. So I'm trying to take those lessons away and apply them over time. *Conner, Reflection 3, Other Learning*

In the next reflection, Conner talked about slowing down and being less impulsive.

> The challenges I faced, I have this thing where my intrusive thoughts intrude way too much and like I do things that I shouldn't do because I'm not thinking and it's spontaneous… I would do it when I'm with others and not thinking with the group in mind. And it's kind of selfish. I'm working on that by noticing it as often as I can, whenever I'm about to do it and think twice about things, be smart, and look at [my choices] from every angle. *Conner, Reflection 4, Professional*

Near the end of the semester, Sam identified how he had changed during the semester with a discussion that starts out specific to travel but extends to his personal growth in leadership.

> I feel like [travel difficulties] definitely helped me in the problem-solving aspect of life. You got to stick with it, and figure it out, and deal with it, which is a very beneficial thing of this experience. And I also feel like I've come out of my shell. I feel a lot more confident in myself from all the trips I've been on with friends. I tend to be the leader. *Sam, Reflection 7, Other Learning*

Ella discussed personal growth and maturity several times. In the first reflection, she said that she had begun stretching herself from the program, which was one of her goals.

> It's a lot of finding balance and growing. It's growing as a person, stepping out of my comfort zone, which is something that I really wanted to do. I'm really happy about. *Ella, Reflection 1, Other Learning*

In the third reflection, she first talked about deciding not to drink and learning that she could be confident and overcome peer pressure.

> I have had to repeatedly stick to my own personal moral values of not drinking. And I feel like a lot of people would find that really challenging, and they would give in, but I learned that if it's something that is really crucial to who you are, and your values as a person, it's not all that hard… Given the fact that I usually lack self-control in a lot of other aspects of my life, I thought I would feel more pressure to conform and to do this, but I don't, and I think that's pretty cool. *Ella, Reflection 3, Other Learning*

In the same reflection, Ella discussed a travel experience where she did not have accommodations and had to stay out all night. She learned that she could grow from a stressful experience but in the future, she would prioritize safety more.

> As an early 20-something year old, you're supposed to make mistakes and do things and learn from them. I think I learned that it's not always worth it to save the few dollars if it compromises your safety and your well-being… I learned that it's important to push yourself sometimes and to put yourself in uncomfortable situations so that you can grow. I think that my ability to function under duress and under extreme circumstances has increased since this experience. *Ella, Reflection 3, Other Learning*

In reflection 5, Ella talked about reordering her priorities, which was the same learning that Conner had previously in this section

> I went through a lot of personal changes over the summer, and this is kind of the first time I've been in an academic environment after these personal changes... I think I have taken a slightly different approach to my academic, not rigor or work ethic or anything like that, but my priorities personally. I try, and I think I have the ability, to be more balanced now than I had before because of these changes. *Ella, Reflection 5, Other Learning*

Personal growth was a unique and significant aspect of learning that students emphasized as they reflected on their semester-long experiences.

Chapter 6

Case Report: Collaborative Online International Learning (COIL)

6.1 Overview

This chapter is the case report for the Collaborative Online International Learning (COIL) case. It contains a summary of the case, including the data sources used to create this report, visualizations of the Competency and Capstone codes by reflection along with an overview of the themes by code (Figures 6.1 - 6.4), and summaries of each student's experiences and each code. It also includes the details of the quantitative survey results for this case in Section 6.7. The detailed reports on each individual and integrated competency follows.

6.2 Summary of Experiences

6.2.1 Data Sources

This case report draws from the reflections from Software Engineering students who enrolled in the COIL capstone program in Spring, 2024. The reflections were analyzed through the lenses of the GEC and Capstone Coding frameworks. I also interviewed the course instructor and the graduate assistant who supported this program's travel to Switzerland, who was the

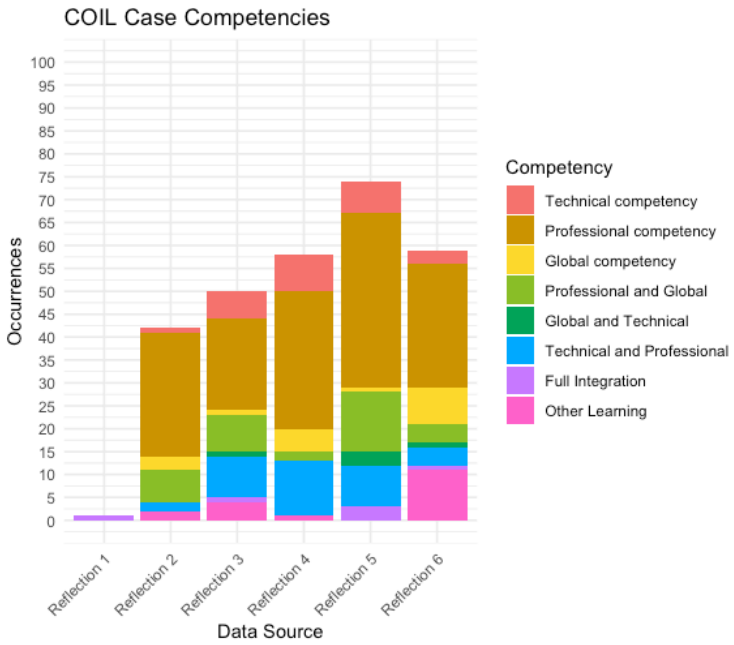

Figure 6.1: COIL case competencies

same civil engineering graduate assistant who supported the prior case.

6.2.2 Case Visualizations

The visualizations of this case include a summary plot of the coded competencies over time (Figure 6.1), the Capstone codes and subcodes over time (Figures 6.2 6.3), and a diagram of the themes by code (Figure 6.4). Table 6.2 includes the participants in COIL case.

6.2.3 Narrative Summary

This section is a narrative summary of the learning and experiences in the COIL case. In the COIL capstone, the students at the U.S. institution worked in teams with international students from Egypt and Switzerland to solve an open-ended software problem with a real client. There was a semester of remote collaboration before all the teams traveled to Switzerland

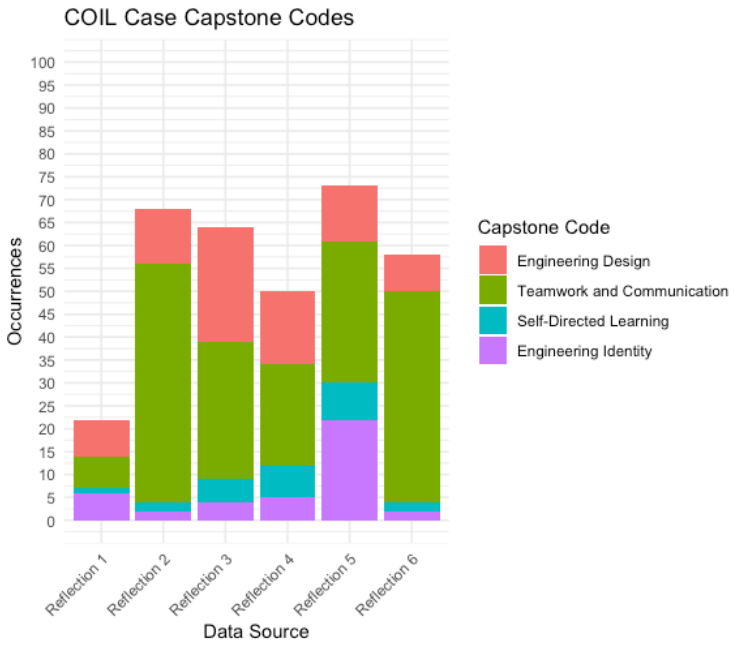

Figure 6.2: COIL case capstone codes

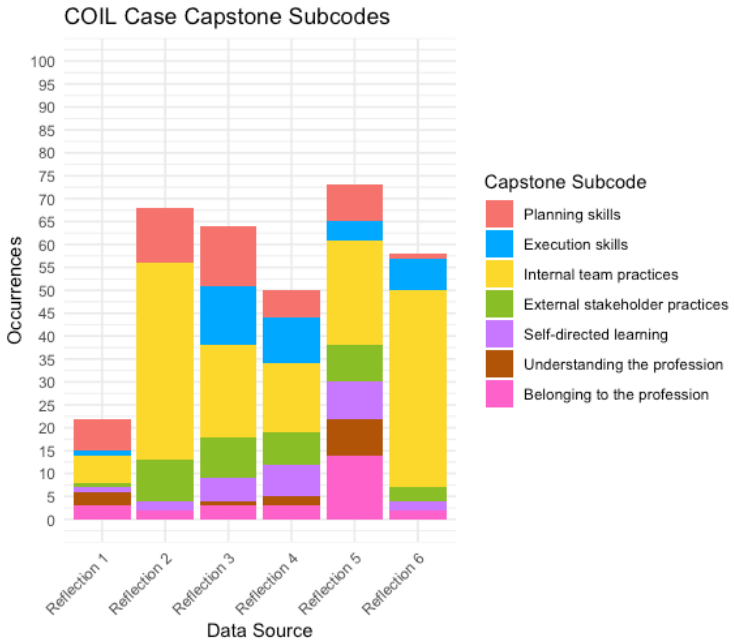

Figure 6.3: COIL case capstone subcodes

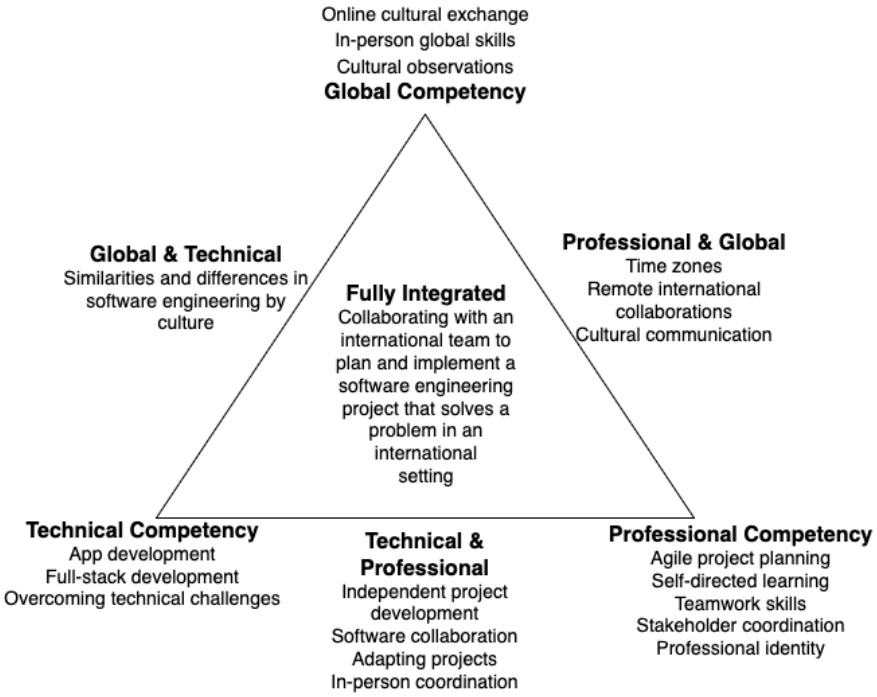

Figure 6.4: COIL case GEC diagram

Table 6.1: Relationship between competencies and capstone coding

Codes	*Planning Skills*	*Execution Skills*	*Internal team practices*	*External share-holder practices*	*Self-Directed Learning*	*Understanding the profession*	*Belonging to the profession*
Technical		X	X		X		X
Professional	X	X	X	X	X	X	X
Global			X				
Professional & Global	X		X	X			
Global & Technical		X				X	
Technical & Professional	X	X	X	X	X		X
Fully Integrated			X		X	X	

to spend ten days together.

During the semester, there was a weekly course meeting across programs. These were difficult to schedule with time zone differences and academic calendars. The U.S. students were all in a room together in person and the students from other countries joined online. The projects were proposed by the Swiss professors who provided feedback, and the U.S. professor gave academic feedback as well. The first part of the semester, during which the first reflection was completed, was spent on Agile, problem formation, and team formation and bonding. Agile methods are a common computer science design guideline. Approximately half of the students had previously had an industry internship. Several students said Agile was used during their internships, but the students did not necessarily understand what was happening and why. Students appreciated formally learning the Agile process from class.

After the design problems were selected, the teams set their goals and schedules for three concentrated periods of work, known as sprints in the software engineering industry. Professional competencies were the most frequent as students coordinated with their teams and stakeholders, and adapted to self-directed learning. Technical outcomes included app development, full-stack development, and overcoming technical challenges. The students did not spend as much time talking about purely technical learning as they did professional and cultural aspects.

Challenges arose from both the online and international aspects of the course. Since the collaborations were remote, students needed to make sure they were communicating clearly and frequently. They had to divide the work in a way that it could be accomplished and integrate all the parts together at the end.

Navigating cultural differences also required careful communication and flexibility. The universities had different semester schedules, and the Egyptian students celebrated Ramadan.

The instructor said that this was an opportunity for students to become more aware of Professional and Global interactions. When there were team issues, he encouraged the students to not make generalizations, which they seemed not to do. An additional aspect of Global learning was cultural presentations in class, where each team was assigned to present about one of the students' universities, cities, or countries.

After the semester, the students from Egypt and the United States traveled to Switzerland for the in-person portion. The final sprint was five days long and took place at the U.S. university's international study abroad center and the university in Switzerland. Each day had two three-hour academic course blocks from nine to three, and then free time for working on the projects or exploring the local area. For the final sprint, students needed to finish their projects and prepare a presentation in which they would demonstrate their product to their peers and stakeholders. As the students completed their projects, the faculty instructor observed that the removal of the logistical barriers of working online were eliminated, which allowed the students to focus on the technical engineering aspects.

All the groups had their final presentations for the clients and faculty at the Swiss university. The faculty instructor and graduate assistant were satisfied with the final projects. The GA was from a non-software engineering field, and she asked questions when students used inaccessible technical terms or abbreviations during their final presentations to encourage them to make their projects accessible to multiple audiences. Their projects included some global perspectives. For example, one group made their website available in Arabic, English, and Italian. Arabic is written and read right to left, so it cannot be solely translated. The website's layout has to update.

After the presentations, the students from all three countries traveled together for five days of excursions. The goal of the cultural presentations were to prepare students for the excursion portion of the trip. The instructor was able to refer back to the presentations as they

traveled and students' preferences were taken into consideration. The final reflection was done before the excursions, but the instructor and graduate assistant shared that students saw cultural sites in Italy in Switzerland. Public transportation and diet differences, as well as the natural beauty of the area stood out to students. They were able to compare Italian-speaking Switzerland to Italy and learn more about each country's culture. The excursions also included engineering portions. The group traveled to Milan and toured Politecnico di Milano to hear about their engineering department and research.

The students quickly bonded with their peers from each country when they were able to meet in person. The Swiss students guided everyone as they explored the area during their free time. Students said that they enjoyed becoming friends with one another and learning more about their cultural backgrounds and differences. When compared to communicating online, they appreciated the opportunity to share meals and laugh together as they experienced a new experience and location for both the United States and Egyptian students.

6.2.4 Student Summaries

Table 6.2 includes a summary of the participants in the COIL case. An overview of each student's experiences and learning follows. Appendix C.3 contains the details of their coded data.

Selena was in a group with Willow, working on a project for the international study abroad center as their stakeholder. Several times, she said that her project was behind schedule. This was impacted by their decision to split up the project and because they had to pivot their plans and goals based on their stakeholder's preferences. Next time, they would plan to meet with the stakeholder even more frequently and work to find a unified vision. Selena's most frequent competency was Professional, followed by Global. There were no Technical

Table 6.2: Overview of COIL students

Pseudonym	Project Team	Gender
Selena	Team A	F
Willow	Team A	F
Michael	Team B	M
Lila	Team B	F
Andrew	Team C	M
Ryan	Team C	M
Joshua	Team D	M
Benjamin	Team D	M
Alessandra	Team E	F
Zara	Team E	F

competencies discussed in her reflections. Her Capstone codes were focused on Engineering Design and Teamwork and Communication, with both internal and external shareholder coming up frequently. Her favorite part of the program was building relationships with her teammates. Selena's most significant learning outcomes were communication, how to work towards stakeholders' needs, and cultural differences in software engineering.

Willow was in the same team as Selena. She offered background information that she grew up in a wealthy area and was excited to work with an internationally diverse team for the first time. Willow discussed learning about Agile processes, coordinating remotely, and app development. This was reflected in her competencies developed: most frequently professional but additionally Technical, Technical and Professional, and Professional and Cultural. Her reflections included all the Capstone codes, as her team learned how to manage a large, technically complex project. She was happy to build relationships, learn about other cultures, and see that even a large project can be accomplished with committed teamwork.

Michael was working on the same team as Lila to design a math education game. Earlier in the semester, his reflections focused on project planning skills, coded with Engineering

Design, Professional, and Technical and Professional competency. His team had one member drop the class, and the remaining members prioritized setting expectations and communicating. He learned about Agile processes, breaking down a complex project into manageable milestones, and prioritizing users' needs in technical decisions. Michael found the pre-trip presentation helpful and he gained Global competencies as he prepared himself for the cultural experience and trip abroad. During the semester, his team connected by playing games instead of only working. He wished they had done that more and enjoyed traveling to a new country with the Egyptian students. The tour of the Swiss university stood out to Michael and he learned about the university's research and curriculum.

Lila worked with Michael on the math education game. In the first reflection, Lila set a goal of creating a software engineering project from scratch with a team. She returned to this initial goal throughout the semester. For the planning stage, Lila got to know the strengths of her team members and they created goals for the project from the perspectives of the users. They overcame the challenge of misaligned expectations and were able to adapt their project throughout with Agile methods. From a technical perspective, she gained experience in game design and programming. Lila said she met her initial goal as they accomplished what they set out to do through communication and teamwork, and she had a more positive experience with working with teams than at her previous internships. Every code in both frameworks appeared at least once in her responses, except for Technical and Cultural. The most frequent were Professional competencies and Technical and Professional. Within the capstone framework, she discussed Engineering Design Planning skills early on, then transitioned to Execution skills. Internal team practices were also frequent.

Andrew was teammates with Ryan, working on a project to use AI and computer vision to identify Lego pieces. He placed a high priority on Technical learning during the course, and technical challenges were significant during the project. Other notable incidents were

learning how to coordinate remotely and distribute the workload. Even though he is on a different team than Selena, Andrew's group also planned to divide tasks by time zones but found that more collaboration was a more effective plan. He perceived that coordinating across cultures improved his professional skills, and he saw how much was left for him to learn as a computer scientist. Professional competencies were the most frequently mentioned in his responses, followed by Professional and Cultural integration and Technical. Engineering Design and Teamwork and Communication were still significant in his Capstone codes, but a unique feature was that Self-Directed Learning and Engineering Identity were discussed regularly. One of the two was in every reflection except the final one, so they were spread throughout the semester. During travel, Andrew had good interactions with his team, but it did not challenge his understanding of them or the project. He learned about culture and what to ask to understand a new culture in the future.

Ryan was working with Andrew on the Lego AI project. Ryan actively selected team members who had experience with AI because his goal was to gain technical experience and learn about the impact of culture on software design. He took on the task of designing the app, which was a new experience that he ultimately succeeded at. During the first part of the course, he learned about Agile methods but wished that his group had planned their project to more detail. A Swiss student in their group ended up dropping the class and they were behind on their work by the time they had a client meeting with the instructor. These difficulties, along with coordinating internationally, were learning experiences that gave him professional confidence for the future. The result of his initial goal for the course was that Ryan learned that programming is similar internationally. The most common competencies were Professional, Technical, and Technical and Professional integrated. There was cultural integration in the final semester reflection. Teamwork and Communication both internally and externally were the most common for Capstone codes. In Switzerland, his team worked

hard to finish the project, including an overnight work session. He included an Egyptian student in his final reflection, and they were joking and said they enjoyed working together.

Joshua worked with Benjamin on an AI chatbot that can be added to hospitality industry websites. He was comfortable with back-end programming and had some struggles with front-end work, which did not advance to Technical competency development. He learned about Agile methods and his team communicated well. They finished their project before traveling abroad, which was unique among the groups. His team struggled to collaborate instead of just dividing up the work. Joshua did not gain a new perspective on the field of computer science. The most frequent competency was Professional, then both of the Professional integrations. His Capstone codes were about Design and Teamwork and Communication. When abroad, Joshua observed cultural differences in the food and pace of life. He was glad to become friends and found it easier to learn from his teammates in person.

Benjamin worked on an AI chatbot project with Joshua. He began the course with a goal to learn about cultural differences in the workplace and significant interest in other cultures, already saying that he might want to live abroad. His team learned how to communicate and coordinate across time zones, and designed a structured workflow with Agile methods. Benjamin continued to emphasize learning about culture and said that hearing about the similarities between his experiences and the Egyptian students was one of the most significant experiences. Professional competency and its integrations were the most common, and Benjamin said that his team coordinated well and stayed organized. All the capstone codes appeared, with Teamwork and Communication as the most common. For Engineering Identity, Benjamin said that he learned that he can never know everything about the field, but he gained confidence and understood the importance of Self-Directed Learning. He enjoyed meeting teammates in person, and they re-solidified their goal for the project. He would try to become friends earlier in future collaborations.

Alessandra worked with Zara on a website for a hotel in Switzerland that would include an AI chatbot. Their team faced challenges with working online and internationally. It was difficult to work separately and coordinate across time zones, but they overcame this challenge by planning the project with Agile methods. One student dropped the course and another was difficult to get a hold of, but the students tried to keep communicating with them. Alessandra learned new technical skills and practiced merging code online, but there were some code conflicts. Her most common competencies were Professional, Technical, and Professional and Cultural integration. She described technical abilities and coordinating a project with a team as the most important takeaways. Her Capstone codes were primarily Teamwork and Communication, then Engineering Design and Engineering Identity were also significant. Alessandra was happy that the project worked, and she was able to understand the context better when she visited the hotel in person. She also built more personal relationships when traveling and wished they had met more on Zoom instead of voice calls.

Zara worked with Alessandra on a hotel reservation website, with the goal to improve her knowledge of AI and Machine Learning skills as she contributed to the website's chatbot. She appreciated the opportunity to work with a real client, and meeting the stakeholder was a significant experience as they aligned expectations between the client and all the team members. Some challenges were communicating, splitting up the project, and time management. A couple of her teammates were difficult to get a hold of and they had to practice more active communication for the virtual environment. Her competencies were primarily Professional and both of its integrations as her team worked to coordinate the project. Teamwork and Communication was the most common Capstone code, but Self-Directed Learning was also a notable code. Zara said that she felt less prepared to enter the workforce after the course, but excited to continue learning. In-person, she had fun

working on the project and learning about cultural perspectives on engineering. She liked experiencing a new culture as a group.

6.2.5 Summary of Codes and Subcodes

Technical competency: Students learned software engineering technical skills from working on the project. They were able to put themselves in positions to gain targeted technical learning outcomes by their project choice and role within the team.

Professional competency: The experiential, team-based aspect of the project led to professional competencies.

Global competency: There were some cultural observations made by students, particularly when they traveled to Switzerland.

Technical and Professional: Students learned competencies that are relevant for working on computer science teams, such as organizing projects based on given requirements, pivoting to satisfy stakeholders, and coordinating large projects across team members.

Global and Technical: A couple students said that they learned about software engineering abroad, but they did not specify what was different.

Professional and Global: The online remote collaborations across time zones led to some professional and global competency development.

Full Integration of Technical, Professional, and Global: A few students learned specifically how to collaborate with international colleagues on a software engineering project in a way that integrated all three competencies.

Other Learning: Students built relationships with their U.S. and international peers and saw how relationships are formed differently virtually and in-person.

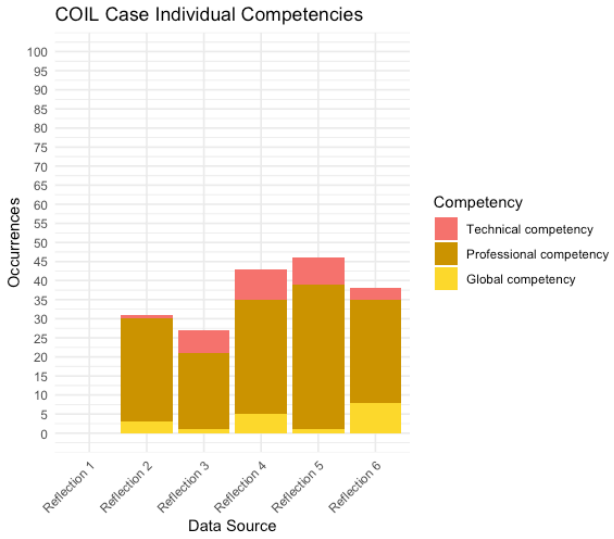

Figure 6.5: COIL case individual competencies

6.3 Individual Competencies

The COIL case's most common individual competency was Professional, as seen in Figure 6.5. Technical and Global competencies were less frequently coded but still present throughout the case. A detailed report of the themes that emerged in each code follows.

6.3.1 Technical Competency

There were several areas of software engineering that students became more familiar with. Some specific technologies that students mentioned were: React, TypeScript, GitHub, Godot, Visual Studio Code, C#, Ngrok, Django, and more. They devoted more time to talking about app development, full-stack development, and what they learned by overcoming technical challenges.

App development

Several students cited learning how to make mobile applications as one of the most significant learning outcomes. Andrew said that app development experience would help him in future jobs:

> I feel like this project gives me a chance to really dive deep into app development, getting a chance to experience what it's like to make a fully working product, and then later, maybe in the future, I'll apply these skills one day towards [a] job. *Andrew, Reflection 2, Technical*

Willow advanced her Android Studio skills through Self-Directed Learning and seeking out relevant resources and experiential learning.

> I feel like being able to learn Android Studio during this project has made me a better coder and has also revived a part of the learning process that I forgot about. And this [aspect] is learning through actual experience and not just learning in a school context. Since this class does not dive deep into the specifics of coding, you really have to learn it by yourself. *Willow, Reflection 4, Technical and Self-Directed Learning*

Ryan said that app development was unexpectedly different and he enjoyed the new experience.

> Initially, I assumed [Android app development] would be fairly similar to web development, but I am learning that is not the case. Using the Android development studio has been very different than using just coding regular HTML...

> it's been really fun. And I've enjoyed getting to learn something new. *Ryan, Reflection 3, Technical and Engineering Identity*

Familiarizing themselves with a new programming project helped students to practice teaching themselves and prepared them with applicable skills for their future careers.

Full-stack development

This course was an opportunity for students to practice full-stack development. Lila talked about building on prior experiences of back-end development:

> [Experiencing] full-stack programming in a more fun way since creating a game is a very different set of criteria than what the usual programming that we do, which is usually mostly back-end... I get to experience a whole different way of programming, a whole different world almost. *Lila, Reflection 4, Technical*

Alessandra discussed how implementing the full-stack of a project increased her self-efficacy as a computer scientist.

> I felt like the project I was working on in this class really helped me become an expert on [user interface programming] skills and prepared me to do full-stack development in the future, whether it's from scratch or a preexisting code, it showed me how you can solve problems when you're building a website. *Alessandra, Reflection 5, Technical*

Since the project was done from scratch, students could do full-stack development if that was an area they wanted to improve in.

Overcoming technical challenges

Andrew described a critical incident of a specific technical challenge his group had to overcome. They wanted to do a project related to categorizing LEGO pieces based on Artificial Intelligence. Training the AI was difficult. He said:

> In order to actually [overcome] this challenge, we have to either design some kind of novel approach, or use our own photos to train a machine learning model… We are going to try exploring both approaches. If our easier approach of taking photos of ourselves doesn't seem to work well enough, then we'll make our own model using 3D images of Lego pieces that we synthesize. *Andrew, Reflection 2, Technical*

Andrew's teammates were able to help him find an easier solution and they created their machine learning algorithm.

> With the help of some of my teammates, I was able to discover certain tools online such as [a computer vision tool], for instance, and certain APIs that I could integrate to help make my life a little bit easier while labeling these images… And now combining these two tasks, using the API to do a preliminary labeling of images, followed by using [the computer vision tool] for a more formalized, complete data set, we were able to really speed up the process, and overall I think it was a great learning experience for me. *Andrew, Reflection 4, Technical*

Students had to try different methods to overcome challenges as they worked on a real-world problem.

6.3.2 Professional Competency

The most common competency appearing in the data is Professional. The Professional competencies were often associated with the a priori Capstone codes: project planning, internal and external communication, self-directed learning, and professional identity. These codes are tracked in Figure 6.2.

Professional outcomes were associated with students' work within teams, communication with stakeholders, and project planning. Alessandra touched on several professional aspects when she summarized near the end of the semester what she wishes she had done differently:

> It helps if you're able to start [work] early because there's many members in the group and if you all work on it last minute, it's hard to get feedback. And because we're working in an iterative [cycle], we want to be able to get feedback and keep making it better until the product aligns with what the client wants. *Alessandra, Reflection 5, Professional*

The structure of the course around engineering project development encouraged Professional learning.

Agile project planning

Agile software engineering methods were the framework for students' project planning, organization and development. Eight of the ten students explicitly talked about Agile. One of the students who did not directly mention Agile discussed story points, which is a part of Agile development.

Students spoke favorably about their experience with Agile. Two students compared the course's use of Agile methods favorably to their prior experiences.

> I think the most valuable thing I've learned in this course is I've learned a lot about Agile development... The two companies that I interned at did Agile development very differently. The first one I interned with did it very strictly and followed Agile very meticulously, while the other company that I interned at didn't really focus on Agile very much and kind of just used the buzzwords but never actually did anything with them. And so I feel like learning it from a classroom standpoint really helped me get the grasp of what Agile is and why it's loved by many companies and many managers and teams. *Willow, Reflection 3, Professional*

> I fell behind a lot over my internship because I was too afraid to ask people for help… [In the capstone course], my peers were so willing to help me out with stuff, hop on tasks with me, look at my progress, ask me for my input on their progress and stuff like that. It was a way more positive experience and it made me a lot less afraid almost of tackling big projects and doing big development and software. Because before I was a lot more timid and a lot more afraid and I tend to need a lot more green lights as I'm going through something to make sure that I'm on the right track. *Lila, Reflection 5, Professional*

Implementing Agile methods led to broader professional learning for some students. Lila learned about flexibility and openness to changing projects as new information is gained, and planned to transfer this knowledge to her future career.

> The Agile framework allows you to step back and make changes and keep making updates to previous steps, while still continuing to make progress based on what you know as you get further into the development process. And so getting to see

> that was really nice because especially going into the workforce, it can be intimidating to feel like you're stuck within some rigid model that was created before you knew what you know now… I'm definitely seeing how the Agile framework is different than the standard one step at a time waterfall approach that we think about when we think of developing software. *Lila, Reflection 4, Professional*

Benjamin learned more about product iteration because of its fundamental role in the Agile framework. He also connected this knowledge to future work

> Something I really liked about Agile is that it allows for small iterations of the product to be made and verified before moving on to the next step... I know that Agile is very popular in the industry and having this extra practice with Agile methodologies will help me fit right into whatever software development project I take on in the future. *Benjamin, Reflection 4, Technical and Professional, Professional, Engineering Design*

Specific aspects of Agile development that other students found helpful included burn up-/burn down charts, requirements analysis, user stories, personas, planning sprints, Jira story points, and assigning tickets. No student said that they left the course with a negative impression of Agile methods.

Self-directed learning

Self-directed learning was an a priori Capstone code that showed up in the project management discussions. Willow learned about time management and her own preferences for work from the project management experience and compared the self-directed learning to previous classes.

> I feel like this class gives you a lot of leniency in how you can approach things and approach deadlines. And I think that's very important to me because I am able to work on this [project] when I am most free and I am able to put in my best work and be in my best headspace. And I think that's very useful to do because without being able to learn by yourself, you would never be able to really get anywhere. *Willow, Reflection 4, Professional, Self-Direct Learning*

Zara discussed Self-Directed Learning in four of her six Reflections. In Reflection 2, she compared the course to her prior experiences:

> This is not your regular school project where you're given a very strict guideline and there's not much communication that needs to be done. For this type of project, I've recognized that a lot of communication needs to be done and that since it's a lot more open-ended, we need to learn to listen to each other a lot more. *Zara, Reflection 2, Professional*

In Reflection 3, Zara talked about managing her schedule to make progress towards deadlines with the multiple competing aspects of the project

> This was definitely one of my busiest semesters, so I think setting aside time for this class, and not setting aside time to just do the work for this class, but setting aside time to then meet with our client and then meet with other people in our group, I think was really challenging. And I think there were definitely times where there were parts that might have gotten mildly neglected from that. But I think [the way of] dealing with that challenge was setting many goals for myself. *Zara, Reflection 3, Professional*

And in the final reflection, she discussed her progression in the skill of following self-imposed deadlines, saying that she wish her group had figured out a better system:

> I think in any project, you have your external deadlines which [are] given by a client or teacher, boss, whatever, but I think the important part is having internal deadlines so you know where your own group is at, and I think that's something we originally struggled with... and we'd just be ready for the main deadline, but then we'd be struggling to integrate everything at the end. *Zara, Reflection 6, Professional*

The instructor had scheduled the first few weeks for planning, but students had to set their own internal deadlines and their project schedules. This was an important time to practice independence in engineering projects.

Teamwork

Completing a project in teams is the main focus of this course. Multiple aspects of teamwork were significant to students, including creating positive team norms of behavior, communication, and division of work.

Team norms of behavior

Students had positive perceptions of their team members throughout the course. They said that team members were respectful. One assignment in the course was the team charter, which asked students to define expectations for values and how to work together. Students found this effective in setting expectations. Andrew talked about making compromises to ensure that everyone's opinions are valued.

> I think it's important that you respect what everyone's saying and make sure to

> really take everything into consideration when making decisions that can impact the direction of any project that you're working on. I feel that our team has done a good job at this. *Andrew, Reflection 2, Professional*

Joshua discussed healthy communication during disagreements in his group.

> It seems like we're all open to hearing everyone else's ideas and catch along what people are thinking. So maybe one person has a certain point of view on something, and then someone else is comfortable enough to reach out and say, oh, in my experience, that hasn't been the case. So you can see the differences in people's perspectives without being afraid of being attacked, which is very cool, because that at least is more productive conversations. *Joshua, Reflection 2, Professional*

It was important for the students to have expectations for healthy interactions as they worked with new people across multiple universities.

Communication within teams

Internal team practices are a huge component of this course and the most frequent capstone code. One of the first decisions was how to communicate and update remote team members. Selena said that her team improved in their amount of communication throughout the semester, but they could have done better from the start:

> I think if I could start over, I would definitely make sure that we communicate better and give each other progress updates more frequently than we did. I do think we definitely improved a lot over the semester, but I think that would be nice to know going into the semester to begin with so we could avoid any trouble that we faced. *Selena Reflection 5, Professional*

Joshua's team effectively utilized multiple platform for different aspects of team communication:

> But I can go over what our team does well. So when we have to share larger files that cannot be seen over text, we will utilize our Discord... If there's something that needs really close attention really quickly, the WhatsApp can [be used to] immediately reach out to any person in the group, and they will see it assuming they're not asleep. So that's actually really cool that there's two separate group chats that will allow for that kind of communication. *Joshua, Reflection 2, Professional*

Zara said that her team would have benefited from using multiple platforms:

> [In the future], I think I would just focus on having multiple modes of communication. We only had one or two, which was WhatsApp and Zoom. I think while that was helpful in the moment, I think after it would have been helpful to maybe have a Discord, or maybe scheduled meetings to meet up every week. *Zara, Reflection 6, Professional*

Students had to explore the most effective options for communicating within their teams.

Division of work

Distributing tasks for the projects often involved trial and error before students figured out a balance. Selena concisely summarized the progression that was done by multiple groups of initially dividing the work by country and later deciding to incorporate further collaboration.

> I learned that there's better ways of splitting work. Initially, we thought that because we're working on a team where we're all from different countries and

> different time zones, it would be easier to split it up so that no one's work really overlapped with each other's. But because we reworked the way we were splitting up our tasks, we realized that it's actually possible to take a more collaborative approach to the project. *Selena, Reflection 4, Professional*

Andrew's group's difficulty was in distributing work based on prior experiences and ability. In Reflection 4, he tied the experience to Professional competency of finding a different way to optimize the distribution of work other than experience. Their initial plan was to allow the people who had the most background in a task complete it themselves, but that left the less experienced members with little to contribute. Their new plan was to add collaboration to more tasks which lessened the burden on some members and helped others to learn more about software engineering. In Reflection 5, Andrew discussed the additional impact of time zone differences and integrated Professional and Global competencies.

> Basically after 6 p.m. every single day, I can't even personally contact my teammates in Switzerland or Egypt because they're fast asleep. So in terms of dealing with this challenge, what our group decided to do was we decided to split up our project into parts such that we made two main parts, the machine learning aspect of the project and the application and user interface aspects of the project. And we distributed our project such that people worked [together] in one time zone… And so we have this setup where there's always someone working on some aspect of the project no matter what time zone they're in. And if they ever need to ask a question about some aspect, they can go ahead and ask someone in a similar time zone. *Andrew, Reflection 5, Technical and Professional, Professional and Global*

The downside of this model from a program leader's perspective is that the U.S. students

are collaborating less internationally. Alessandra similarly discussed dividing up tasks and working independently on the project.

> We like to meet on the workday and then assign what we're going to work on. And if there's anything that needs to be done together and not asynchronously, we'll do that on the call. Otherwise, we'll just all complete our respective parts and get feedback from each other and then eventually turn in the assignment once we're finished. *Alessandra, Reflection 2, Professional*

Later in the semester, her group was more specifically coordinating through Agile but keeping the same process, which helped their global collaboration.

> I think that's been the biggest struggle so far, making sure we all are able to get our work done on time while also accommodating for the fact that we don't have communication with each other all hours of the day, since some of us may be asleep. So collaboration is definitely something that's harder, but I've learned that in Agile process you're able to split tasks by assigning tickets to certain people, so that we all do pieces of the project and then bring it together at the end of the sprint to make one final product, which I think is really cool that we're able to do in this global environment. *Alessandra, Reflection 4, Professional*

Joshua also said that distribution of work and completing tasks without delegation was the biggest challenge for his team.

> I still think that the hardest challenge that I've dealt with throughout this project is as a team really is figuring out how to properly delegate the work out between all of us. It seems like once someone gets something going, they kind of just

> finish it all the way through instead of maybe delegating it around it. *Joshua, Reflection 5, Professional*

Several teams were tempted to work independently and try to integrate all the parts at the end, but most groups found that collaborating was a better option.

Stakeholder communication

External shareholder practices was an a priori Capstone code and a significant learning opportunity for students. Benjamin discussed coordinating the vision for the project with stakeholders:

> Not all of us were at the same level understanding about the implementation requirements of the project. So when we got into meeting with our stakeholder, we were able to easily clear that up with him and he was able to demonstrate exactly how we intended the project to work and what he expected from us. So in general, communication allows for a united understanding of project requirements and tasks especially in a setting like this, and without it we wouldn't be working towards the same goals. *Benjamin, Reflection 3, Technical and Professional, Professional*

Alessandra had a communication disconnect with her project's stakeholder, which extended the timeline of getting on the same page.

> I would say one of the biggest challenges of this project is coordinating with our stakeholders as it's a business and obviously they get many emails a day... Another struggle was trying to understand exactly what she wanted for the

> product. We had some ideas that we pitched to her, but not all those ideas were something she wanted to see in her website, which is totally understandable because it doesn't cater to her needs, and it was interesting to see how to agree [on] what to design for her. *Alessandra, Reflection 3, Technical and Professional*

Zara was a part of the same team as Alessandra and presented the stakeholder interactions more positively as a growth opportunity. She was happy to have the realistic experience of working with a stakeholder and took away professional competencies.

> I never met with a client to see what they had wanted in past internships... This [project] was very much you meet with your client on your own terms, you're the leaders of this, you are your own group, this is your client, meet with her, find out what she wants and execute it. So I think that was something I found really helpful because it's something that I'm going to keep on encountering in my life, in my career. And I learned a lot about workplace professionalism, if you can call it that, learning how to interact with a client, listening to their requirements, building off their requirements, proposing our own ideas in addition to that. *Zara, Reflection 4, Professional*

Midway through the semester, the teams presented their projects to the instructor. The professor's feedback was illuminating to the groups about the technical work and how to approach professional meetings. For Ryan's group, there was a mismatch of what students thought would be best to present and how to answer the questions

> Last week we had a [team] meeting with the instructor. And my team thought that this was going to be like a sprint one update, telling the work we've done and showing the code. But our surprise, he actually wanted us to have a client

> meeting… It's really a lesson in making your work understandable for all people. You can't expect the people you're talking to to necessarily know programming or anything related to anything but just the visual front end, which they want to see. So it would be much better if [we] come in with even a wireframe or something like that, because then they can at least visualize what we're working on. *Ryan, Reflection 4, Professional*

Interestingly, Ryan had said in the previous reflection that creating wireframes and presenting the project were a goal of his team, which would have been what the professor wanted in the meeting:

> I think one thing I'm realizing right now what we need to do differently is we jump straight in and just making the application, so the problem with that is I'm going to make a lot of user design choices, UI front-end choices, on the fly because we didn't go through the step of actually making the wireframe first… I think we should stop for a second, create the wireframe, present that wireframe to the client, have him write off on it and approve that that's actually what he wants it to look like and that'll be good to go. *Ryan, Reflection 3, Technical and Professional*

Since this was a formative assessment, students were able to pivot and get back on track. For all groups, the interactions with a real-world stakeholder was a valuable experience, with an additional layer of coordinating remotely.

Professional identity

When asked if this course changed how students viewed themselves as software engineers or the field of computer science, most students said that they had learned transferable skills or their perception had not significantly changed. One notable response was Benjamin's comment about overcoming imposter syndrome.

> I tend to doubt my abilities or have imposter syndrome very often, and I believe this is just due to the vast amount of information technology in the computer science field. Knowing that I can do whatever I put my effort and mind to is something that is reassuring to me and helps with my confidence. It is normal not to know or not to understand something immediately or just take longer time to learn it and obviously you can't know everything, but as long as you set your mind to a task and focus on it you can accomplish whatever you want. *Benjamin, Reflection 5, Professional, Engineering Identity*

In contrast, Zara became more aware of what she does not know. She still said she was glad to learn about gaps in her knowledge and to gain competency in some of those areas.

> This course definitely changed how I view myself as a computer scientist, in the sense that I think I feel a lot less ready for the industry than I thought I did. I think this course definitely prepared me for what industry is more similar to... and I think it made me realize how much I didn't actually know until I started doing it. So in that sense, I felt underprepared going into this. I'm coming out knowing more, but then feeling a little bit more overwhelmed, but excited. I learned a lot of new things. *Zara, Professional, Reflection 5, Engineering Identity*

The COIL capstone exposed gaps in students' knowledge. Overcoming these challenges helped prepare them to be professionals in the industry.

6.3.3 Global Competency

Global competency was most commonly discussed in reflections 4 and 6. Reflection 6 was completed mid-travel. Students made some cultural observations from the course, their teammates, and their program abroad.

Preparation for travel

One course meeting was a travel preparation presentation with a guest speaker. It included a travel overview with specifics about Swiss culture and a discussion of culture shock. This presentation stood out for one student's cultural competency development but was not discussed by the other students. Michael stated:

> The [travel preparation] presentation was helpful and that it helped me to learn more about the country, the history too. And also the language, culture, and also to help me prepare what to pack... The other thing that I really liked during the presentation was she kind of gave us an insight on culture shock and that it's okay, because we're going to a different country, so things might not be the way they are here. But to support each other. So if one is kind of feeling overwhelmed, which she told us that it's okay to be overwhelmed as soon as we get to the airport, but when one feels overwhelmed, not to judge them, but just to be like, it's okay. They have a support group. *Michael, Reflection 4, Global*

Though it did not appear significantly across students' reflections, the travel preparation

session provided students an overview of what to expect during the time abroad.

Online cultural exchange

In the first reflection, some students said that their biggest goal from the course was to gain cultural competencies. Willow talked about her prior background, primarily involving interacting with Americans:

> In [U.S. institution] specifically, there's a lot of people from where I grew up. And so while I do see diversity in the people that come here, there's not that much diversity for what countries people are from. I want to specifically work with people that live in different countries and get guidance on how they live their life and how it differs from mine, because I believe that this gives us a better perspective on how the world really works. Instead of being sheltered in a college campus, I'm able to expand my knowledge on other cultures and other people's experiences and how they do their day-to-day life, which can differ vastly. *Willow, Reflection 1, Global*

At the end of each course meeting, students would give a cultural background presentation about their university, city, or country for the United States, Egypt, or Switzerland. The faculty instructor described how these interactions provided an opportunity to understand each other's cultural backgrounds.

> Even within the three countries, they're coming from many different places... how people do stuff, how people eat, how people drink, how people say jokes. I have been watching so many conversations about students just sharing how different things are or how similar things are. *Faculty Interview*

By Reflection 3, Willow said she had taken advantage of this opportunity to learn about the range of backgrounds of her group members.

> I also think that one of the most valuable things I've learned from this capstone class is that I am able to be friends with people from other countries, which is an opportunity that I typically wouldn't have had. I think that this is really interesting because I am able to talk to new people, see the cultural differences... most times when you meet new people, since they grew up in the same environment that I have grown up [in], it's very easy to get along with people and you don't really find that many differences. But talking to people from who have lived, who were born, grew up in, and continue to live in that in different countries really opens up a new world to the possibilities of what you can learn. *Willow, Reflection 3, Global*

Benjamin discussed lifestyles and hobbies with his team members as well and discovered similarities to his own background

> Throughout the semester, we have been learning about the different countries everyone is from. Specifically we have heard from [Egyptian students] about their experience living in Cairo. And it was just really interesting to see how similar Cairo was to some of the cities we have here in the United States. [Egyptian student] described how Cairo was the city that never sleeps, which I thought was funny because that reminded me of New York City... I learned that even though we are from very different parts of the world, we still generally enjoy the same things. For example, [Egyptian student] talked about how video games are very popular in Cairo. They even have dedicated lounges for video games, which I thought was pretty interesting. This is important because video games

> is something that I grew up with and it basically shaped the person I am today. And I realized that even though we are thousands of miles apart, we are very similar and enjoy many of the same things, which is pretty meaningful to me. *Benjamin, Reflection 4, Global*

Students began to learn from and about one another during the online portion.

In-person cultural exchange

Students had more cultural observations once they traveled to Switzerland. Several students had similar reflections about discussing their team members' backgrounds. Lila and Michael were members of the same team:

> It was really cool to meet everyone after seeing everyone on Zoom and working with everybody through Discord… I learned a lot about not only Italian culture, since we're in the Italian part of Switzerland, Italian culture as well as what's in Egyptian culture to an extent. So a lot of our [team] are from Egypt. So when I was talking to one of our friends, getting to see the different hand gestures and stuff like that, and her teaching me some of the phrases that they say that are really common. *Lila, Reflection 6, Global*

Michael discussed learning from his team members about their education system:

> It was great to see everybody coming together, the people from Egypt and our partner from Switzerland and us just meeting up all one place. It was good to finally see each other. And when we met up together, we talked about our experiences, how things are in each of our universities. *Michael, Reflection 6, Global*

Andrew had a similar experience when he met his teammates:

> In terms of what I learned on this travel experience, I really had a chance to learn about different cultures and really get to know about people and their backgrounds a lot more than I did when I was interacting with them virtually. And so overall I've had just a great time learning a lot about people's cultures and just meeting them. *Andrew, Reflection 6, Global*

Students made firsthand cultural observations once they met in person and had more time to share with one another.

Cultural observations

Students made a few cultural observations about Switzerland. For example:

> I learned that [in Switzerland,] they actually serve anchovies on pizza. It's actually insane. That was actually so exciting. I was so excited for that. I'm kind of geeking out a little bit. That was great. That was awesome. It was so salty. I don't know about the olives though. Maybe the olives don't need to be on there. But the anchovies, that went hard. *Joshua, Global, Reflection 6*

> So in Zurich, that is the German part of Switzerland, you can definitely see there's heavy German influence and everyone speaks German. It was just really cool to see that right off the bat. *Benjamin, Global, Reflection 6*

Possibly because of when they recorded their final reflections, there was not significant cultural learning about Switzerland across all of the students. The excursion portion of the program took place after the final reflection.

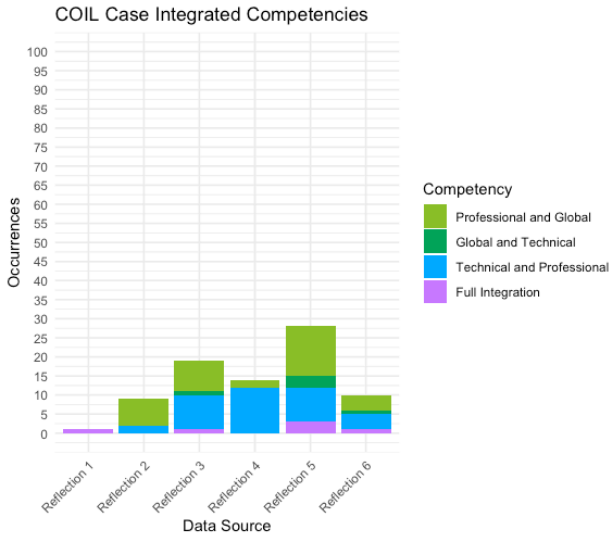

Figure 6.6: COIL case integrated competencies

6.4 Integrated Competencies

Integrated competencies that included Professional skills were the most common in the COIL case, as seen in Figure 6.6. Integrated Global and Technical and fully integrated were much less common. Quotes and emergent themes for each competency integration follow.

6.4.1 Professional and Global

Professional and Global competency was frequently integrated as students worked in international teams. The competencies they developed were different during the remote work and in-person portions of the course.

Time zones

Every student mentioned time zones as an aspect they were required to accommodate in their collaborations. Sometimes it was the main topic for discussion and sometimes it was

a component of a larger discussion of online collaborations. Following is an example from Joshua of how it was a frequent but not overly difficult issue:

> I've definitely learned what it's like to have partners that have a six-hour time shift from my current time. It's definitely a factor. It doesn't make it unbearably difficult, but it's certainly something that I've had to think about when scheduling meetings or times to meet up and such. *Joshua, Reflection 5, Professional and Global*

Willow discussed the added cultural dimension of students' observation of Ramadan:

> Recently, we've been having a lot of assignments and it takes a lot more effort to actually find a time that works for everyone. And with Ramadan and other cultural differences, we have been having a harder time to find times to meet. But fortunately, everyone in my team is very well versed in just getting overcoming challenges and obstacles that we are still able to meet up, find times, and everyone is very flexible. *Willow, Reflection 3, Professional and Global*

As discussed in Section 6.3.2, some teams divided their tasks based on time zones:

> We're trying to organize it so that people in similar time zones are working on the same tasks together. So Michael and I are both at [U.S. institution]. And so it would be really easy for us to sit down and do buddy programming and work on a big task that way. And same for [Egyptian students]. But [Swiss student], he's on his own in Switzerland. So it's going to be interesting to see how we split up user stories and tasks based on time zones, based on work. *Lila, Reflection 3, Professional and Global*

Zara also said that the international nature of the course and time zone differences forced her to be more intentional in her team communication:

> I think working with people that are across the ocean has really made me become a better communicator because I know it's a lot more necessary. I can't just say "Hey, let's meet up and get this done." We have to take into account time differences and a lot bigger different schedules, so I think communication in a team setting has become a lot better… We're willing to communicate even after hours and not afraid to share our ideas and have a conversation, not afraid to have a conversation over text to make things move faster instead of just over Zoom meetings. *Zara, Reflection 3, Professional and Global*

The time zone differences impacted the coordination of meeting times, frequency, and ease of communication.

Remote international collaboration

This course had the goal of preparing students for future global collaborations. The faculty instructor said that this project provided a low-risk experiential learning environment for students to experience the difficulties of the workplace.

> Many software development teams are currently international and they work with partners and clients around the world. So I think it's a benefit that students got to experience this, making all the mistakes and trying to learn more about how this might work so that when they get into the real job market, it's not something new. I've seen many of them ask me to write recommendation letters for them.

> They wanted to highlight this experience as something that they did because they believe it would be beneficial for them in the future. *Faculty Interview*

Students' responses indicated that they were facing new collaboration challenges. Zara said that communication continued to be the most significant learning outcome. She compared the intentionality required to work remotely instead of in-person.

> Working with people from other countries made me realize how important communication is, because you're not going to have time to just talk to them after class... You have to set aside time and meet with them on Zoom [since] you can't meet with them in person. And you have to make sure what you're saying over text or in Zoom is conveyed properly because you can't just meet up at a coffee shop and then hash everything out at once... it's a lot more challenging than that. So I think good communication was one of the biggest things I've learned from this course. *Zara, Reflection 5, Professional and Global*

Alessandra discussed the challenges of collaborating online remotely multiple times during the semester. In Reflection 2, she talked about finishing the group's work early to ensure that everyone could review the assignments:

> We have to plan ahead and make sure we get our things done in time, so all people from the different time zones can check in and make sure the work is good, and we're submitting our best work. And if, for example, if the U.S. people take too long and do it the day of, the Egypt and [Switzerland] people might be all asleep. So we have to keep that in mind and make sure we get our done work early. *Alessandra, Reflection 2, Professional and Global*

In Reflection 3, she said that time zones affected their coordination and submission of assignments:

> I believe the most valuable thing I've learned is communication and really knowing how to collaborate in a space where all the people in the group come from different backgrounds in different countries, and being able to manage your time, especially in an environment where we're all working in different time zones. All our assignments are due in the U.S. time zone, so the students from Switzerland and Egypt have to start ahead of time and then the students from [U.S. institution] would often times start a little bit later. *Alessandra, Reflection 3, Professional and Global*

And in Reflection 5, she said the remote collaborations was the biggest challenge of the semester with the additional element that the stakeholder client was remote:

> I would say the biggest challenge I've had on this project is working with people from different countries and different time zones. It's really hard to coordinate a time that works for everyone and a time where you can meet up and collaborate and make sure we're all on the same page... And this is not just for the students. I would say even with talking to stakeholders, it's a challenge to make sure we meet at a time that works for them. *Alessandra, Reflection 5, Professional and Global*

Students were used to collaborating in person, so they had to adapt to the online methods and ensure that they were delivering high quality work.

Cultural communication

A significant Professional and Global competency was cultural differences in communication beyond time zones and the remote environment. This was aligned with the faculty instructor's observation that students seemed more prepared to collaborate and find common ground with colleagues from different cultural backgrounds.

> I think many of [the students] commented that they feel more comfortable now talking to people from different countries, knowing that they will find some common ground. And even if there are major differences, they know that they can easily work around and find a way for them to get [projects] to work. *Faculty Interview*

Specific cultural aspects were not frequently discussed, but Alessandra talked about the strengths of working with team members who were multilingual:

> It's really great to have someone from [Swiss university] as well, as our professor said, some of the people who work [our project stakeholder] don't speak as much English as we do, and they might need some Italian translation, [so] is good to have somebody there. *Alessandra, Reflection 2*

A few students said they generally gained competency in global collaborations.

> This is a great opportunity, a great trip, and a great way to learn how to communicate internationally with students that have a significantly different background than I do. *Joshua, Reflection 6, Professional and Global*

> Oe of the most valuable things I believe that I've learned is this aspect of working with people who aren't in the same environment as I am... I'm not talking about just the fact that we're all students studying computer science, but I'm referring to the fact that we all come from such different backgrounds, different countries, different time zones, have different skill sets, are of different ages, and so on. I feel like this experience is a very unique experience that isn't something you typically get from a CS course... I think this aspect of collaboration and really getting to learn how to work with such a diverse group of individuals is a super, super valuable life skill to have. *Andrew, Reflection 3, Professional and Global*

Ryan said that he felt prepared for future global collaborations in the workplace, especially with stakeholders:

> It's good to have that cultural awareness so that if I do end up having to go move into a position where I communicate with stakeholders, I'll have that experience. And then also if those stakeholders are foreign citizens or from other countries, now I have experience working with other people. *Ryan, Reflection 5, Professional and Global*

Students' professional and global competencies included communication with teammates and stakeholders, and seeing the differences and similarities with students from different cultural backgrounds.

6.4.2 Global and Technical

Technical and cultural integration was the least frequently appearing competency, as seen in Figure 6.6. The faculty instructor said that software engineering practices are similar across

contexts, and students were observing that the engineering work was easy to coordinate, even if other cultural aspects were different.

> One thing that's interesting about software engineering is that the practices are pretty common in different countries. If you're writing code, it's very easy for them to speak technology. It's not that [dissimilar]. But then everything else, they start to realize how very different or very similar things are. *Faculty Interview*

Ryan's experience reflected what the instructor described, and he said that he learned about the international similarities of software engineering due to the common programming languages and approaches.

> We're realizing that everyone in the world runs on the same programming languages in computer science. We all speak English, but more so than that, the way they program is the same as the way we program. It seems to be universal throughout the three countries. We're using the same software tools, we're using the same languages. So it's a very unifying discipline in that sense. I think, no matter what country you're from, even if we didn't speak the same language, I think through the code, we'd be able to communicate with each other. *Ryan, Reflection 5, Global and Technical*

A few students said that they learned about cultural differences on technology and software engineering. None of the students shared what the specific insights were, with Selena's statement as an example.

> I know that going into this class and this project, I was really worried about how it would be to work with an international group, given our cultural differences

> and differences in our educational backgrounds, as well as just communicating virtually, but I think that meeting each other in person has really eased any concerns that I had, and I think that I learned a lot about how computer scientists work in different countries. *Selena, Reflection 5, Global and Technical*

The similarities in the field of computer science were significant to students as they realized they were able to collaborate on their projects

6.4.3 Technical and Professional Competency

Several of the experiences that were associated with Professional competencies also led to integrated Technical and Professional Competency.

Independent project development

The instructor and students anticipated building a software engineering from scratch as an important learning experience. The faculty instructor described this process as building significant self-efficacy for students

> [A significant outcome is] students learning on their own and knowing that they can actually build something from scratch and it can work at the end. It's something that they usually don't believe that they can do. So, building this confidence and believing that they can actually learn a new tool in this very short time and then put it into implementation and deliver it. *Faculty Interview*

Early in the course, Joshua's team struggled to move from project requirements to technical implementation. This was an early experience with self-directed learning.

> The biggest issue that I've dealt with this project is just knowing how to start it. It seems like based on our project description and the talks that we have had with the project stakeholder, it really seems that we have set guidelines of what we need the project to look like. We have set guidelines on what is expected of us, but as far as the overall presentation of the actual project, there is really no clear defined start of what's going on. We know what the end product should look like, but as far as actually getting to that location, there's a lot of unplanned ground between here and the final product that we have to figure out. *Joshua, Reflection 3, Technical and Professional, Engineering Design*

The process of building a project from scratch successfully built Technical and Professional skills and confidence in the field. Both Willow and Zara used the same wording (a project built from scratch) to describe their experiences

> I think [this course] has changed my view of myself because I am realizing that I am more capable of learning new tools and learning new applications than I thought before. And I believe it is a clear indication of talent when my entire team is able to deliver a product from scratch. *Willow, Reflection 5, Technical and Professional*

> The whole process of working on a project from scratch, from start to finish, there were so many more components that I'm not used to that I now have to think about because when we're getting projects from a regular class, there's base code, there's starter files, there's a framework to work off of. But for this, we had to make our own framework. We had to design that framework and then we had to implement that framework and then finally deploy it, which we're still in the process of. So I think that really opened my eyes to how intricate or how

> complex doing a project from start to finish is. *Zara, Reflection 5, Technical and Professional*

Creating an entirely new software engineering project was an opportunity to see the parts of the work that students may have taken for granted or never practiced implementing before.

Software collaboration

Students had to team-based issues that are specific to software engineering. These included code merging conflicts. One team took the approach of dividing the work between team members, which is not the best outcome for students' learning, since it is not a viable solution in computer science workplaces.

> Another challenge was also working on the same code base with many, many people. This makes a lot of room for error. When we're trying to all push different changes, we need to learn how to [handle] merge conflicts and make sure all the pieces that every single person in the group makes works together. I'd say that was a really big challenge that we've had so far. But to deal with this challenge, we just make sure we try to assign each other different tasks that are not touching the same pieces of code. *Alessandra, Reflection 5, Technical, and Professional*

Another team similarly struggled with work being replicated. During the final reflection, Ryan left the course with an idea for a more transferable solution of wishing that his team had used GitHub, which is used to merge collaborative code and save ultiple versions.

> We both did the same code, but just in different ways. If we were using GitHub, we would have seen that all the person was committing all that stuff. So we

> wouldn't have wasted that manpower. But now we know. *Ryan, Reflection 6, Technical and Professional*

Selena expressed a similar idea of integrating everyone's components into the final project. Her team successfully communicated and edited every part into a working project.

> Because we aren't all physically there in person to look at each other's progress frequently, it was a little bit difficult to integrate all our separate parts into one final working product and making sure that this integrated product is consistent across all our parts. We had to go back and forth a lot in changing each other's parts [of the code] to make sure that we have one cohesive working product. *Selena, Reflection 5, Technical and Professional*

Merging and integrating code can always be difficult for a large project, but the international setting and remote collaboration forced everything to be done remotely, leading to integrated Technical and Professional development.

Adapting projects

Two students discussed adapting during the project and what that changed for them technically and professionally. For Selena's group, new information from the stakeholder showed them that technical success is not enough for a good project. It has to truly meet the needs of the product's users.

> Our group had to work our project to fit the criteria that we got from meeting with [the stakeholders]. This experience was meaningful to me because it allowed me to recenter the goals and priorities for our project. And it emphasized that

> the product that we are building is something that when we design, we need to keep in mind that it's going to be used hopefully in the future years to come by the [International] Center. And so we can't just put together something that is going to work, but we need to create something that will have a lasting impact. *Selena, Reflection 4, Professional, Technical and Professional*

Zara's group had made their initial plans for the project based on a technical assumption that turned out to be incorrect. Her team had to use their technical knowledge to propose potential solutions and select a new path forward

> It was a WordPress website which meant that there was no editing existing code that we can do, and we were planning to make a website based on a React framework which would not interact… And I think that that was one of the major decisions we had to make early on and I think it was really meaningful because it was the first big obstacle we had as a group besides communication and collaboration… So we really went through the problem-solving stages of trying out what already exists, mapping out new ideas, and then bringing it back. *Zara, Reflection 4, Technical then Professional, Technical and Professional*

Testing and improving software products is important in engineering design and Agile frameworks, and students had the opportunity to practice this step based on feedback.

Remote coordination

When asked to compare working remotely to working in-person during the last portion of the program, a few students discussed the ease of technical collaboration. The faculty

instructor said he had observed this difference after the semester's struggle to coordinate across schedules.

> I think they felt they worked more in these [in-person] five days than during the semester. But I believe that one of the reasons for them to feel that way is that because they were not worried about having a meeting time or who's going to be there. *Faculty Interview*

Joshua made a similar statement when he spoke about a different aspect of improving his technical collaborations and learning more about engineering from his teammates.

> Do I think I observed anything that cannot be replicated via remote connections? Well, eye contact, being there with the other person... having someone over my shoulder explaining how things work was very nice and very productive, significantly better than going online the whole time. So I was a lot more productive here than I ever was back in [the home campus]. *Joshua, Reflection 6, Technical and Professional*

For most of the other students, the differences were in the personal relationships they built and not Technical and Professional skills. Personal relationships are discussed in 6.6

6.5 Full Integration

There were a few incidents of students integrating all three competencies. First, designing and implementing a project without a course framework was a source of early anxiety for students and a path towards Professional and integrated Technical and Professional competencies. Lila stated that successful project management was her goal from the course.

> I don't have much experience in doing large scale design. Any design stuff I've done has been with people that have already done the foundational designing for me. So I think it would be really cool to be able to play project manager a little bit and see what building a successful design looks like. Because I'm sure since a lot of us are doing this for the first time, it means that we won't know what a successful design should look like, or we'll realize when we're halfway through that we need to go back and change something that we, like, change something that we set up in this particular way and realize that that's not working or that's inefficient and we need to like reorganize or restructure. And I'm sure we wouldn't make that same mistake the next time we are designing something at a large scale from scratch. *Lila, Reflection 1*

Mid-semester, Lila had gained experience in this topic and found the process of planning and implementing a project easier than expected because of her team members. She was able to complete more difficult work than she expected, which demonstrated Technical and Professional competency. Her description of working with an international team was an integration of all three competencies.

> The most valuable things I believe I've learned from this course so far has been just seeing the process of mapping out how a game or an app or a product is going to look. Because at the beginning when I would think about all this work that goes into designing a product, it's so overwhelming, but when you have even a group of four or five it's so much easier to take on this designing of product under this Agile framework... it makes it so much more digestible. And in my head I thought you would need so many more people on a team to like be able to visualize and develop something like this, but it's seeming a lot more feasible

> and that's really, really exciting because as a student I know I never considered that I'd be able to stomach such a big task, but being able to be a part of it, especially with people from different parts of the world and different experiences, to make something that's in line with all of our interests, this is a really exciting experience that I'm so happy to be a part of and get in my senior semester. *Lila, Reflection 3, Technical and Professional, Integration*

Alessandra connected the integration of competencies with working on a project for an international stakeholder.

> The next question is, has this course changed how you view the field of computer science? I would definitely say yes, especially because we're working in an international context, building something for a different country, for a hotel in Switzerland, I think it shows your project and ideas can go very far and can reach the world globally, which is really cool. *Alessandra, Reflection 5, Integration*

Zara and Selena gained insight from working with their international team members. As a result of this course, they learned about technical differences and collaboration in a global context.

> I think that it's been really interesting to work with people from completely different backgrounds and I think I've been able to gain a lot of insight on how computer science is done in different countries and different educational backgrounds. It's been really cool to see how all of us within our group have differences in both our technical backgrounds as well as the way we tackle problems. *Selena, Reflection 5, Integration*

> I would say the highlight of my travel experience was meeting new people. I learned a lot about other cultures and interacting on a global scale, and learned a lot about other perspectives within computer science, and different cultures, and how that works. It was honestly really helpful because it allowed for different viewpoints and it allowed us to gauge what the different levels of knowledge people were. *Zara, Reflection 6, Integration*

These competencies were aligned with the instructor's goals for the COIL, in which students could connect with a shared goal of completing their project instead of solely becoming friends.

> Students can live abroad, students can travel abroad and have some fun, but to work with people abroad it puts you in a different mode. So you know that you have to get something out of this meeting, it isn't just we're here and chatting and hanging out, we have to build something together. So I think it creates another layer of this relationship that is being built amongst these students. [It's] good and bad because sometimes there are conflicts, sometimes they are stressed, sometimes they need things done and they're not. *Faculty Interview*

When students collaborated across cultures and integrated multiple perspectives in their project management and technical design, they integrated competencies across all three dimensions.

6.6 Other Learning

The relationships that students built with their teammates was a significant takeaway from the course. Some students mentioned these friendships pre-travel, but they were more

strongly built after the groups met in-person.

6.6.1 Virtual Relationships

Michael's team set aside time for connecting personally during the semester by playing games and chatting more casually.

> A few weeks ago, [our team] did something a bit extra where we tried to do bonding moments. So we try playing games together to really get to know each other and just be more comfortable. And I feel like people are much more than just a project. So getting to know each one's background, each one's interest, their plans after this class or anything beyond that. Because we don't really get to see each other. So we might as well get to know each other a little bit more. *Michael, Reflection 4*

Few teams had planned for casual times of connection when they were working online.

6.6.2 In-Person Relationships

Most students found the in-person collaboration much more enjoyable than online work. Andrew said that even though they worked together well online, they built team spirit and became friends after meeting in person.

> I really think that meeting [my international peers] in person has solidified our bond as a team and I think it's just great that we can laugh together, share jokes, and I think overall it has improved our team spirit and team dynamics greatly… Because up until now, all conversations I've had with my teammates

> have been strictly formal, strictly work-related. Now that we're actually here in person, I feel that I've just had such a fantastic time getting to my teammates, and I feel that if we had shared this dynamic from the start and much earlier in the project, I think we could have had an overall much better experience working together. *Andrew, Reflection 6*

Joshua said that the collaboration and communication improved during their meeting in person.

> They were definitely much more direct [in person]. I could much better understand them. We had a much better cohesive flow of what we were up to, which was good because that was a huge part of the actual project. We actually did a shocking amount of work here compared to the workflow that we were dealing with [virtually]. *Joshua, Reflection 6*

Joshua said that the same idea applied to the U.S. students bonding by traveling.

> Before this course, I don't think the whole class was that close. We weren't doing anything crazy, but now that we're here, this is significantly more involved. We all know our names now. That's crazy. We're going out late at night, we're hanging out, we're making jokes, we're being friends, which is great. *Joshua, Reflection 6*

Ryan completed his reflection with his international teammates. They frequently bantered and described bonding during their last push to finish the project.

> Ryan: We were all collaborating late into the night until like 5:30 in the morning. So that was really fun though (laughs) because we all felt pressure to finish it.

> None of us went to bed, not [any of my teammates]... The perceptions of the team didn't change. Actually, it was how smart they were, when I met them in person, how smart and talented they all are.
>
> Egyptian student: He's very good at making jokes.
>
> Ryan: No, it wasn't a joke. I was so serious. Look, [other student] can tell... Yeah, so our teamwork's been really great, especially as we've gotten into the country together. *Ryan, Reflection 6*

Alessandra described both the project and team collaborations improving by coming on-site.

> I would say the project felt more real when we were doing it here in Switzerland because we could see the hotel that we were working for... I would say I've [also] grown to like the people I'm working with now that I've actually seen them in person. The connection feels more real… I'd definitely say team bonding is something that's really hard to be replicated via remote connections. I feel like what helped us bond here at the [International] Center was having group meals, sitting down with everybody, talking with them about things other than school and work made it feel more real. *Alessandra, Reflection 6*

Connecting in-person was more familiar to students, and they were able to quickly feel bonded and get to know one another. They were able to compare the semester experience to traveling and saw how they could bond with students from other countries.

6.6.3 Improvements in Future Collaborations

The reflection prompt included a question of what students learned that would transfer to future remote projects. Students said that they would try to encourage team members to

meet with their cameras on and incorporate more personal conversations to replicate the relationships they achieved in-person.

> I would say I'd try to meet up with them more face-to-face with Zoom camera on rather than just voice calls or text messages. The connection is not the same, I would say, originally. A lot of the times when we had meetings, some of our team members would not turn their cameras on. They would still actively participate, but I felt like the connection was different. It felt like I was talking to a screen rather than a person. *Alessandra, Reflection 6*

> So, if the only option is to work remotely and we cannot ever meet in person, I would say that having meetings more frequently where you could at least get to know the person on a more informal level will definitely help create better relations with the person you're working with. I feel like if you connect a little bit with the people you work with, you'll be more productive and just in general feel better about the work environment and produce better work. I think that's what happened this week in [Switzerland] when we met [Swiss students], we were able to open up a little bit more, learn more about each other, and then create somewhat of a friendship and produce better work afterwards. *Benjamin, Reflection 6*

After seeing the difference between their semester remote work and in-person work, students had gained a better perspective on how they could better approximate the face-to-face connections while online.

6.7 Quantitative Survey Results

An additional data source for this case is the results of the Global Engineering survey. The survey's questions can be seen in Appendix B.8, and the results are in Figures 6.3 and 6.7. The sample size is small, but general observations can be made from the survey about how students perceive their learning and development. The mean values can be seen in Figure 6.3, where the Likert scale responses were translated to numbers (i.e., Strongly Disagree equals 1, Strongly Agree = 5). The distribution of answers can be seen in Figure 6.7. The COIL Capstone students had lower pre-test means in Engineering Cultures and Ethics, Standards, and Regulations–more students Disagreed that they had skills in those areas. The greatest mean gains were in these two categories. The other categories saw smaller improvements to the mean but still had approximately 0.5 point increases in the mean: General Global Engineering Performance, Technical Coordination, and Metacognition. The results indicate that by these survey measures, students reported higher skill levels on these items at the end of the course relative to the start of the course. In the post-course survey, COIL capstone students more frequently said that they Strongly Agreed with the survey measures, as can be observed in Figure 6.7. There is additional data, not included in this dissertation, from a traditional software engineering capstone that indicates that the pre-course means are not unusual for the COIL case, which I discuss in the Future Work section of 8.5.

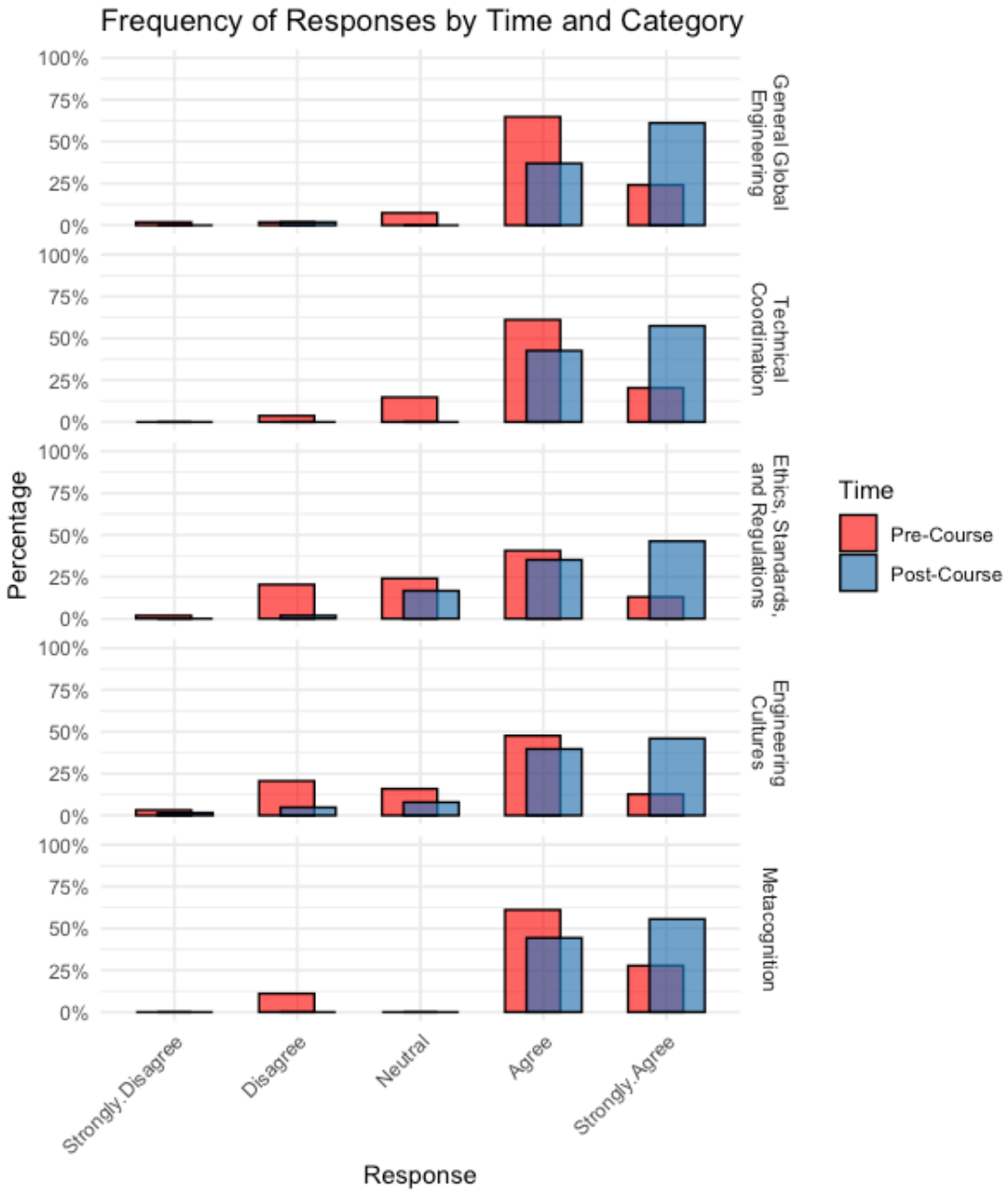

Figure 6.7: Percentage of answers by Likert scale response in each category, pre and post-course

Table 6.3: COIL case survey results

Category	Time	Mean	Median	SD	Min	Max
Engineering Cultures	Pre	3.46	4	1.06	1	5
Engineering Cultures	Post	4.24	4	0.91	1	5
Ethics, Standards, and Regulations	Pre	3.43	4	1.02	1	5
Ethics, Standards, and Regulations	Post	4.26	4	0.81	2	5
General Global Engineering Performance	Pre	4.07	4	0.75	1	5
General Global Engineering Performance	Post	4.57	5	0.60	2	5
Metacognition	Pre	4.06	4	0.86	2	5
Metacognition	Post	4.56	5	0.50	4	5
Technical Coordination	Pre	3.98	4	0.71	2	5
Technical Coordination	Post	4.57	5	0.50	4	5

Chapter 7

Cross-Case Analysis

This chapter is the cross-case comparison. The overview diagrams for each case's competencies are Figures 7.1 - 7.3. For each GEC, the summary of its appearances in each case along with a Figure showing the comparison is given in Section 7.1. I also selected the case that seemed to impart each competency the most effectively.

Following is a methodological reflection comparison between cases that details the length of responses for each participant, in Section 7.2.

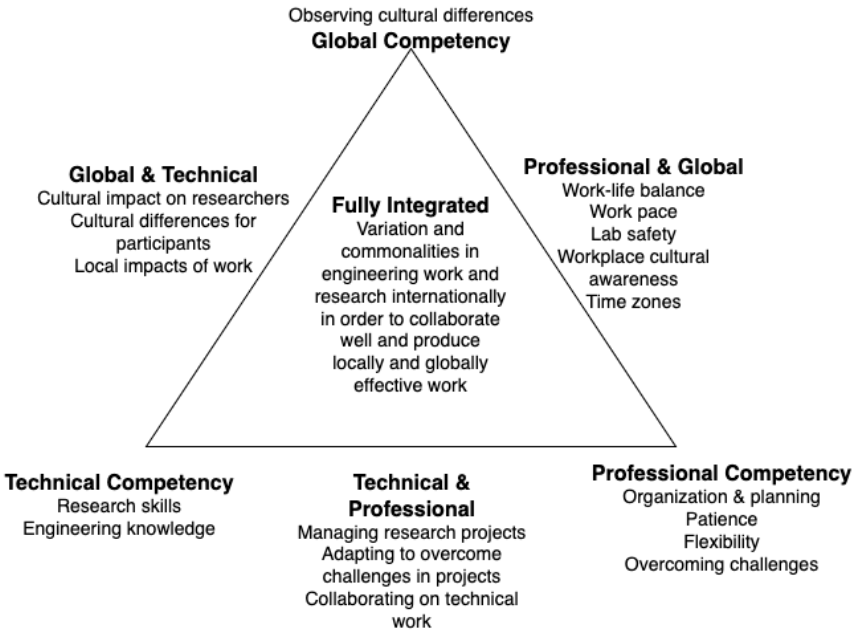

Figure 7.1: IRES case GEC diagram

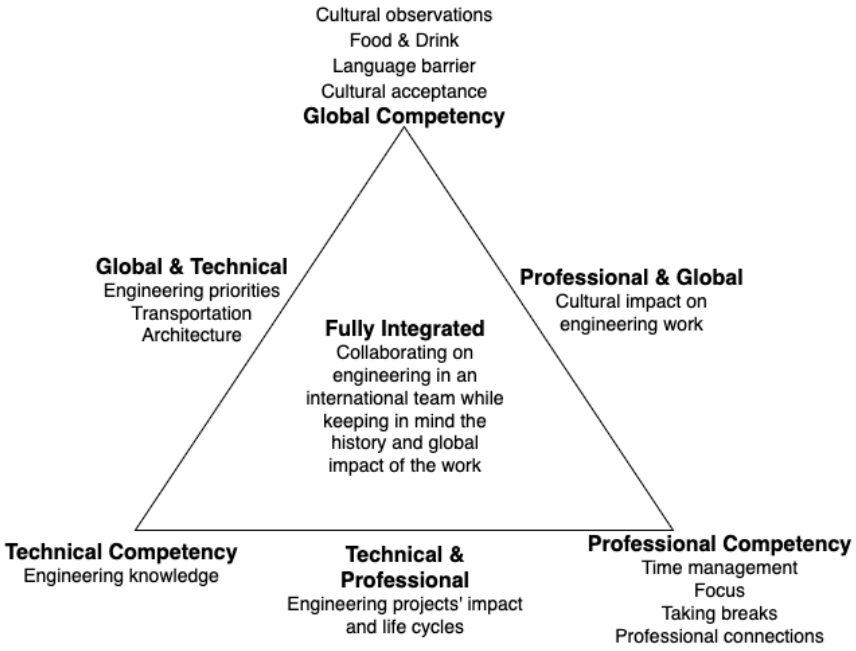

Figure 7.2: International Center case GEC diagram

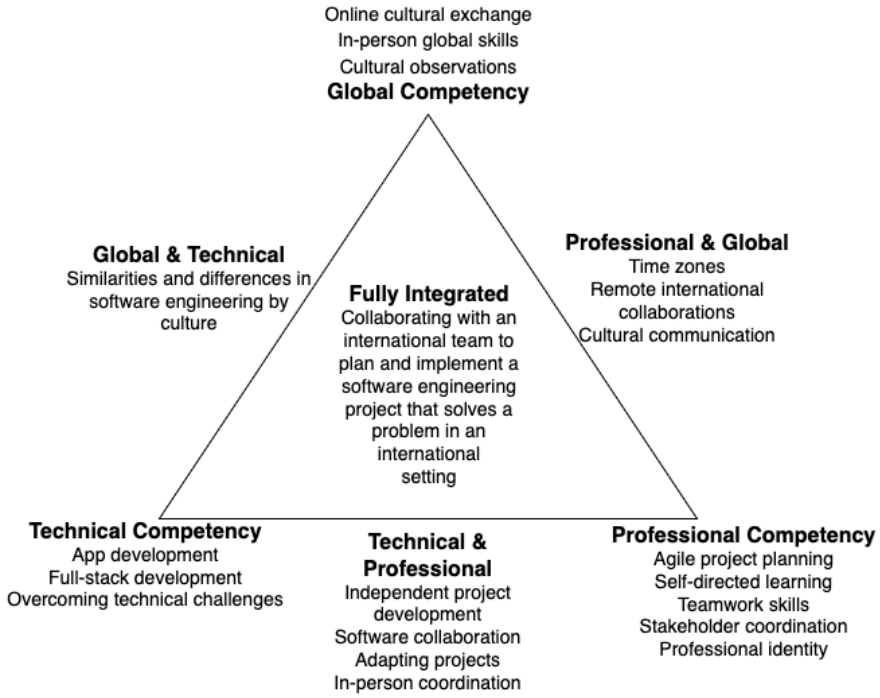

Figure 7.3: COIL case GEC diagram

7.1 Summary of Competencies

Technical Competency: The research project experiences in the IRES case primarily filled in gaps for areas in which students were less experienced, which could be research or engineering. Students who were new to research learned about the process by experiencing it. For engineering skills, primarily the students who were entering a new discipline gained technical competencies. If students had significant prior technical experiences, IRES did not necessarily push them beyond what they already knew. In the International Center case, examples of technical competency development were isolated incidents of learning from coursework. The COIL Capstone case gave students the opportunity to select engineering projects and roles within projects where they could strengthen their technical skills based on their goals. All students learned new technologies. The themes of Technical competency can be seen for each case in Figure 7.4. The COIL Capstone case was the most effective because students could target areas of technical growth that they wanted to achieve and push themselves to learn.

Technical Competency		
IRES	**International Center**	**COIL**
Research skills Engineering knowledge	Engineering knowledge	App development Full-stack development Overcoming technical challenges

Figure 7.4: Technical competency comparison

Professional Competency: Professional learning in the IRES case included skills such as organization, patience, and flexibility from working on research. Students in the International Center case balanced competing priorities for their time, which was an informal Professional learning experience. Professional competencies were a formal and informal

learning outcome in the COIL capstone case. In course activities, students learned Agile methods; during their projects, students had to coordinate and communicate within teams and with stakeholders. Figure 7.5 shows the Professional competency themes in each case. The COIL capstone conveyed Professional competencies the most effectively because they were both naturally learned during the projects and formally taught in the course.

Professional Competency		
IRES	**International Center**	**COIL**
Organization & planning Patience Flexibility Overcoming challenges	Time management Focus Taking breaks Professional connections	Agile project planning Self-directed learning Teamwork skills Stakeholder coordination Professional identity

Figure 7.5: Professional competency comparison

Global Competency: IRES students observed cultural differences as they adapted to life in the United Kingdom, but they found the cultures to be fairly similar. The International Center case was a full semester abroad in Switzerland. Even though the participants were living with their peers from the U.S. university, they experienced the stages of cultural adaptation and homesickness. They learned about different European cultures through their personal travel, experienced a language barrier, and had mindset shifts towards cultural acceptance. Students in the COIL Capstone were able to learn about Egypt's and Switzerland's culture from their teammates and presentations, although the presentations did not have significant presence in the reflections. They had two weeks traveling abroad at the end of the semester to make other cultural observations. Each case's themes for Global competency development can be seen in Figure 7.6. The International Center case had the most effective global competency development, which came from living and meeting new people abroad for a significant period of time in a location with cultural distance from the home culture. The free time that students spent traveling was particularly meaningful for their Global learning.

Global Competency		
IRES	**International Center**	**COIL**
Observing cultural differences	Cultural observations Food & Alcohol Language barrier Cultural acceptance	Online cultural exchange In-person global skills Cultural observations

Figure 7.6: Global competency comparison

Professional and Global Competency: In the IRES research work, the Professional and Global integrated competencies were focused on the differences in professional practices. Students joined an existing research team and adapted to their context. They saw how culture impacts professional norms and they adjusted their work-life balance and communication to the new setting. They had an additional few weeks of online collaboration, during which they had to adapt to different time zones. Students in the International Center case had awareness that engineers should have Professional and Global competencies, such as being capable of working with other engineers abroad. However, they did not have specific experiences that developed their competencies in this area. The majority of the work in the COIL Capstone was done through virtual international collaborations in newly formed teams. Students gained Professional and Global competencies for online work, such as communicating across different cultural backgrounds, adapting to differences in scheduling, and learning from remote stakeholders. The integrated Professional and Global competencies can be seen in Figure 7.7 for each case. Overall, the IRES Professional and Global competencies are transferable to adapting to a new, in-person global team, while the COIL Competencies would be effective in future remote international collaborations.

Global and Technical Competency: In IRES, students learned how culture impacted research work as they adapted to a different culture's rules and procedures for their projects. They also learned about the impact of engineering on local stakeholders and communities.

Professional & Global Competency		
IRES	**International Center**	**COIL**
Work-life balance Work pace Lab safety Workplace cultural awareness Time zones	Cultural impact on engineering work	Time zones Remote international collaborations Cultural communication

Figure 7.7: Professional and Global competency comparison

In the International Center case, students learned about cultural priorities in disciplinary relevant areas of engineering: bridges, trains, and architecture. These topics were taught by the faculty in class and through observed examples during multi-day tours. For the COIL Capstone case, Global and Technical integration was an infrequent competency. Students initially stated that they wanted to see cultural differences in technical fields and later observed that software engineering is similar across cultures, but they did not describe specific understanding. Figure 7.8 shows the integrated Global and Technical competency themes for each case. The International Center case was most effective in teaching integrated Global and Technical competency, and it was done by conveying theoretical knowledge in classes which was reinforced to students as they reflected on their observations of differences between cities during personal and group travel. It was observed to be the most effective because of the prevalence of its appearance among students and its transferability between contexts.

Global & Technical Competency		
IRES	**International Center**	**COIL**
Cultural impact on researchers Cultural differences for participants Local impacts of work	Engineering priorities Transportation Architecture	Similarities and differences in software engineering by culture

Figure 7.8: Global and Technical competency comparison

Technical and Professional Competency: Students in IRES learned about managing research projects, adapting to overcome challenges, and collaborating on research. Their Technical and Professional competency development came from their work on research teams. Two students in the International Center case learned a Technical and Professional competency, which were focused on engineering collaborations that they learned about in coursework. During the COIL case, students gained experience in developing projects independently, collaborating with peers, communicating with stakeholders, and overcoming challenges. The three cases' themes of integrated Technical and Professional competency can be seen in Figure 7.9. The COIL Capstone case was the most effective at developing integrated Technical and Professional competencies because of the independence and ownership of their projects. Students iterated approaches to their work as they managed their own engineering projects.

Technical and Professional Competency		
IRES	**International Center**	**COIL**
Managing research projects Adapting to overcome challenges in projects Collaborating on technical work	Engineering projects' impact and life cycles	Independent project development Software collaboration Adapting projects In-person coordination

Figure 7.9: Technical and Professional competency comparison

Full Integration: In the IRES case, students saw that culture had an impact on the interactions between coworkers along with the research and engineering projects' procedures and outcomes, which was a fully integrated competency. They observed differences in professional norms, intellectual property, and uses of technology. Students in the International Center case discussed fully integrated competencies when asked to define a global engineer. They frequently included that global engineers should have a positive global impact by incorporating ideas from different sources. Overall, they seemed to have an understanding

of global engineering but were not applying these skills during the program. In the COIL course, students connected the three competencies in the context of working with and for international stakeholders, which led to the integration of multiple perspectives in their project management and technical design. However, it was infrequently discussed. Figure 7.10 includes an overview of Fully Integrated competencies in each case. The IRES case was the most effective at full integration because students were immersed in a global engineering workplace. Four of the six students learned a fully integrated competency, which they typically discussed at the end of the program.

Fully Integrated Competency
IRES
Variation and commonalities in engineering work and research internationally in order to collaborate well and produce locally and globally effective work
International Center
Collaborating on engineering in an international team while keeping in mind the history and global impact of the work
COIL
Collaborating with an international team to plan and implement a software engineering project to solve a problem in an international setting

Figure 7.10: Fully Integrated competency comparison

7.2 Reflection Lengths

In the IRES prompts, I explicitly said that there were no length requirements for the reflection, as inspired by previous prompts [56] (Appendix B.5). I sent the same questions for each reflection prompt. As seen in Figure 7.1, the IRES reflections were the shortest. There

was not an incentive for reflecting, and two students did not submit any reflections. Three students submitted five or more reflections. The data in this case was significantly supplemented by extended interviews. Based on feedback and observation of the IRES students, I updated the prompts for the International Center to say "speak about your experience in a 6 to 10-minute video or audio reflection", with different prompts each week (Appendix B.6). This was successful, so I repeated the process for the COIL course with different prompts (Appendix B.7). For both of these cases, reflections were given a completion grade.

It is additionally notable to compare the reflection length and frequencies in Figure 7.1 between the International Center and COIL cases. Students in both cases completed around the same number of reflections. The International Center students had evidently longer mean recording times when compared to the COIL case, though the COIL students were reaching the requested 6 to 10 minute time frame. A plausible explanation for this is that students in the International Center experienced a completely new context and had more to share about different facets of life, while the COIL students only discussed the capstone course as they were still in the context of the domestic university.

The extended length of the International Center students' reflections is also significant because students shared fewer competencies in this data. They shared more Critical Incidents, which may take longer to talk about. Even though the Competency summary graphs show that fewer competency codes were assigned to this data, time was being spent on non-GEC topics. Other aspects of reflections could be explored in future work.

It is also notable that the vast majority of students opted to complete audio-only reflections, with one to two participants per case recording videos.

Table 7.1: Summary of reflection attributes

Pseudonym	**Program**	**# of Reflections**	**Mean Word Count**	**Mean Length**	**Shortest**	**Longest**
Colleen	IRES	5	940	5:26	1:36	7:39
Noah	IRES	6	450	3:05	1:35	4:56
Hailey	IRES	0	-	-	-	-
Nathen	IRES	5	270	1:29	1:10	1:48
Joey	IRES	0	-	-	-	-
Arthur	IRES	2	230	2:13	1:47	2:39
Ella	Int'l Center	6	1520	10:00	6:39	13:33
Elizabeth	Int'l Center	5	1100	8:09	7:15	9:14
Sam	Int'l Center	6	940	6:43	6:07	7:44
Abigail	Int'l Center	5	1140	8:25	5:28	10:04
Penelope	Int'l Center	4	1080	6:54	6:04	7:21
Conner	Int'l Center	6	860	8:11	7:08	9:15
Jackson	Int'l Center	6	940	7:52	3:32	10:22
Selena	COIL	6	850	6:38	6:06	8:05
Willow	COIL	6	900	6:29	5:09	7:31
Michael	COIL	5	920	6:13	5:09	8:10
Lila	COIL	6	960	5:41	4:19	7:58
Andrew	COIL	6	1090	6:26	6:08	7:09
Ryan	COIL	6	1000	6:18	5:23	7:27
Joshua	COIL	5	1050	6:28	6:14	6:49
Benjamin	COIL	6	820	6:31	4:45	8:56
Alessandra	COIL	6	880	6:37	6:08	7:38
Zara	COIL	6	1040	6:29	5:33	8:00

Chapter 8

Discussion and Implications

Engineering students today need to be trained in global engineering competencies, as seen in the ABET requirement to prepare students to work responsibly in global contexts [1]. International programs were originally conceived as long-term, immersive language programs, study tours, or summer disciplinary work [58]. The types of programs have evolved to accommodate engineering degree curricula, especially since there are curricular and coursework restrictions within engineering that can make traditional international programs challenging to access for engineering students [49, 125]. As new types of programs have emerged in the last several decades specifically designed for engineering students, there is a need to investigate how program design decisions may impact students' experiences and learning. My dissertation did so for three types of engineering international programs: an international research experience, an engineering semester at an international center, and a collaborative online engineering capstone course. My study also meets the calls for open-ended exploration of students perspectives by collecting data in a manner that gives students the opportunity for reflection on any salient ideas [107]. In this Discussion chapter, I return to the research questions:

1. What do engineering students learn within different international engineering program designs?

2. How do students develop global engineering competency across different international

engineering program designs?

I summarize what students learned in each case in Section 8.1 to answer the first research question. I compared the previous findings to the cases' program types to my results in Section 8.1.1 and explored the emergent learning outcomes outside GEC in Section 8.1.2.

To answer research question 2, I explored the critical incidents present in each case in Section 8.2.1. I also compared students' learning by program dimension to prior works in Section 8.2.2.

This chapter closes with a discussion of the implications of this dissertation for research and practice and the study's overall conclusions.

8.1 Longitudinal Learning

Each case's longitudinal learning is summarized in the following section. It includes an overview of the Global Engineering Competency codes and development that went beyond this framework.

Global Engineering Competency

To answer research question 1, the learning outcomes in each case have been tracked in Chapters 4 - 6. The competency summary graphs are reprinted here in Figures 8.1, 8.2, and 8.3. It is worth noting that the competencies are not represented cumulatively, but each reflection is a new opportunity for them to appear.

Additionally, each individual participant's Global Engineering Competency coding and summaries can be found in Appendix C.

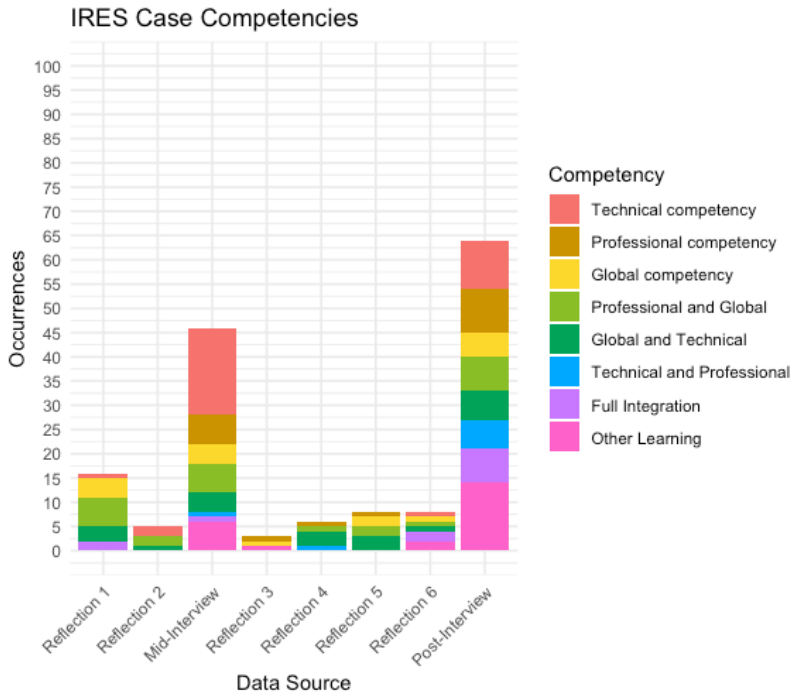

Figure 8.1: IRES case competencies (repeated figure)

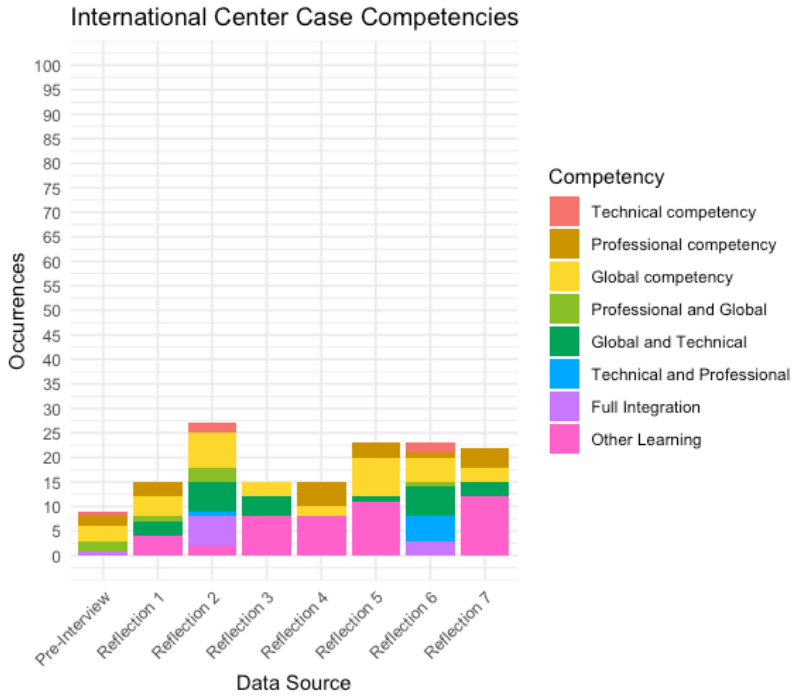

Figure 8.2: International Center case competencies (repeated figure)

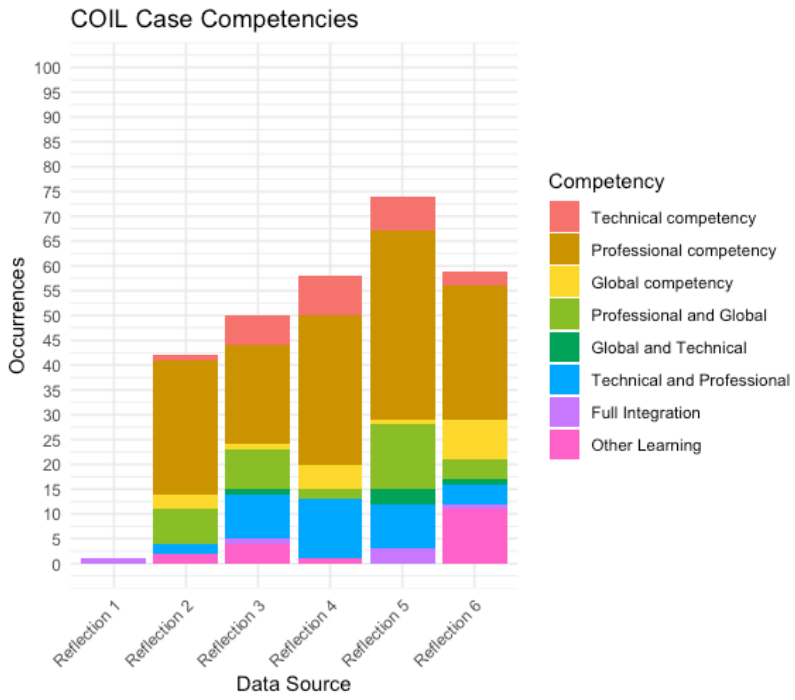

Figure 8.3: COIL case competencies (repeated figure)

8.1.1 Program Types

This section compares my dissertation's findings on what students are learning to prior research on these specific program types (IRES, International Centers, and COILs) to answer Research Question 1. Each of these programs was designed for engineering students. There have been calls to further investigate the impact of experiential learning and extracurricular activities during international programs [48], and each of these cases has implemented different types of learning interventions.

IRES

As can be observed in Figure 8.1, the IRES case included notable occurrences of each dimension of GEC. In the mid-program interview, Technical competencies made up a large

portion of the responses; integrated Technical and Professional competency was absent. By the final interview, all the competencies were present at relatively equal frequencies as students looked back over their entire experience, demonstrating that every competency was significant to the students at the end.

Some outcomes from this case were aligned with prior research about IRES. Other studies have indicated that students develop preparedness to go abroad, work-life balance, confidence in research skills, and understanding of the competencies necessary for global engineering work [31, 55, 65, 69]. Knight et al. [69] found that clarity on their future career goals is the most significant outcome across IRES programs. This included six dimensions, such as selecting graduate school or industry, professional networks, or future work abroad. These outcomes were present in my study, but my dissertation also uncovered an additional aspect described in Section 4.5: students learned that their careers will likely have unexpected turns and that their degrees could be used in completely unexpected fields.

In Davis's study [32] with participants from multiple types of international programs including IRES, the results indicated that students focus on cultural learning more than engineering learning when looking back at their experiences post-program. In contrast, the integrated competencies in my theoretical framework illuminate that purely Global competencies were a small portion of the IRES students' reflections. Technical competencies were commonly discussed in the interviews, and Global competency was frequently integrated with either Professional or Technical, showing that the intercultural learning during this particular program was tied more explicitly to the engineering workplace context.

Overall, IRES programs' outcomes have been explored in-depth previously [18, 19, 31, 55, 69]. Many of the outcomes are aligned with my study's results, and the longitudinal data collection illuminates how students achieve these outcomes. For example, in Reflection 2 Noah said that he thought engineering as a discipline was similar around the world. By the

end of the program, he described the cultural differences in project design and outcomes.

Another contribution of my study is its detailed exploration of students' thoughts and experiences, which shows the range of learning experiences across students. For example, Hailey discussed intellectual property law and its international differences, which is under the ethics, standards, and regulations dimension of Jesiek et al.'s [65] definition of global engineering competency. Other studies have indicated that students enter with lower levels of confidence in this dimension [28]. Wrobetz found that ethics, standards, and regulations is a difficult learning outcome to impart [130]. The large amount of qualitative data collected from each student allows for the identification of less common learning experiences, such as this one.

Overall, the framework applied to this study showed how students were becoming global engineers. Four of the six students demonstrated fully integrated Global Engineering Competency, usually related to how the culture of engineers impacts collaborations and engineering work around the world. The specific GEC framework provided new insights into students' development to reach these outcomes.

International Center

Several competencies' consistency throughout the International Center program can be observed in Figure 8.2, particularly Global competency, integrated Global and Technical competency, and Other Learning. The other two individual competencies—Professional and Technical—traded off, and the other integrated competencies appeared and disappeared throughout.

Prior work about engineering International Center programs has been very limited. The previous study from Grove City College indicated that students were satisfied with their decisions to enroll and saw grade improvements [22]. Students in this study's case expressed

that they enjoyed their experience and Sam noted that he had received better grades, as discussed in Section 5.3.2. Since this is a growing type of program [126], my study's investigation is significant. The targeted learning outcomes from programs at an international center include foreign language skill development, exposure to other cultures, and learning about cultural disciplinary differences [126]. The case in my dissertation did not include advanced second language learning, but minor incidents of cross-cultural communication occurred. Cultural observations were a significant part of students' experiences, as Global competencies were one of the most commonly coded from this program. Students had enough time living abroad to experience culture shock and homesickness, and to evolve to cultural acceptance. They also observed cultural differences during their frequent travel during free time.

Students' description of their integrated Global and Technical learning in this case indicated that they were learning cultural disciplinary differences, which was the third targeted outcome [126]. Since engineering programs at international study abroad centers are rare, the success in reaching this goal in engineering is a significant finding. It was achieved by faculty discussing the connections between engineering and culture in class and by showing students examples of the outcomes of these differences during course excursions. Students were able to transfer this learning to travel in their free time.

Unlike the IRES program, the results from the International Center case align with prior findings that students focus on cultural learning more than engineering development in international programs [32]. This is the only case where individual Global competency was more common than integrated Global competencies. The comparison of cases is a benefit of my study's methods and illuminates specific differences in the impact of program designs. Another difference is that critical incidents were more frequent and emphasized than learning in the reflections. An area for future improvement for this program would be to find ways to

further advance students' Professional competencies in a global context, since students were not having collaborative international experiences in this case.

Other Learning was a frequent code, indicating that notable learning was occurring beyond the framework of Global Engineering Competency. This additional learning included travel skills, future plans, and personal growth, which were post-program outcomes from Davis's [32] multi-program critical incident study. The insights into how students were observing their own maturation and personal growth during the program is a valuable insight, particularly since it was not present in the other cases. This observation may indicate that when students reflect on their experiences in hindsight after shorter or less immersive programs, they are able to see their personal development, but when students stretch in their day-to-day life, they can observe these changes immediately. Overall, my dissertation provides a base of research in a context that has not been previously investigated and can be compared to insights from future research.

COIL

The COIL case's competency development can be seen in Figure 8.3. In the COIL, Reflection 1 was primarily about prior knowledge, so it was not frequently coded for new competency development. Professional competency was a consistent feature starting with Reflection 2. From Reflection 3 onward, Technical and integrated Technical and Professional competency were consistently present. Global and integrated Professional and Global competency had varying frequency.

Research into STEM COILs has shown that the learning students gain includes new perspectives on their learning, confidence, openness to new perspectives, intercultural competence, and global citizenship [45, 88]. Munoz-Escalona et al. [87] collected survey data post-COIL

and found that communication skills were one of the greatest competencies developed and that the COIL context reinforced their engineering learning. Ghosh and Verma [45] used surveys, assessments, post-course interviews, and instructor reflections to investigate the effectiveness and best practices for an engineering COIL.

My study differed from prior work by collecting open-ended qualitative data throughout the COIL. Themes that overlapped with prior work included coordinating across time zones and practicing cultural communication [45, 87]. New aspects, included the capstone setting, provided an environment to develop Professional and integrated Technical and Professional skills in collaboration and project management that are not specific to the international context. Though prior work has emphasized Global learning such as intercultural competence [45], Professional competencies were more common in my study, which is a significant finding. Even during the last reflection while students were experiencing the international portion, Professional competency was the most frequent competency present. This result further differentiates the outcomes that students can anticipate in different types of international programs.

Working with international stakeholders is also an uncommon aspect of COILs that my dissertation was able to investigate. The experience was associated with Professional, integrated Technical and Professional, and integrated Professional and Global competency development. Students' primary learning was in aligning the needs of stakeholders with their projects, with a few students additionally incorporating cultural communication.

Overall, students gained unique transferable skills for virtual collaborations compared to the other cases. My dissertation provides a detailed longitudinal examination of students' learning in a capstone engineering COIL. It is notable that students spent more of their reflections discussing integrated competencies than Technical learning, which will be a worthwhile investigation in future work to compare the COIL program to traditional software engineering

capstones.

8.1.2 Other Learning

International programs can impart learning that is complex and difficult to measure [32]. The code of Other Learning was used when students described learning that did not fit into Global, Technical, Professional, or integrated competencies. This section explores the Other Learning code to answer the call from prior research of being open to emergent types of learning, instead of focusing on our own expectations as researchers [128].

In IRES, the significant themes that fell outside Global Engineering Competency were adapting to a new environment, building mentorship and peer relationships, examples of changing careers, and clarity into their own future careers. The first was a product of being hosted by a university abroad, and the other three came from connecting with their research group abroad. These outcomes were similar to those found by Knight et al. [69] in their multi-case study of IRES programs, though there was a new subtheme within Career/Future Outcomes. Students in my dissertation learned about their coworkers' career paths and learned that their career trajectories will be long and unpredictable, so they may discover a new passion in the future. This helped students to feel less pressure to have their entire careers planned out.

In the International Center case, students clarified their interests in traveling or living abroad, learned how to navigate travel challenges, and experienced a unique outcome of personal growth, which was one of the Critical Incident codes. Personal growth was varied and included new values of connecting with others, self-control, leadership, confidence, and reordering priorities. Except for travel challenges, the Other Learning in this case was not associated with specific experience. These outcomes have been found in other study abroad

programs [32] but had not surfaced in prior research on International Center programs.

In the COIL case, the Other Learning outcomes were primarily centered around relationships. These relationships included bonding with international classmates, connecting in person with U.S. and international peers, and how students would try to recreate "closeness" in virtual relationships in the future. There were not any extracurricular learning outcomes, as there were with the other two cases. Building relationships has been observed in prior COIL research [94], but the understanding of how to strengthen virtual connections was a new result of this study since the program uniquely contained both online and in-person engineering collaboration.

The learning outside GEC is notable for answering the first research question about students' learning. It also answers the call to be open to diverse learning outcomes during international programs [107].

8.2 Program Design Decisions

This section includes an exploration of what students experienced by reviewing the Critical Incident and Capstone coding for each case in Section 8.2.1, which gives insights into how students are developing global engineering competency. Section 8.2.2 explores my dissertation's findings related to the different program dimensions as compared to prior research to provide insights into how the design of programs can impact what students experience and learn.

Table 8.1: Case counts of Critical Incidents

Critical Incidents	IRES	International Center
Connecting with people	28	38
Gaining knowledge or awareness	19	30
Experiencing a foreign culture	27	47
Navigating a foreign country	9	25
Personal growth or awareness	0	10
Being on your own	0	8
Iconic experience	2	44

8.2.1 Incidents

This section includes a reprint of the Critical Incident (Figures 8.4 and 8.5) and Capstone coding (Figure 8.6) graphs to provide insight into what students were experiencing as they developed Global Engineering Competencies. Table 8.1 is a summary table for the total appearances of each Critical Incident code in the IRES and International Center cases

In IRES, the most common incidents came from students' research work. The Incident coding can be observed in Figure 8.4, and the totals are in Table 8.1. Students connected with people through the program, gained knowledge or awareness in research or engineering, and experienced a foreign country as they experienced differences in and out of the workplace. There was some discussion of navigating a foreign country, as students adapted to the environment.

The International Center case was the only setting where Critical Incidents were coded significantly more frequently than competencies. Figure 8.5 is the case Critical Incident coding graph. All types of Critical Incidents were present, including the two that were absent from IRES: personal growth or awareness and being on your own, as can be seen in Table 8.1. Some of the most common incidents came from class or individual travel; i.e., experiencing a foreign culture, navigating a foreign country, and iconic experiences. Students also frequently discussed connecting with others in and beyond the program and

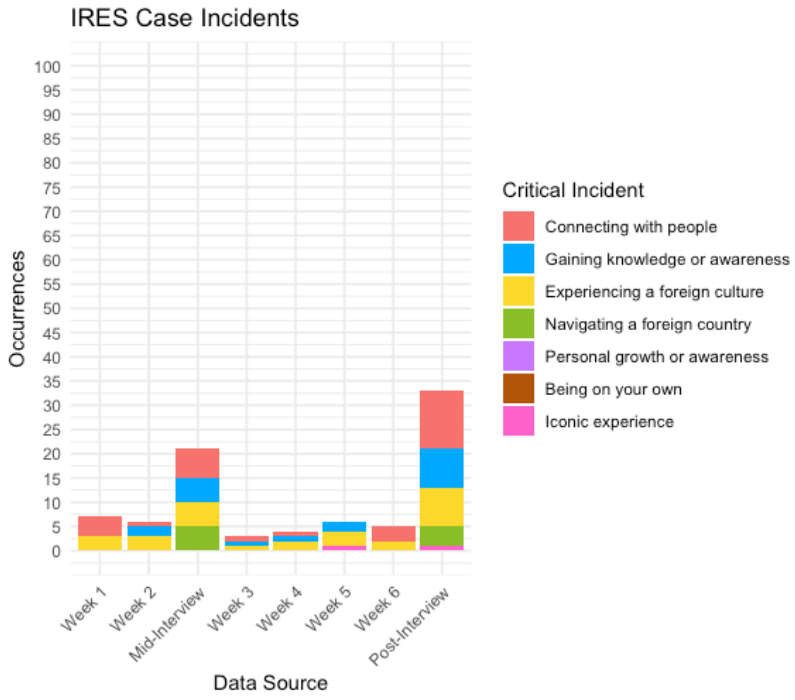

Figure 8.4: IRES case incidents (repeated figure)

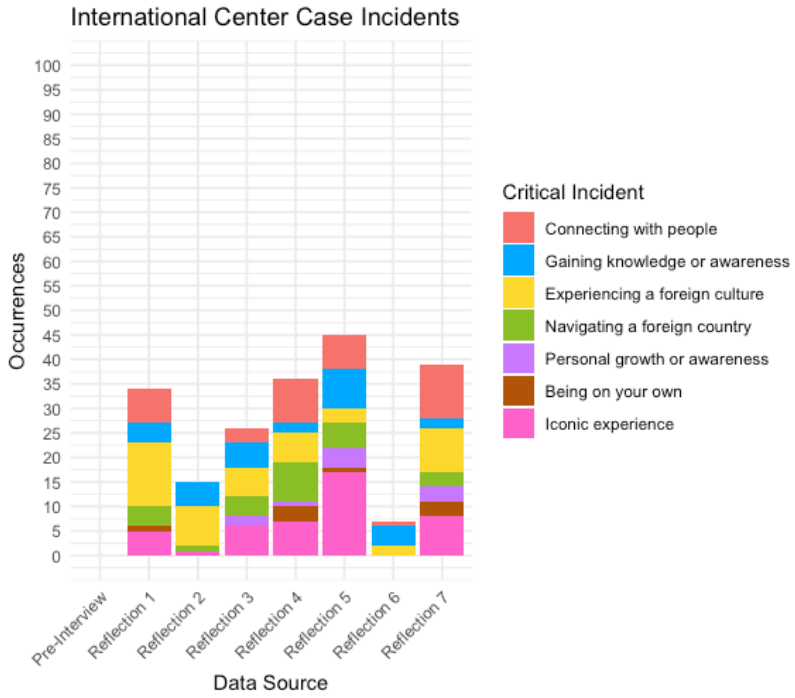

Figure 8.5: International Center case incidents (repeated figure)

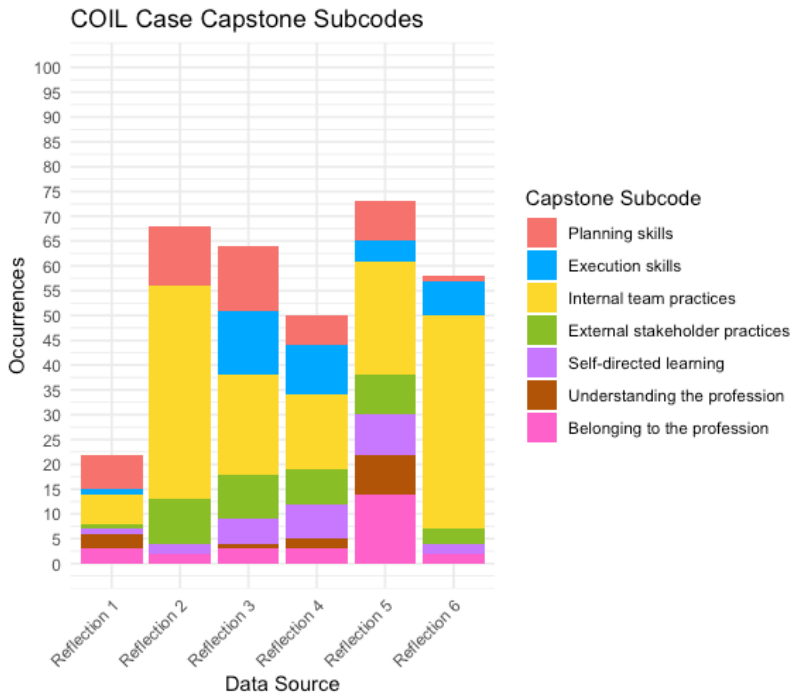

Figure 8.6: COIL capstone case subcodes (repeated figure)

gaining knowledge or awareness as they observed cultural practices.

Although the Capstone coding framework is not directly about incidents, it provides insights into what students were experiencing throughout the course and can be seen in Figure 8.6. Planning skills were important early on and gradually traded off with execution skills, as expected. Internal team practices were discussed more frequently than external shareholders, particularly in the final reflections abroad. Students discussed self-directed learning and understanding/belonging to the profession less frequently than the previous codes except in the final semester reflection, where they were significant. In the profession codes, belonging was more commonly coded than understanding, which is understandable for students near graduation.

Davis [32] authored a previous study investigating the most significant Critical Incidents that students shared during interviews after studying abroad. The programs included a study

tour, short-term coursework, IRES, internships, and semester-long study abroad. Across all participants, the most common incidents were connecting with people, personal growth or awareness, and experiencing a foreign culture. The least common incidents were being on your own, research, and iconic experience [32].

My study had several differences in program design to this previous research. Both studies had IRES participants, but the International Center context was unique to my study. Students reflected longitudinally during the programs, instead of in hindsight as in that prior work. I coded every story students told of events as incidents, even if it was outside the critical incident prompting. IRES students were given the critical incident prompt each week, but it was only explicitly in Reflections 3 and 5 for the International Center students, as can be seen in Appendix B. Additionally, I coded personal growth or awareness differently. Davis defined personal growth as situations where internal change was the event that was most significant to students, as opposed to an external occurrence [32]. Since I was coding competencies as in a separate coding process, I was looking for events where the main focus was growth, instead of all events that included personal growth.

The results from my study show what students spend time reflecting on during programs, instead of in hindsight. My results in Table 8.1 were that the most common incidents in both cases were connecting with people, gaining knowledge or awareness, and experiencing a foreign culture. The frequency of connecting with people and experiencing a foreign culture aligned with Davis's findings [32]. Iconic experiences were uncommon in Davis's results and in my IRES case, but very common in my International Center case [32]. This difference indicates the significance of traveling and seeing new places to students enrolled in the International Center. However, it could be possible that in the months or years following the program, those events may not retrospectively be as important to those students. With my definition, personal growth was an uncommon code and only seen in the International

Center case. A similarity with Davis's findings were that in the longer program, being on your own and iconic experiences occurred more frequently [32]. A difference is that in my study, experiencing a foreign culture and gaining knowledge or awareness were frequent in both cases and uncommon in her results.

These insights into students' immediate perceptions of their experiences are valuable since most studies include pre-post program data, or only post-program reflections [116, 130]. Returning to these cases and investigating how these same students look back on their experiences with the benefit of time could be a valuable future investigation.

8.2.2 Program Dimensions

To explore the second research question of how students develop global engineering competency across different international engineering program designs, I examine the dimensions of comparison that were first discussed in Section 2.3 and how this study's results compare. The section organization is based upon the case characterization given in Table 3.2.

Virtual programs

There was a call for further research into the impact of virtual programs on student learning, particularly since STEM involvement has been limited in COILs and other online international programs [8, 9, 105]. A prior study that compared virtual to in-person international programs indicated that in-person programs were associated with multiple cultural competencies: understanding, interest, and openness [8]. In Ball et al.'s study [8], students completed a quantitative survey to self-assess the programs' impact on their learning. If these outcomes are categorized through my current study's global engineering framework, there were indications that in-person students gained more integrated Technical and Global

competencies, with gains in understanding the impact of culture on engineering products [8]. In contrast, during the COIL case through the virtual component, there were themes of learning about the impact of culture on engineering projects and cultural exchange. This finding indicates that the longitudinal qualitative data may illuminate learning in COILs that students are less confident in when completing a quantitative survey. When examining their learning emergently during the program, however, it is clear that students in the COIL case were developing Global competencies, in particular integrated with Professional or Technical learning.

Additionally, comparisons with the in-person cases can illuminate learning that was absent or significant to the COIL. The in-person collaborative engineering work in IRES and the immersion in the International Center can be explored compared to the COIL's virtual experiences. Learning that was discussed in IRES but not in the COIL included integrated Professional and Global aspects of lab safety, work-life balance, and workplace cultural awareness. In the International Center case, the Global competencies that were not repeated in the COIL included language barrier, cultural acceptance, and day-to-day cultural experiences. The COIL students said that when they traveled in-person at the end of the semester they built relationships and continued their online cultural exchange.

My study found that students were able to begin learning about cultural exchange online, but not to the level of in-person experiences according to the COIL students themselves. The online experience conveyed integrated Professional and Global competencies effectively, along with some Global and Technical understanding of similarities and differences in software engineering, which was a new finding compared to previous research. Overall, my study illuminated the strengths and weaknesses of learning during the COIL case, which was a suggested future area of research [8]. This investigation was needed since COILs are a low-cost international encounter and can broaden access to global experiences for students who

may be uninterested in or unable to travel. It is notable that students are gaining significant Technical and Professional learning, as they likely would in a traditional capstone. Though the Global competencies were less extensively developed than during the most immersive experiences abroad, they were beyond what would have been gained in a traditional, domestic engineering course.

Duration

Previous studies found that semester-long programs tend to have the most positive intercultural results, especially when compared to short-term programs [23, 124]. There was not a true short-term experience in my study (i.e., of the one- or two-week duration). The two semester-long programs (International Center and COIL) were about 16 weeks long, and IRES was 6 weeks long. The closest to a short-term program was the COIL's 10-day program abroad, but that experience followed the longer-term virtual COIL experience. Isolated cultural learning during IRES was less extensive than the semester-long International Center program, likely because of the combination of duration, close cultural distance with no language barrier for the site in the United Kingdom, and limited time to travel extracurricularly, which was aligned with previous research [34].

By looking at Technical, Professional, and integrated competencies, however, it could be seen that IRES was still effective in teaching global engineering competencies, seemingly because of its experiential learning structure. This finding aligns with calls for interventions to support students' learning in shorter programs [10]. Students in IRES improved their organization and planning skills, ability to work cross-culturally, and research skills. This included integrated Global skills that students can apply to international workplaces. The results are that programs of at least medium length can impart aspects of GEC if they have impactful experiences.

The COIL students' program abroad was a short-term international excursion, and their final reflections took place in the middle of this portion. During this reflection, students made surface-level cultural observations, such as of the beauty of the area and differences in food, and this result is aligned with previous findings of limited learning during short programs abroad [23, 124]. These results indicate that it is difficult to gain significant global engineering competencies during study tours if they are not designed very intentionally. If a program is short, it is important to have high-impact experiences where students will be stretched beyond their comfort zones and superficial observations, as can be seen by the development during IRES. If a program is longer, it is more likely that students will naturally develop cultural learning as they experience new situations and meet people, so interventions are less necessary to meet the goal of global competencies. However, Technical and integrated Professional and Global competencies did not emerge unprompted in the International Center case, so interventions still are needed in programs of any length to develop these competencies, as discussed in Section 8.2.2.

Destination

Destination is a frequent method of comparison in prior literature but has been found to be difficult to disentangle from other program elements [34, 100, 117]. Students traveled to Switzerland or the United Kingdom in each of the three cases, with the International Center students traveling to several other countries during their extensive free time. The IRES students said that they perceived the United Kingdom as particularly similar to the United States during day-to-day interactions, but less so in the workplace. One interpretation is that the comfort and lack of culture shock in students' free time allowed them to observe and adapt to workplace differences without being overwhelmed by other cultural learning, which is a similar finding to previous work [114].

The International Center students had the most extensive standalone Global competency development, likely because of language differences, cultural distance, and time spent exploring new countries, all of which were discussed by the students. The language difference alone could have a major impact, as shown by prior research [34] and the IRES students' perception of the United Kingdom being similar to the United States since English is spoken.

A prior study compared students' learning in IRES programs in Australia and China, which offers a starker destination contrast than my study [35]. This research indicated that students who went to Australia were focused on their research and engineering skills, while the students who went to China discussed adapting to a new context and three cultural dimensions: experiences, skills, and challenges [35]. Though the cultures in the current study were more similar than in this example, there were similarities to the results in the IRES students' focus on research in a more culturally similar destination, though they connected cultural aspects to engineering. International Center students spent significant time reflecting on cultural interactions and observations, as the students in IRES China did [35].

Other studies have defined the depth of students' understanding of international experiences as moving from observation to interaction, then participation, and embracing other practices as the most advanced cultural learning [119]. By this definition, students in both the IRES and the International Center cases were achieving advanced cultural understanding, but in different spheres. IRES students observed and took on local norms when it came to workplace interactions, running research studies, and collaboration. In the International Center, students were conscious of their culture in personal interactions and embraced new perspectives on eating customs and perspectives on engineering priorities.

In the COIL case, students spent the semester at their home campus before traveling to Switzerland for 10 days. The destination did not seem to have as significant of an impact as their interactions with peers from both Switzerland and Egypt, since their time to explore

the area was limited. During the online portion, students observed cultural similarities and differences in their international peers' descriptions of their interests and made observations when they arrived in Switzerland. COIL students also learned about interacting with other cultures and said that they became more comfortable communicating across cultures.

Overall, this study underscores the difficulties of isolating destination as a factor but provides indications that students cannot be stretched in every area of international programs, as previous studies have found [114]. If the cultural context is more similar to what students are used to, they may have more capacity to observe detailed differences in workplace collaborations and reflect on how they can adapt, as the IRES students did. If students are overcoming language differences and overall culture shocks, such as in the International Center program, they can come to cultural acceptance over time but may overlook professional and technical cultural differences that are specific to engineering.

Experiential learning

Prior quantitative and qualitative comparisons indicated that experiential learning is vital to gain intercultural skills and technical competency [24, 117]. There have also been calls to comparatively investigate the differences between types of experiential learning [48]. The International Center case was the only one without hands-on, collaborative experiential engineering learning. Students in the International Center case were still able to gain Global competencies from extracurricular and program-led travel. Integrated Technical and Global competency came from coursework, which did involve a level of active learning as students toured cities and learned about engineering priorities and differences.

During experiential learning programs in the IRES and COIL cases, students learned extensive Technical, integrated Technical and Professional, integrated Professional and Global,

and fully integrated competencies. In IRES, students joined an existing research team and applied their skills to projects led by the PI faculty. Students compared their experiences to domestic research groups and saw how culture can impact researchers and participants. They also took on new perspectives on work-life balance, lab safety, and collaborations.

As students in the COIL case built their teams and collaborated on a new project, they gained skills in self-directed learning, international communication, and collaboration on software projects. They were able to lead their teams with more ownership of the work, though the dimensions of competency development overlapped with IRES.

In Spenader and Retka's study [117], they found that service learning was associated with quantitative gains in intercultural learning. Programs without hands-on activities had little or negative intercultural development, such as increased biases or resistance to adaptation. In contrast, the qualitative data collection in my study illuminated that students in each program were learning about global skills, but the domains of knowledge were different. In the IRES and COIL cases, significant cultural learning was in the professional and engineering contexts, which can be seen because of the development of integrated competencies. Students in the International Center had positive intercultural gains, but it was primarily personal and outside of engineering, coded as Global competency. By comparing the different program dimensions, experiential learning seems to be one of the most important program design elements to include in international programs in order to increase integrated Global Engineering Competencies.

Program dimensions with less apparent influence in these cases

Dimensions from Table 3.2 that were not impactful or not substantially different between programs in my study included mode of program delivery, entry target language competence,

coursework language, and housing [38, 84].

The home (U.S.) institution was substantively involved in all three international programs. U.S. institution program leaders partnered with the U.K. institution for IRES, and home institution faculty taught the courses in the International Center and COIL cases. It is notable that students in IRES and the International Center programs particularly valued the mentorship and relationships they built with program leaders. In the COIL case, students appreciated the insights they gained from the faculty instructor, but the higher student-to-faculty ratio led to a less individualized relationship.

The coursework was taught in English in all cases, with additional introductory language learning in the International Center. Language learning can be considered a global competency [3, 65]. IRES took place in an English-speaking country, which contributed to the minimization of cultural differences from students' perspectives. In the International Center case, students were in a non-English speaking country (Switzerland, although many individuals speak English) and regularly communicated with individuals who did not speak English as a first language. If they had second language competence, students were able to practice. Students were required to take an introductory Italian language course, but did not discuss the course in their reflections. The COIL course was instructed in English, and the international peers all spoke English well enough to take the course. The time abroad was short-term, and students did not discuss language in this case. Overall, a shortfall of multilingual competence has been a barrier to engineering students' enrollment in international programs, particularly since foreign language coursework requirements are often limited in engineering curricula [49]. The cases in my study and many other engineering global programs purposely do not have entry target language competence requirements to improve accessibility for U.S.-based students. My results showed dimensions of what students could learn about other cultures without language immersion.

Housing was not significantly different between cases. Prior studies that discuss housing frequently investigated the impact of host families [5, 48]. No students in my dissertation's cases lived with a host family. In IRES, students had purchase items for their dorm rooms quickly which taught them about adapting to a new context. In the International Center case, students formed relationships with the staff at the center and enjoyed living and eating their meals together. For the COIL, students did not experience abnormal housing during the semester since it was a virtual program.

For the program design dimensions of mode of program delivery, entry target language competence, coursework language, and housing, my current study does not differentiate these elements enough to offer new insights into existing literature. It shows how programs which are accessible to engineering students in these areas advance students' global engineering competencies.

8.3 Implications for Research

This section includes a summary of my dissertation's contributions to Engineering Education theory and methods.

8.3.1 Contributions to Theory

In its original form, the Global Engineering Competency framework used as the basis for the codebook of this study includes the three individual competencies: Global, Technical, and Professional (Figure 2.1) [3, 18]. Cook [25] combined the same framework with other definitions [66, 101] to create a conceptual model of global comparison. Prior research has noted the issue of apparent visual connections but definitional disconnects between the different

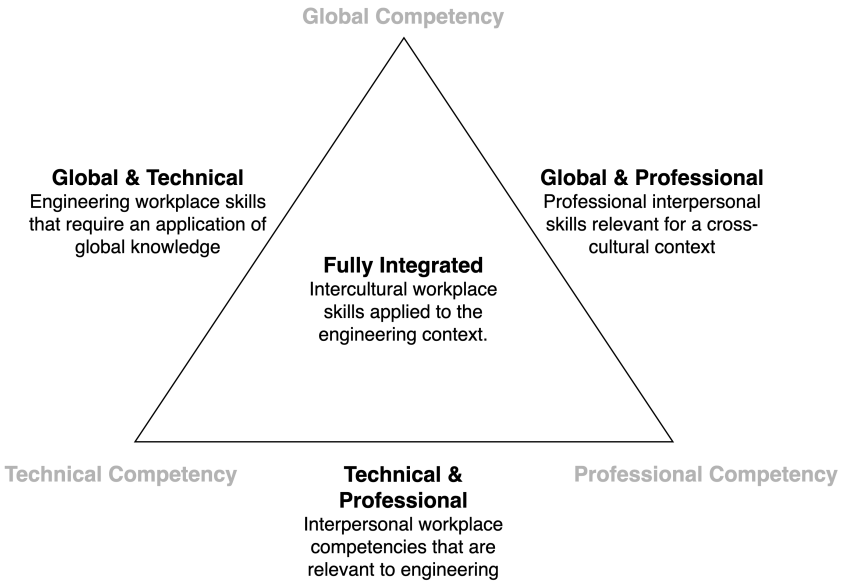

Figure 8.7: Global Engineering Competency with integrated competencies

dimensions of Global Engineering Competency in this framework [25, 32]. My dissertation addressed this issue by defining each integration (Professional-Global, Global-Technical, etc.) as seen in Figure 8.7 and demonstrated the framework's applicability to qualitative coding with updated definitions for each competency. The definition of each code can be seen in Table 3.10. I also identified emergent themes within each defined code, as discussed in the case reports. My expanded version of this framework has the benefit of illuminating a range of individual and integrated competencies and elucidating students' learning in each case. This clarifies findings from prior research that students focus on intercultural learning more than engineering development in international programs [32]. The use of the expanded GEC framework illuminated that students' global learning is intertwined with their engineering development. For example, the occurrences of purely Global competencies were not extensive in IRES. By coding using the integrated framework, the results showed that students were consistently learning integrated Professional and Global competencies (as seen in Figure 8.1), which may be a more useful learning outcome for their future engineering careers

than Global competency on its own. Students also demonstrated an understanding of fully integrated Global Engineering Competency, and the significance of that form of learning would not have been captured with only the original three competency domains.

Allert et al.'s original model was developed out of qualitative data collection: discussion sessions, interviews, informal conversations, and presentations [3, 18]. Other research by Cook [25] and Davis [32] used this framework in their creation of a conceptual model of GEC and in comparison to other definitions [3]. My study was the first to use it as a coding framework for reflection and interview data. The results showed its utility in illuminating longitudinal development by revealing stark differences in experiences in cross-case analysis. One example is a comparison of the proportional frequency of integrated Technical and Professional competency in the International Center and COIL cases. In Figures 8.2 and 8.3, it can be seen that Technical and Professional competency infrequently occurred in the International Center cases except during Reflection 6, while it emerged and remained consistent in the COIL case.

The Capstone coding framework was developed in settings with the following engineering disciplines: Mechanical, Chemical, and General [76]. Ford et al. [39] used it as a framework in a study with Mechanical Engineering and Engineering Science students. Computing Education Research's framing as a discipline or sub-discipline has been a subject of discussion due to Computer Science's placement within or separate from engineering departments [29]. My study's use of this framework for a Computer Science capstone with a focus on Software Engineering increases the argument for the robustness, usefulness, and transferability of the framework.

8.3.2 Contributions to Methods

There have been prior calls for investigations into international programs to include data collection that moves beyond pre-/post-surveys [32, 119, 128]. Researchers who implemented video reflection data collection encouraged others to do so in more contexts and investigate its applicability [130]. The spoken reflections in my study similarly provided an open-ended medium for students to speak about their most meaningful incidents and learning. The prompts, listed in Appendices B.5 - B.7, are a resource for other researchers to use as they create relevant prompts. The findings on best practices for their implementation are a significant contribution to research and follow in Sections 8.3.2 and 8.4.2. In particular, the consistent IRES prompts proved to be less useful than creating different prompts—as was done in the other cases—which is an insight that future researchers should take into account.

Reflection feedback

To collect feedback on the data collection method, I asked "What was your experience with the video and audio reflections?" during the IRES interviews. In students' responses to this question, students gave feedback to change the prompts for each reflection, which I went on to do in the other cases. One example of negative feedback on the prompts from a student who did not complete the spoken reflections included not wanting to put in time to reflect and disliking the questions:

> I struggle with open-ended questions. That's just a thing. And then I was just lazy and I just don't want to do more work and have to use my brain, and I feel bad, but I have no idea to answer this question. *Hailey, Post-Program Interview*

Previous research compared media of reflection and found that recording reflections can be

stressful. In a prior study of reflections during a short-term program, very few students preferred recording spoken reflections over writing or face-to-face interviews [17]. My study differed from the context in this previous work by taking place during longer programs. I asked IRES students to compare their thoughts on written and spoken reflections. Two of the six students preferred spoken over written. Nathen discussed the difference in his opinions from his peers:

> I personally prefer written because I think I can expand more on things because I'm not a very good speaker. So it helps to be just writing stuff up and then editing and things like that instead of just going. But that's just personal. I heard that Noah or some other kids, they preferred [spoken reflections] because they can talk about it personally and go in more depth because they don't like writing as well. *Nathen, Mid-Program interview*

Colleen preferred spoken reflections because of the quick completion. She also referenced the reflections being useful in the future, which was a finding in previous work [17].

> Thinking and consolidating my thoughts, even though I'm not going to put that recording in my portfolio is helpful to think of like lessons I've learned... I think If I did write it out, I might not say as much just because it can be a little more time intensive. *Colleen, Mid-Program Interview*

In the other two cases, I did not ask about the experience of reflecting but some students gave positive extemporaneous feedback:

> I actually do really like these audio recordings. A lot of other people in the program say they don't, but I'm a big rambler. So it's fun to just break [everything] down. *Abigail, International Center, Reflection 4*

> Checking in with the final reflection of the year. These have been pretty nice for just recollecting and reminiscing on this semester. So I'm actually glad that I ended up doing them. Hopefully I'll go back and listen to them when I get home. *Conner, COIL, Reflection 7*

Conner noted the positive aspects of the recordings that correlated with findings of other studies. Students hope to listen to them in the future, which can encourage further reflection [15, 17].

A notable incident in the COIL case was during the final reflection abroad. A student included a group member from Egypt to participate in his recording.

> **Ryan:** The perceptions of the team didn't change. Actually, I was how smart they were, when I met them in person, how smart and talented they all are.
>
> **Egyptian student:** He's very good at making jokes.
>
> **Ryan:** No, it wasn't a joke. I was so serious... Our teamwork's been really great, especially as we've gotten into the country together. *Ryan, Reflection 6*

This example is indicative that he was enjoying doing the reflection and saw it as an opportunity to record his interaction with his teammate.

As discussed in Section 7.2, the reflection lengths in my study varied from 1:10 to 13:33 across all cases. Outside of IRES, the shortest reflections were over three minutes long. The lengthened reflections in the other two cases indicated the effectiveness of the improved prompts. In Heinrich and Rivera's study [56], students were reflecting daily during a week-long experience and students submitted videos between three and 29 minutes long. It is also notable that in my study, a majority of students chose audio reflections instead of video. Prior studies have frequently required video reflections instead of giving the option

of audio-only [67, 100, 130]. In Chan and Wong's study, 151 students could select between interviews, written, audio, or video reflections. Only five students selected video and one selected audio [17]. Participants' preference for audio instead of video is a new finding from my study. Audio-only recordings reduce the amount of non-verbal communication that can be observed by researchers but may be worth tradeoffs in reducing the anxiety of recording themselves. A notable difference is that the participants in my study who recorded video reflections would typically sit at their desk to record, while the students who recorded audio would frequently be outside or walking around. This may support the informal and off-the-cuff nature of the audio-only reflections. A few students referenced looking at their notes, and the amount of preparation students may do before reflecting was a question raised by Chan and Wong [17].

Overall, the high participation rates and positive responses are a contribution from my study since prior research on the impact of audio-recording reflections is limited [17]. Further recommendations follow in Section 8.4.2.

8.4 Implications for Practice

The implications for practice include summarized differences between program types and learning from them in Section 8.4.1, along with best practices for implementing reflections in experiential learning in Section 8.4.2. Suggestions for stakeholders are included in this section and in Appendices D and E.

8.4.1 Program Differentiation

Program leaders should differentiate the international programs they are running so students can make informed decisions of how to spend their money and time [38]. Institutions can use the detailed exploration of each case in my dissertation to provide in-depth overviews to students of what they can expect to learn in each program type. Following is an example summary for each of the three cases:

IRES: Through the IRES program, you will be embedded in a research group abroad. You will gain professional skills in managing research projects and collaborating with others. This program provides you with opportunities to see how engineering research is completed in a new setting and the impact that culture has on the workplace, which will prepare you for future cross-cultural collaborations. You will gain an understanding of the global nature of engineering work and rethink prior assumptions about how work must be done, such as work-life balance and how the same project can have different impacts across cultures.

International Center: The International Center program offers the opportunity to spend time immersed in another culture while you learn about your own values and capabilities to adapt to new situations and cultures. In your engineering classes, you will see firsthand how engineering projects and processes differ abroad as you connect this learning to sites that you are visiting across Europe. You will meet new people from diverse backgrounds as you explore new cultures, overcome challenges, and see iconic sites. By living abroad, you will learn about the day-to-day cultural differences of life in Europe. The quick pace will help you to learn about time management and focus. This will be a time of intense personal growth.

COIL: Students who enroll in the COIL capstone can expect to gain the same competencies that you would in a typical capstone: technical engineering skills, the ability to

creatively solve a real-world challenge, and professional communication and project management abilities. In addition, you will gain awareness of other cultures' communication styles and engineering practices while you build relationships with your peers from other countries. You will be able to point to this experience as a time when you coordinated with a stakeholder to meet their requirements by working with remote colleagues. These experiences will well-prepare you for future online and international collaborations.

Additional high-level recommendations for program leaders of these three program types are in Appendix D. Overall insights for stakeholder groups are in Appendix E.

8.4.2 Best Practices for Spoken Reflections

When introducing spoken reflections to students, emphasize the positive benefits of completing the activity. These include:

- The overall benefit of reflection is deepening learning [56].
- When comparing spoken to written reflections, less time is needed to prepare and edit spoken reflections.
- These reflections provide a chance to practice speaking about your experiences, which will be a valuable skill when referring back to your international engagement in the future, particularly in setting such as job interviews.
- The reflections themselves can be a valuable reminder of your learning.

Additional lessons that I learned for effectively implementing spoken reflections are listed below:

- Provide a guideline on the recommended minimum length of reflection.

- Change the prompts for each reflection based on relevant recent activities.
- Have an incentive for students to complete the reflections, such as a completion grade. Students may hesitate to record themselves but once they do, they often find that they enjoy doing the reflections or it is at least manageable.
- Allow students to select either video or audio reflections.

My study had students submit their reflections by email or online form, which is a free method. Prior research has used paid services such as Indeemo [130] or ReCap [100], so the transferability to an unpaid platform is a benefit.

Overall, students need to set aside time to process their new experiences, and spoken reflections are an option that can be integrated into programs without significantly increasing their workload.

8.5 Future Research

Along with the three cases discussed in my dissertation, I collected data from a traditional version of the software engineering capstone course. Both sections of this course (i.e., the traditional and the COIL) were taught by the same professor, and the students in each section worked in a team to deliver a solution to an open-ended software engineering problem. The future comparison of the two courses will allow me to uncover differences and similarities in learning outcomes across the two different versions of the capstone design course and interrogate the extent to which international elements contribute to students' global engineering competency development.

Future research will include applying this research design to different types of domestic experiential learning programs. In all new experiences, encouraging students' real-time reflection

can deepen their learning [56, 70]. It would be valuable to longitudinally investigate undergraduate research programs, early hands-on courses, and co-op experiences to see if students are achieving the targeted learning outcomes.

For international programs, my dissertation has provided a baseline investigation into examples of an International Center engineering semester and a capstone COIL. Previous research into these types of programs is limited, so further investigations with different data collection methods could differentiate which aspects of learning are generalizable to these types of programs and what is specific to program design decisions.

This study uniquely examined students' real-time experiences and reflections during global programs, as opposed to other pre/post-program comparisons. Combining both approaches would be a valuable future study. By following up with the students who participated in my dissertation study, I can examine if the experiences that were significant to them during the program are still at the forefront when time has passed, particularly as they have entered the workforce. These findings could lead to a transferable understanding of the correlation between real-time reflections and long-term impactful experiences.

There are more types of engineering-specific international programs to which the expanded GEC framework could be applied. A significant context would be a short-term study tour program, since short programs are a growing percentage of study abroad experiences [61]. In engineering, these experiences are often paired with a course before the time abroad (as described in [68]. Other experiences that could be investigated include on-campus international experiences, engineering exchange programs, and internships abroad. The process in my study and the updated framework, particularly with the conceptualization of integrated competencies, would be valuable to apply in these new contexts

8.6 Conclusions

The reasons to engage in global programs have been grouped in four categories: curricular, cross-cultural, development, and career enhancement [59]. Each of these benefits were seen in one or more of the cases included in my research. Students had learning experiences that would not have been available otherwise, experienced cross-cultural interactions, developed and matured personally, and said that these experiences would prepare them for future career decisions and advancement. My study met the goal of investigating whether global programs designed to be accessible to engineering students were having positive impacts on students [92]. It also differentiated the experiences and learning between different program dimensions using the Global Engineering Competency framework [3, 84, 129].

This multi-case study created an understanding of the Global Engineering Competency outcomes that students develop during different types of international programs that are designed for undergraduate engineering students, which was one of the guiding research questions. The richness of data from a case study allows the reader to identify elements that can be transferred to other contexts [12]. My study adds to comparative international programs literature and includes a unique group of experiential learning contexts. Global research, international study abroad centers, and COILs are emerging types of international programs designed to fit into engineering students' curricula. The differences in types of experiences and how they were connected to competency development between these programs were explored to answer the second research question. Students' reflections during the programs generated understanding of the types of experiences they are having and how students viewed these experiences as affecting their learning. The data were collected in the moment throughout engagement in the programs, so that longitudinal changes were explored. The spoken medium was valuable to illuminate new dimensions of learning com-

pared to prior work that relied on written reflections or quantitative measures. The act of reflecting is valuable, and leaders of both international and domestic experiential educational experiences may be interested in implementing similar spoken reflection into their planning.

The outcome of this study is that the alignment between the purposes of different types of international programs and how they are designed can be more clearly understood. A significant theme was that one of the most effective ways to convey global engineering competencies is to introduce and reinforce learning in different formats. For example, if students can learn about a topic in class and then apply that in experiential projects or observe it with real examples, they are much more likely to achieve a learning outcome. Program leaders can make design decisions about the program dimensions based on their desired learning outcomes for students. For existing programs, institutions can communicate to students what they can hope to learn from them. Institutions can implement the types of experiences that are meaningful to students in their international programs that are offered domestically or abroad. At a very high level, my research aimed to help engineering programs continue designing a variety of ways to support the development of global engineers who can effectively collaborate in international and intercultural settings to solve global problems.

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Appendices

Appendix A

First Appendix: IRB Documentation

A.1 Recruitment for Participation Script

Done in the orientation meeting.

You are invited to participate in a study seeking to understand your experiences at [study abroad program]. The purpose of this study is to identify what you learn in the program and why.

You all will be doing video/audio reflections during the program and submitting them to program leaders. We would like to include these in our study of your experiences by learning from your reflections. We will also be offering a survey and conducting interviews before and after the program, which we will follow up on. If you are willing to let us use your data, please sign the consent form. Let us know if you have any questions.

A.2 Recruitment for Interviews

Subject Line: Invitation to Participate in Interview About [study abroad program]

Dear [student],

You are invited to participate in a study seeking to understand your experiences in [study

abroad program]. The purpose of this study is to identify what you learn in the program and why.

We are writing to invite you to participate 30-45 minute interview about your experiences in the program. These interviews will be completed on zoom. Please reply if you are interested and we will schedule a time with you.

We do hope you will choose to participate in this exciting research. If you have any questions, please let me know.

Sincerely,

Andrea Schuman

A.3 Participant Consent Form

Informed Consent for Participants in Research Projects Involving Human Subjects

Title of Project: Engineering Students' Development of Global Competencies through International Programs

Investigator(s): Dr. David Knight, Andrea Schuman

I. Purpose of this Research/Project

The purpose of this study is to investigate how and why students develop competencies in international research experiences in order to learn about their experiences and improve the programs.

II. Procedures

You will be asked to participate in interviews and agree for us to use your video reflections and survey responses as valuation data for academic publication and presentation purposes.

III. Risks

The risks associated with participating in this research are minimal.

IV. Benefits

Data from the project may enhance the program this semester or in the future. More broadly, data from the study could improve similar international research experiences for students more broadly.

V. Freedom to Withdraw

You are free to withdraw from participation from the research at any time without prejudice, penalty, or any other negative consequences.

VI. Extent of Confidentiality

Your identity, and that of any individuals you mention, will be kept confidential at all times and will be known only to members of the research team. The interview will be audio recorded and later transcribed. The video/audio reflections you submit will also be transcribed. When transcribing the recordings, pseudonyms (i.e., false names) will be used for your name and for the names of any other people who you mention. These pseudonyms will also be used in preparing all written reports of the research and applied to your survey results. Any details in the interview recordings that could identify you, or anyone you mention, will also be masked during the transcription process. After the transcribing is complete, the interview recording will be stored in a secure online location. Identifying information will also be removed from any notes made during the interview. It is possible that the Institutional Review Board (IRB) at [Institution] will view this study's collected

data for auditing purposes. The IRB is responsible for overseeing the protection of human subjects who are involved in research.

V. Subject's Responsibilities

I voluntarily agree to participate in this study and acknowledge that I am over the age of 18. I have the following responsibilities:

- I agree to answer questions honestly
- I agree to allow the researcher to audio record interviews
- I agree to allow the researcher to use direct quotes with a pseudonym

VI. Subject's Permission

I have read the Consent Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent.

STUDENT SIGNATURE

STUDENT PRINTED NAME

DATE

I ***do not*** grant permission to researchers to present this information in the manner described on this form.

STUDENT SIGNATURE

STUDENT PRINTED NAME

DATE

For questions regarding the study, please contact the investigators:

Dr. David Knight

Andrea Schuman

Should you have any questions or concerns about the study's conduct or your rights as a research subject, or need to report a research-related injury or event, you may contact the Institutional Review Board at [email] or [phone number]

Appendix B

Second Appendix: Data Collection Protocols

B.1 Student Pre-Program Interview Prompts

Welcome

- Introductions and overview of research goals.
- Overview of the interview process/IRB information
- Questions about the conversation/confidentiality

Interview Questions

1. What motivated you to enroll in a study abroad program?
2. What prior international experiences have you had?
3. How have these influenced your college and professional decisions and goals?
4. What is a global engineer? What does it mean to be a global engineer?
5. What skills do you think global engineers need to be successful?

6. Which of these skills have you begun to develop? How?
7. What do you anticipate you will get out of your enrollment in [this study abroad program]?
    - Professionally?
    - Personally?
8. What are you most excited about as you look forward to the time abroad?
9. What are you most nervous about as you prepare for the time abroad?

Closure

1. Is there anything I didn't ask you about that I should have?
2. Do you have any final thoughts you have not mentioned yet that you think would be helpful for the research team to know?

Thank you very much for your time and consideration!

This is a semi-structured interview, where relevant follow-up questions may be asked.

B.2 Student Mid-Program Interview Prompts

Interview Questions

1. How has your IRES experience been so far?
    - What have been the highlights?
    - What challenges have you faced? How have you managed them?

2. What are a few things you have learned in the first half of the program?
    - Knowledge, skills, attitudes
    - What have you learned about yourself?
3. How has the program changed or expanded your understanding of what it means to be a researcher? What research skills have you begun to develop?
4. How has the program changed or expanded your understanding of what it means to be a global engineer?
5. What global engineering skills have you begun to develop?
6. What do you anticipate you will get out of your participation this program?
    - Professionally?
    - Personally?
7. What has been your experience with the video and audio reflections?
8. What are you most excited about as you look forward to the rest of your experience?

Closure

- Is there anything I didn't ask you about that I should have?
- Do you have any final thoughts you have not mentioned yet that you think would be helpful for the research team to know?

This is a semi-structured interview, where relevant follow-up questions may be asked.

B.3 Student Post-Program Interview Prompts

Interview Questions

1. How has your transition back to the U.S. been?
2. What are a few key things you learned through [study abroad program]?
    - Knowledge, skills, attitudes
    - What have you learned about yourself?
3. How has your time at [study abroad program] influenced the work you are doing now that you are back at school?
4. How has the program changed or expanded your understanding of what it means to be a global engineer?
5. What global engineering skills have you begun to develop?
6. I'd like to talk about 2 specific experiences that were meaningful to you during your time studying abroad. For these examples, I'd like you to think of a time where you felt that you learned something important (and this could be any kind of learning, about research, culture, travel, yourself, etc.). For each experience, can you explain:
    - What happened?
    - How did you respond?
    - Why was this experience meaningful to you?
    - What did you learn from this experience?
    - How does this relate to your larger experience abroad?

- How has/will this experience influence you going forward?
- What, if anything, did this experience show you about another culture?
- What, if anything, did this experience teach you about yourself?
- Did this experience relate to engineering in your mind? If so, how?

7. How has your time studying abroad influenced your plans for the future?
    - Professionally?
    - Personally?
8. What was your experience in the in-person and online courses during the semester?
9. What are some practical suggestions to help us improve the program for next year?
10. What were the most helpful parts of the experience?
11. What were the most challenging parts of the experience?
12. What was your experience with the video and audio reflections?

Closure

- Is there anything I didn't ask you about that I should have?
- Do you have any final thoughts you have not mentioned yet that you think would be helpful for the research team to know?

This is a semi-structured interview, where relevant follow-up questions may be asked.

B.4 Program Leader Interview Prompts

1. Please describe your experience with the [program] in detail.
2. What do you see as the value of this program for students? (open-ended first, then the following learning outcomes)
    - Engineering
    - Professional interpersonal
    - Global
    - Personal
3. What factors facilitated and hindered student learning through the program?
4. What do you think is the difference between this type of study abroad program and other international programs? (exchange, long-term, etc.)
    - What are benefits to each model?
    - What are negative aspects to each model?
    - What is the difference compared to studying at the home campus?
5. What are some practical suggestions to help improve future iterations of this program?
6. What were the most helpful parts of the experience?
7. What were the most challenging parts of the experience?
8. In what ways has your future work been influenced?
9. If you worked on this program again, would you do anything differently?
10. Anything I didn't ask about?

This is a semi-structured interview, where relevant follow-up questions may be asked.

B.5 IRES Reflection Prompt

Please record a video or audio of yourself reflecting on the past week of the program. Choose from as many of the questions below that are relevant and helpful to your reflection. There are no length requirements for this reflection.

1. Culture includes aspects of languages, time, space, clothing, food, work, ethics, and technical knowledge. What were your observations about culture this week?
2. Did your perceptions about culture change this week? How?
3. Would what you observed about culture have an impact on engineering in this context?
4. Which activity from this week had the greatest significance to you? Why?
5. What did you see or learn this week that challenged or changed your previous thinking personally?
6. Why did it challenge or change your thinking?
7. What did you see or learn this week that challenged or changed your previous thinking about engineering?
8. Did it affect your perception of global engineering?
9. Why did it challenge or change your thinking?
10. What do you hope to learn next week?

B.6 International Center Reflection Prompts

B.6.1 Repeated for Each Prompt

Video/Audio Reflection Due [date]

Following are the instructions for completing your reflection. Reflecting regularly on your learning has been shown to have benefits while studying abroad and we hope these recordings are valuable for you to take away from the program.

Instructions:

Set up your phone or other recording device and speak about your experience in a 6 to 10 minute video or audio reflection. You are not expected to edit this recording. Use the prompts in the next section to guide your reflection.

Prompts:

Included in next section

Submission:

The reflection is due [date] at 5pm (Switzerland time). Submit the reflection by sending it to Andrea at [email].

B.6.2 Prompts Compiled

Reflection 1

The beginning of a program abroad is a unique time to notice cultural differences that could become normal to you in a few weeks. Culture includes aspects of languages, time, space,

clothing, food, work, ethics, and technical knowledge. Learning about culture can come from observing people's behaviors, speech, and interactions as well as symbols and physical elements of a community. Culture shock comes with observing the differences and conflict between what you are used to and where you are now.

- What were your observations about culture this week?
- Have you had any experiences with culture shock?
- Would what you observed about culture have an impact on engineering in this context?

Since this is the first week, you have had to adapt to a new environment and begin a new semester.

- Which activity from this week had the greatest significance to you? Why?

Feel free to speak about anything else you have been reflecting on as you made the transition to the International Center.

Reflection 2

The program at the International center is designed to give you the opportunity to experience engineering in a new context and to expand your perspective on the field. First, we hope to capture your view on global engineering near the beginning of the program.

- How would you define a global engineer?
- What experiences have informed your definition?

This week, try to observe new or challenging ideas related to engineering or otherwise. Challenging ideas can create deep learning.

- What have you seen or learned that challenged or changed your previous thinking about engineering?
- Why did it challenge or change your thinking?
- Did it affect your perception of global engineering?
- What did you see or learn this week that challenged or changed your previous thinking personally (related to culture, values, etc.)?
- Why did it challenge or change your thinking?

Feel free to speak about anything else you have been reflecting on during the last couple weeks of the program.

Reflection 3

I would like you all to think about two specific experiences that were meaningful to you during your trip last week where you felt that you learned something important (and this could be any kind of learning, about engineering, culture, travel, yourself, etc.). For each experience, can you explain:

- What happened?
- How did you respond?
- Why was this experience meaningful to you?

- What did you learn from this experience?

Since you all have traveled to multiple locations during the excursion and potentially during personal travel, this is a good time to share thoughts on:

- What are the cultural differences you have observed by comparing the places you have visited?
- Are there any differences in engineering you can observe?

Feel free to speak about anything else you have been reflecting on during the last couple weeks of the program.

If you did not do the reflection last week, I would appreciate if you could answer: *How would you define a global engineer*?

Reflection 4

The semester is almost halfway done! I would like you to take some time reflecting on the first half of your experience:

- What have been the highlights of your experience so far?
- What challenges have you faced? How have you managed them?
- What are you most excited about as you look forward to the rest of your semester?

Reflection 5

I would like you all to think about two specific experiences that were meaningful to you during your group trip to Rome or your personal travel after where you felt that you learned

something important (and this could be any kind of learning, about engineering, culture, travel, yourself, etc.). For each experience, please explain:

- What happened?
- How did you respond?
- Why was this experience meaningful to you?
- What did you learn from this experience?

The final question is for you to look back on the effect this program overall has had on you. *How do you think you have changed since you started this semester? Have you learned anything about yourself?*

Reflection 6

I hope that these reflections can help you to capture aspects you may eventually forget about your experience.

- What does a typical day for you in [Switzerland] look like?
- Are there any aspects of the culture or lifestyle that you hope to incorporate into your life next semester and beyond?

Returning to the questions about global engineering from earlier this semester:

- How would you now define a global engineer?
- What have you seen or learned this semester that challenged or changed your previous thinking about engineering?

- Why did it challenge or change your thinking?
- Did it affect your perception of global engineering?

Reflection 7

Here are some prompts to consider as you think back over the whole semester. Feel free to include anything else that stands out to you.

- What were the highlights of your experience?
- What challenges did you face? How did you manage them?
- Were there any intercultural experiences that stand out to you while looking back on the semester?
- Has this experience impacted your plans for the future?

B.7 COIL Case Reflection Prompts

B.7.1 Instructions for Reflection

Reflecting regularly on your learning has been shown to have benefits for reinforcing new material and skills. We hope these recordings are valuable for you to take away from this course.

Read through the prompting questions and think about what you want to say. Then set up your phone or other recording device and speak about your experience in a 6-to-10-minute video or audio reflection, using a voice memo or video app. You are not expected to edit

this recording. This should be faster than completing a written reflection because you will be speaking without editing.

Once it is complete, upload it to your OneDrive and share the link in the following form: [link]

Make sure that the permissions are your file are set up so Andrea can view the submission.

The faculty instructor will never have access to your reflections. All feedback and research will be kept completely anonymous.

B.7.2 Prompts Compiled

Video/Audio Reflection 1

In the first reflection, we are hoping to gain an understanding of your background coming into this course.

- How would you define design in computer science?
- What are your previous experiences with design work?
- What are your goals from this course?
- What do you hope to learn from this course?
- How does this course align with your plans for the future?

Video/Audio Reflection 2

Now that you have selected your capstone project, please describe what you will be working on. Then answer:

- Why are you interested in this problem space?
- How did your team come to this decision?
- What have the interactions with your team been like so far?
- How would you describe the strengths or advantages of the people on your team?
- What have you learned about team collaborations?

Video/Audio Reflection 3

The semester is about halfway done! I would like you to take some time reflecting on the first half of your experience:

- What has been your biggest challenge on this project, and how did you deal with that challenge?
- What are the most valuable things you believe you've learned from this course so far?
- What goals do you have for the second half of the course?
- What do you hope to do differently in the second half of this course?

Video/Audio Reflection 4

I would like you all to think about two specific experiences so far in this course where you felt that you learned something important so far in this course (and this could be any kind of learning; about engineering, teamwork, yourself, etc.). For each experience, please explain:

- What happened?

- Why was this experience meaningful to you?
- What did you learn from this experience?

Final Semester Video/Audio Reflection 5

For the final reflection of the semester, please think about overall what you have learned from this capstone project. Here are some prompts to consider as you think back over the whole semester.

- What was your biggest challenge on this project and how did you deal with that challenge?
- What are the most valuable things you believe you've learned from this course?
- Has this course changed how you view the field of computer science?
- Has this course changed how you view yourself as a computer scientist?
- What do you plan on doing when you graduate?
- How do you see the class preparing you for that situation?
- What would you do differently if you could start the semester over, knowing what you know now?

Trip Abroad Video/Audio Reflection

This reflection is specifically related to your trip abroad. Please describe your overall experience abroad.

- What were the highlights of your travel experience? What did you learn?
- How were your team interactions when meeting in-person compared to online this semester?
- Did your perceptions of the project or your team change from the travel portion of this course?
- Do you think you observed anything that cannot be replicated via remote connections?
- In thinking ahead, what do you think you might do differently when working remotely with international colleagues in the future?

B.8 Global Engineering Competency Survey

The survey is given in Tables X with the instructions *Please rate yourself on a scale of 1 to 5 of how much you disagree or agree with the following statements. 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree.*

Table B.1: GEC survey constructs and questions Part 1

Construct		**Question**
General global engineering performance	Q1	I am capable of working as a global technical professional.
	Q2	I am capable of working with people who define and solve problems differently than I do.
	Q3	I can only work with technical professionals from cultures similar to my own.
	Q4	I can work effectively in the global computer science profession.
	Q5	I can practice software engineering in an international setting.
	Q6	I can represent myself as a professional in a culturally appropriate manner.
Technical coordination	Q7	I understand the norms of team dynamics in different cultures.
	Q8	I can collaborate and work toward common goals as a member of a multicultural team.
	Q9	I can identify, resolve, and minimize conflicts resulting from cultural differences.
	Q10	I am capable of leading a multicultural team.
	Q11	I can function effectively as a member of a multicultural technical team.
	Q12	I can coordinate technical work that spans multiple countries.

Table B.2: GEC survey constructs and questions part 2

Construct		**Question**
Ethics, standards, and regulations	Q13	I am aware of variations in regulations and standards in different countries and regions.
	Q14	I am familiar with cross-national/cultural differences in professional ethics.
	Q15	I can effectively deal with ethical issues arising from cultural or national differences.
	Q16	I am familiar with cross-national differences in intellectual property laws.
	Q17	I can make sound ethical decisions in the context of a culture divergent from my own.
	Q18	I can negotiate ethical conflicts caused by cross-national/cultural differences.
Engineering Cultures	Q19	I am familiar with cross-national/cultural differences in software engineering practice.
	Q20	I understand how culture affects perceptions of the computer science profession throughout the world.
	Q21	I can approach computer science tasks in culturally appropriate ways.
	Q22	I am unfamiliar with how culture influences software engineering project design.
	Q23	I can adapt my technical knowledge and skills to different local conditions.
	Q24	I am familiar with the historical development of the computer science profession in other countries.
	Q25	I understand how my perspective as a technical professional may be different from that of technical professionals in other countries and regions.

Table B.3: Cultural Intelligence Survey constructs and questions

Construct		**Question**
Metacognitive		
	MC1	I am conscious of the cultural knowledge I apply to cross-cultural interactions.
	MC2	I check the accuracy of my cultural knowledge as I interact with people from different cultures.
	MC3	I am conscious of the cultural knowledge I use when interacting with people with different cultural backgrounds.
	MC4	I adjust my cultural knowledge as I interact with people from a culture that is unfamiliar to me.

Table B.4: Demographics questions from survey

Name	(for participant tracking)
What is your gender?	Female Genderqueer Gender non-binary Male Transgender Prefer not to say
What is your race/ethnicity? (select one or more)	Asian / Asian American Black / African American Latinx / Hispanic Native American / Indigenous White Prefer not to say
Are you an international student?	Yes No
Have you lived in a country besides the United States for more than 6 months?	Yes No

Appendix C

Third Appendix: Individual Participant Results

This appendix contains summaries of each participants' reflections. For the three cases, I took notes as I read each reflection. I used the notes and original reflections to write the individual and case narratives in the case reports. This chapter also includes coding graphs for each participant.

C.1 IRES Case

C.1.1 Noah

Reflection 1

- Little cultural difference in personal time, work-life balance, differences in communication, priority of safety and cross-cultural connections from research group
- Learning skills from the research project (PCB design)

Reflection 2

- More collaborative at work, directed to ask other people visiting international scholars

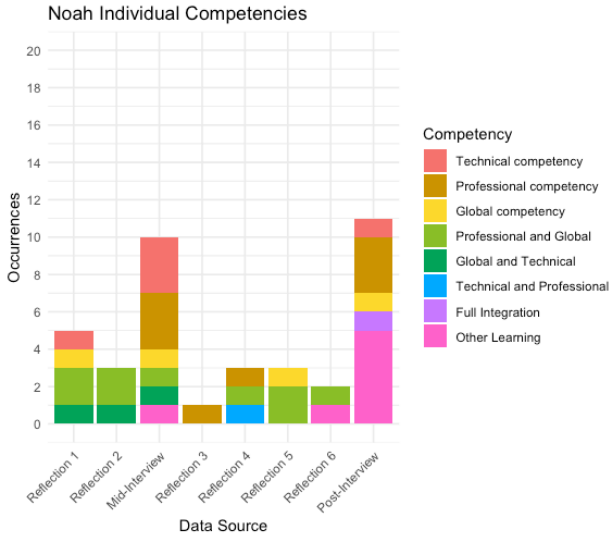


Figure C.1: Noah competencies

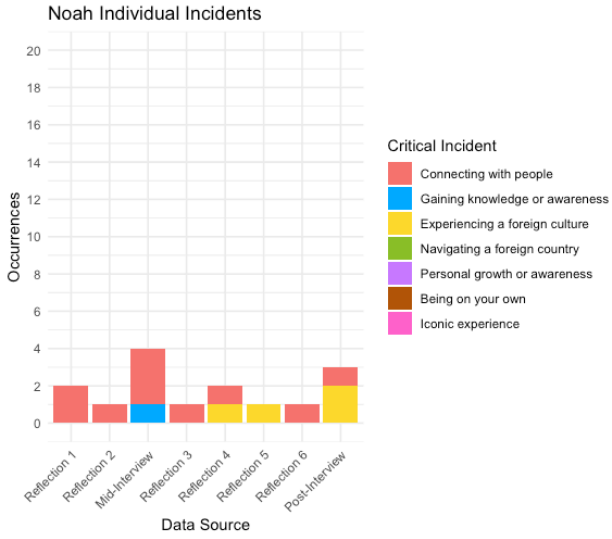


Figure C.2: Noah incidents

- Boundaries between work and life

Mid-Interview

- Favorite part is social aspect at work, getting together outside of work and setting firm boundaries with work
- Learning electrical skills and PCB design, literature review from pre-travel workshops
- Learning about the variety of career paths from talking at work
- Gaining an understanding of future career interests from experiencing engineering research
- Feeling rushed with six week time frame

Reflection 3

- Planned collaboration with other scholars to continue in the future

Reflection 4

- Views collaboration as a selfless act to improve science and knowledge, exchanging information about how to use software
- This experience is introducing the benefit of taking a real lunch break during the day

Reflection 5

- Experienced meeting people who speak English as a second language, motivated to practice another language and considering how that would benefit professional relationships

- Wants to deeply connect and build relationships, subvert expectations about the United States
- The office is empty during vacation, which reminds him of the U.S. workplace

Reflection 6

- Grateful for professional relationships, which were motivating at work
- Said engineering is the same in different countries but the workplace culture is different

Post-Interview

- Is a better researcher when it comes to reviewing literature and designing projects, spends more time planning and continues taking breaks
- Learned that engineers from different countries apply the same work in different ways
- Improved relationships and communication with other cultures
- Learned about changes in career paths
- Trying to build deeper U.S. relationships the same way he did in the United Kingdom
- Wants to stay in engineering research but work in a new context

C.1.2 Colleen

Reflection 1

- Overall observed that the cultures are similar, with some differences in communication having an impact on human factors research

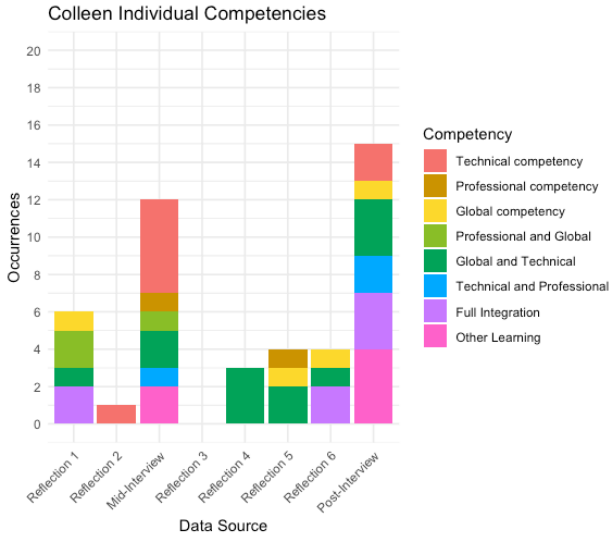


Figure C.3: Colleen competencies

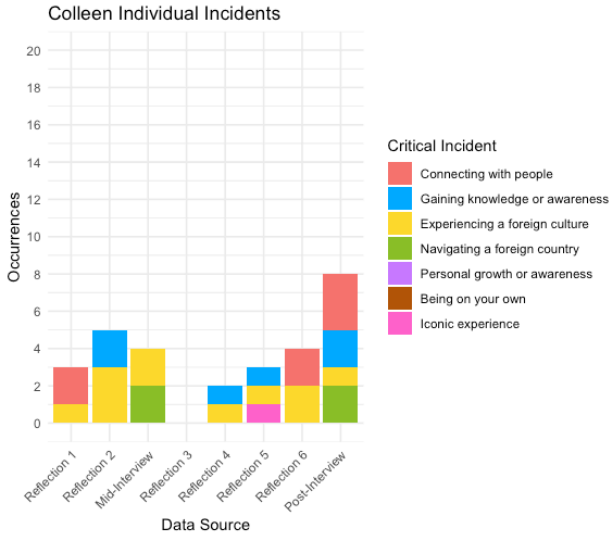


Figure C.4: Colleen incidents

- Connecting with people in the workplace led to the conclusion that professional interactions are different because of culture

Reflection 2

- Cultural similarities outside of work and some differences during work in terms of professional communication and working from home
- New discoveries in the research project lead to a pivot and gaining competencies of managing research projects

Mid-Interview

- Enjoying adapting to a new context with peers (day-to-day tasks in the United Kingdom)
- Experienced planning and implementing a research study (flexibility, managing projects) while observing cultural differences in the approach to work
- Valuing the inputs of local communities when doing international research because of differences in word choices about driving
- IRES is a good chance for personal growth and to gain confidence by trying new things and navigating a foreign country

Reflection 3

- N/A

Reflection 4

- During the first test of their study, Colleen and Nathen came up against the cultural differences between research ethics reviews in the United States and United Kingdom
- Connected to the broader prioritization of safety in both countries

Reflection 5

- Says that she hasn't experienced culture shock in a while
- Integration of technical and professional learning in performing further tests for the study
- Traveled to a national park which led to rethinking perceptions about rural life in the United Kingdom
- Seeing that it is possible to incorporate global participants, wants to repeat in the future in order to make research more robust and applicable

Reflection 6

- Visited Wales and worked with participants not from IRES for cultural experiences
- More awareness of small cultural differences: manual cars and hiking on private property
- By connecting with global participant, increased awareness of the danger of making cultural assumptions in engineering and the importance of communicating
- Observations on the difference between learning about culture and actually experiencing it

Post-Interview

- Specific technical learning (similar to last interview) Unity, human factor testing, protocols, along with broader management of research, flexibility, overcoming setbacks
- Enjoyed connecting with other researchers and goals of future international collaborations
- Based on professional and personal time, there is diversity within the U.K. culture that needs to be taken into account in engineering work and there are helpful similar researchers you can work with to make something specifically valuable
- Comparing lessons that were described vs. experienced for culture: modules said that U.K. culture does not have small talk but during personal time there was some. She learned this by observing local grad student
- Ran into difficulties with the technology, decided to start over with a change and it worked. Overcame sunk-cost fallacy
- Traveled after the program and met diverse people at a hostel. She learned not to assume you understand others. Instead, ask them questions because people can subvert your expectations
- Decided to go into industry
- Not a long enough program to get the dorm fully set up and prepare to cook, timeline was challenging

C.1.3 Nathen

Reflection 1

- Surprised by all the detailed differences in culture like food and clothing

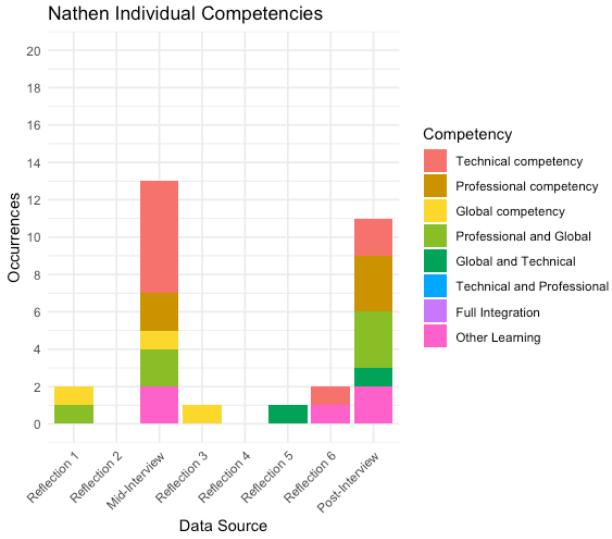


Figure C.5: Nathen competencies

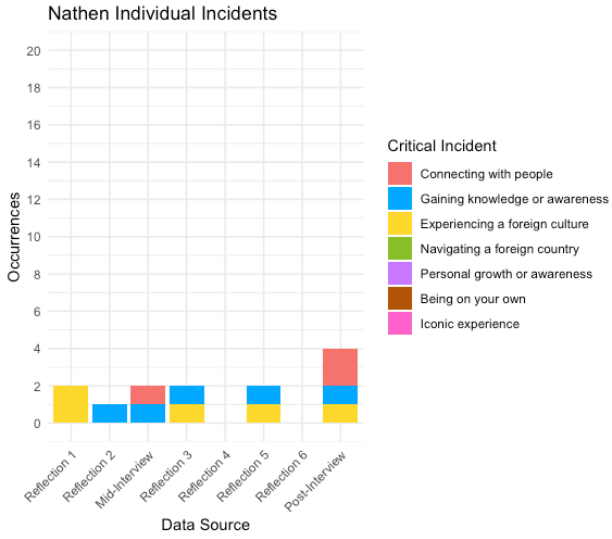


Figure C.6: Nathen incidents

- Happy with support from faculty

Reflection 2

- Described research work and struggles (same project as Colleen)

Mid-Interview

- First time doing research outside of home university, impressed by faculty and equipment, learned about relying on peers and faculty
- Experiencing research and overcoming challenges
- Programming in Unity, doing IRB, using surveys, software, designing research
- Workplace is supportive and has work-life balance but still passionate, anticipates that other countries would do it differently
- Learned communication with accents and flexibility
- Professional and personal connections (with IRES peers)
- Tested out cultural differences that were presented pre-program and found that some were not relevant
- Prefers written reflection but knows some peers really like spoken

Reflection 3

- Observed cultural climate commitment through local sustainable transportation options

Reflection 4

- N/A

Reflection 5

- Received IRB approval and began recruitment
- Observed differences in IRB processes between countries

Reflection 6

- Finished project for the summer and presented preliminary findings
- Developed research skills, connections, and motivation

Post-Interview

- Will continue collaboration on this research project moving forward
- Learned the different approach to research, more detail oriented. Had difficulty articulating how he would apply this learning
- Learned from facing challenges that he tends to get frustrated but by working with peers he improved flexibility
- Learned about literature review and how recruitment is different, curious about what it would look like in other countries
- Biggest incident was changing and having to redo part of the study. He learned that the prior work was not a waste and could be learned from

- Iconic experience with peers was one of his best memories
- Interested in continuing PhD
- Recommended changing the reflection prompting questions

C.1.4 Arthur

Reflection 1

- Adjusting to daily life and research, noted differences in food and side of the road to drive on (similar to others) along with time zones

Reflection 2

- N/A

Mid-Interview

- Excited to learn about the cultural differences in work (Arthur is an international student)
- Gained experience setting up to live in a new place and starting with a new research group
- Challenges of restarting a research project with poor records that has been dormant
- Learning about new software and materials from literature
- Look at the same research from a different cultural lens leads to diverse thought (similar to others)

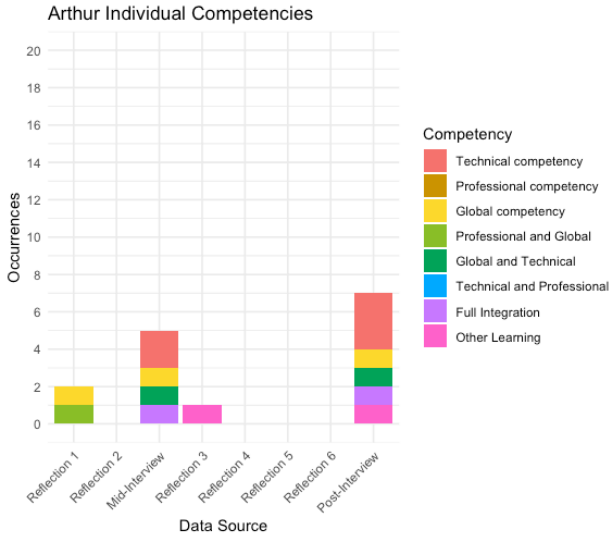


Figure C.7: Arthur competencies

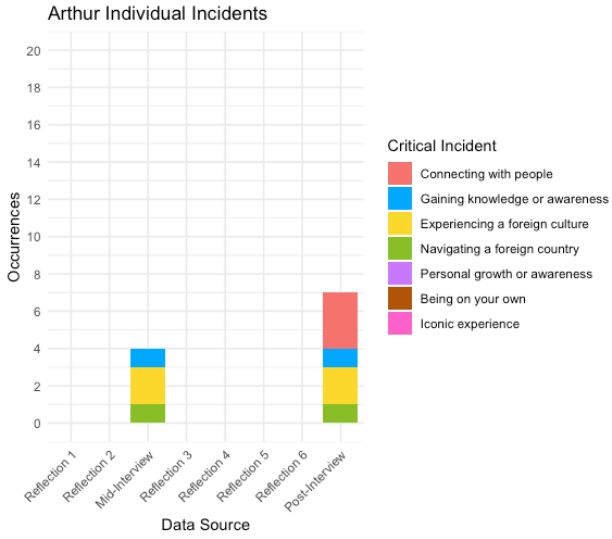


Figure C.8: Arthur incidents

- Chance to think about the social impact of engineering research projects
- Believes that the new experiences and friends will change his long-term perspective
- Prefers written reflections
- Making progress with experiment and writing of research (grad student), at this stage thinks the short projects are better for undergrads

Reflection 3

- Sees someone with an engineering PhD who has gone into a completely different field (similar to others)

Reflection 4

- N/A

Reflection 5

- N/A

Reflection 6

- N/A

Post-Interview

- Happy to work with a new team and have connections for the future
- First time living in a dorm with undergrad peers, says broadly that they learned from each other and enjoyed spending free time together

- Says that he had previously done research but now happy that he experienced doing a rapid project because he learned about efficiency. Additionally, there were no other research assistants on his project so he was in the weeds doing experiments and back to basics
- People have different perspectives on research, scientific units are different
- Mentored by postdoctoral students as he considers postdoc positions
- Culture shocks at first but then got used to things
- Summarizes as happy he enrolled in the program, which is a change from the mid-program interview

C.1.5 Hailey

Reflection 1

- N/A

Reflection 2

- N/A

Mid-Interview

- N/A

Reflection 3

- N/A

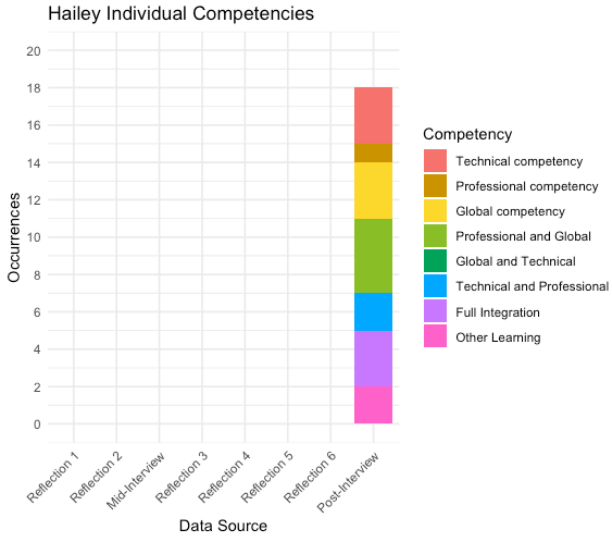


Figure C.9: Hailey competencies

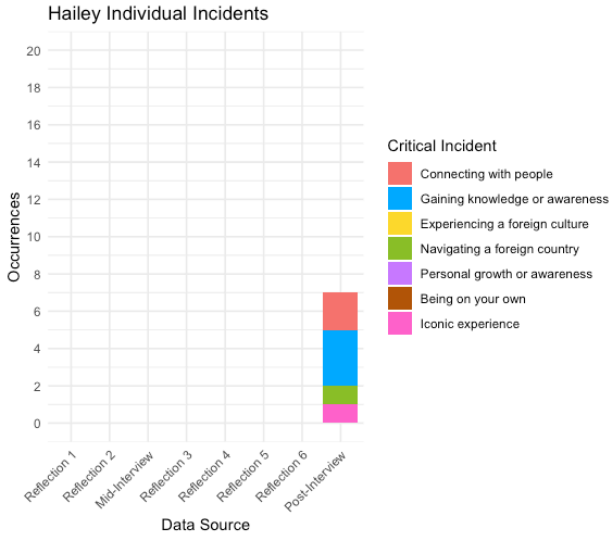


Figure C.10: Hailey incidents

Reflection 4

- N/A

Reflection 5

- N/A

Reflection 6

- N/A

Post-Interview

- Better progress and understanding of the research project from being in-person
- Observed cultural differences in professional spaces such as with communication
- Learned about disciplinary differences from the transition from physics to engineering
- Enjoyed the interplay between engineering theory and simulation in [U.K. Institution], increased disciplinary interest
- Technical skills of simulation, meaningful time learning from [U.K. Institution] advisor
- It subverted her expectations that collaborations in engineering are international as well, despite intellectual property law
- Gained awareness of cultural impact on own communication style (cultural self-awareness)
- Was told by advisor to have better work-life balance and visit sites
- Learning how to schedule and deliver outputs throughout the program

C.1.6 Joey

Reflection 1

- N/A

Reflection 2

- N/A

Mid-Interview

- Typically works alone, satisfied with the quality of the lab equipment which makes it manageable to complete the project in six weeks
- Learned to apply technical skills in a new lab
- Did not find the cultural differences significant
- Standardized safety rules in [U.K. Institution]
- Glad to meet new people and will leverage professional connections in the future
- Learned from travel transportation difficulties
- Hung out with peers outside of work but didn't particularly learn from it
- Never likes to take the time to reflect
- Overall the experience is a 40-hour work week then free time to have fun outside that

Reflection 3

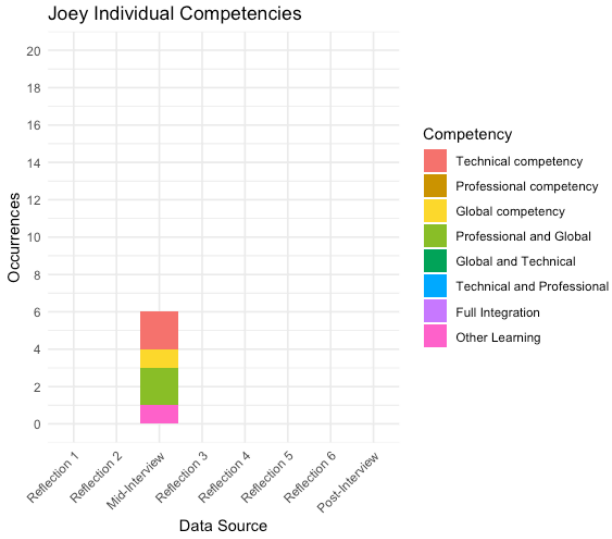


Figure C.11: Joey competencies

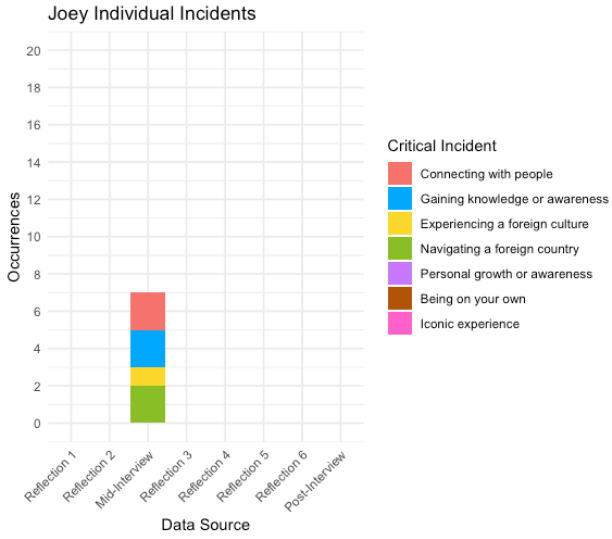


Figure C.12: Joey incidents

- N/A

Reflection 4

- N/A

Reflection 5

- N/A

Reflection 6

- N/A

Post-Interview

- N/A

C.2 International Center Case

C.2.1 Ella

Pre-Interview

- Prior international experiences include visiting family in Central America, plus a school trip to France
- Combines professional and cultural in open-mindedness for definition of a global engineer

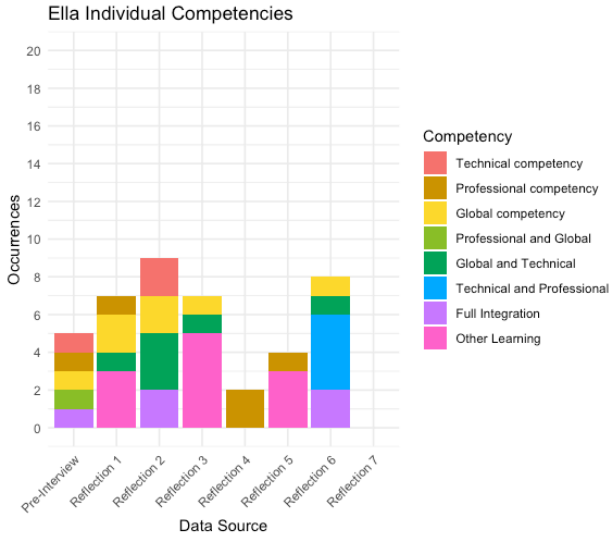


Figure C.13: Ella competencies

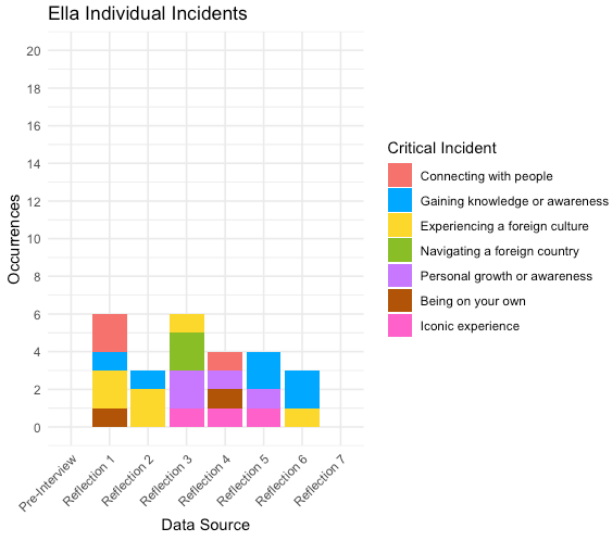


Figure C.14: Ella Critical incidents

- Did mention different regulations later, wants to learn more professional and global skills
- From wealthy part of the state, said she's lived in a bubble

Reflection 1

- In the Global Food class, she has observed cultural differences including that physical spaces are created to encourage connection
- Not significant culture shock because the Center is run by [U.S. Institution] staff
- Cultural difference in civil engineering speed but overall engineering is similar
- Significant to have a group activity with the Civil program and learn more about one another for a small class
- Has casual conversations with the faculty members
- Went outside her comfort zone by going on trips and experiencing new things
- Trying to balance time management

Reflection 2

- Integration of global ideas and technologies in global engineering, while being mindful of the impact
- Learned from classes about the history of civil engineering and influential engineers
- Swiss aesthetic prioritization in design
- Cultural differences in alcohol's role, Europeans are focused on connecting and eating slowly

Reflection 3

- Toured Germany for her birthday
- Described personal growth in standing up for her value that she does not want to drink
- Significant travel issue in Germany, stayed out overnight to save money
- Growth, perseverance, maturity, learned that decision was probably not worth the money saved but sees the value of new experiences
- Observed cultural differences between Germany, Luxembourg, and Switzerland
- Impact on public transportation, connection back to engineering

Reflection 4

- Saw bridges on the course excursions and labs at [Swiss University]
- Took midterm exams
- Challenges are time management and studying, work-life balance
- Learning not to pressure herself
- Intra-program conflict and drama

Reflection 5

- Learned from travel that being on time is important, taking opportunities
- Learned about the historical importance of religion
- History of Rome

- Difficult time personally and academically, has new priorities and balance

Reflection 6

- Day-to-day abroad is similar to a day in the United States
- Value of slowing down and connecting
- Focused on technical and cultural integration for engineering
- History and cultural differences in engineering, then brings up incorporating ideas, methods, and technology from around the world to design for locals
- Says that professional aspects of engineering outweigh technical
- Long lifetime of engineering design and usage

Reflection 7

- N/A

C.2.2 Abigail

Pre-Interview

- N/A

Reflection 1

- Made one good friend so far

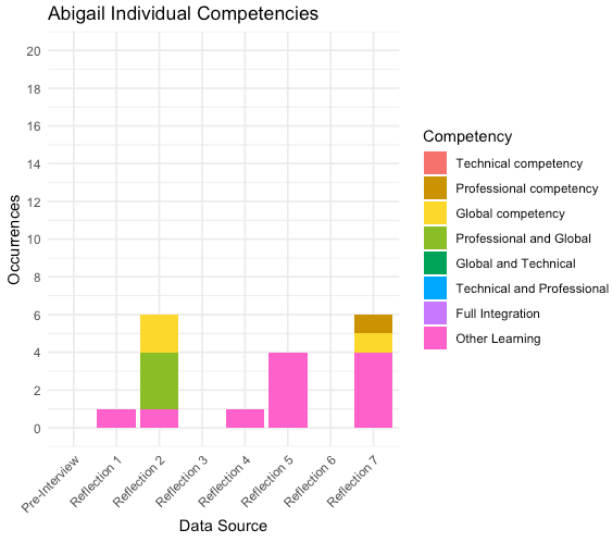


Figure C.15: Abigail competencies

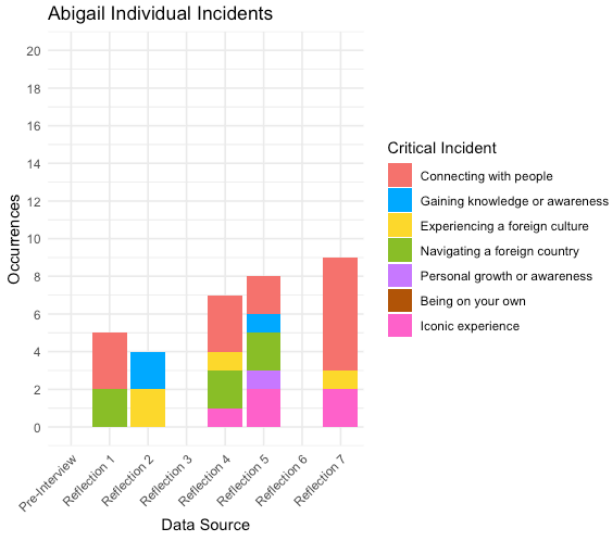


Figure C.16: Abigail incidents

- Group went to La Spezia, first experience meeting Italians and attempting to communicate
- Did preparatory learning of Italian language

Reflection 2

- Professional and cultural definition of a global engineer, working with local needs
- Has gone to see some bridges in class, similar learning about how they accommodate shutdowns during construction
- Observed work-life balance, differences in the economy, societal priorities

Reflection 3

- N/A

Reflection 4

- Solo trip to Copenhagen, visited Lego HQ, met people through hostel, enjoyed the culture of Copenhagen, led to exhaustion
- Conflicting feelings, loves being there but tired of translating and unfamiliarity (homesickness)
- Misses her friends and being in a large U.S. university with anonymity
- Planning two trips to Greece
- Said she enjoys the audio reflections

Reflection 5

- Close with some students but experienced group conflict
- Enjoyed the trip in Capri and Sorrento
- Learned about the history of Rome, navigating travel difficulties
- Learned that she is uncomfortable going into Catholic churches due to religious differences

Reflection 6

- N/A

Reflection 7

- Favorite part was interacting with people in and outside the International Center, practicing Italian
- Seeing great built sites and sharing travel experiences among the group
- Some weeks were lighter workload and other were heavier
- It is important to balance health and self-care
- Dealt with challenges by relying on others
- Biggest cultural experiences were meeting Germans at Oktoberfest and connecting with someone in Denmark, learning about their society
- Wants to be a civil engineer in the United States, not living abroad, too exhausting

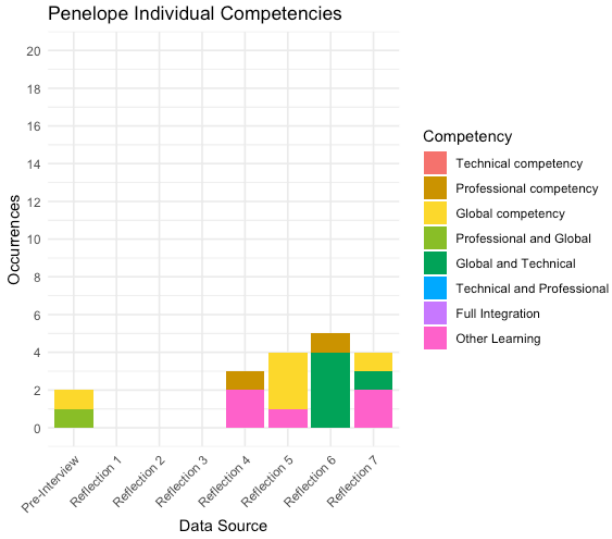


Figure C.17: Penelope competencies

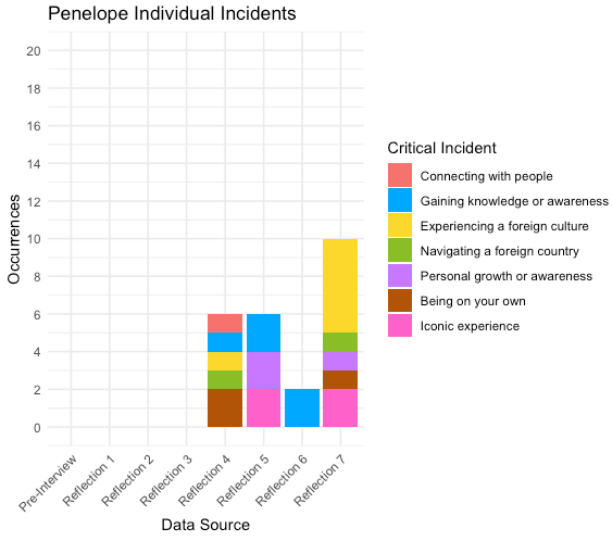


Figure C.18: Penelope incidents

C.2.3 Penelope

Pre-Interview

- First time abroad
- Professional and cultural adaptation definition of global engineering
- Learned a little Italian, excited to meet new people and see new cultures

Reflection 1

- N/A

Reflection 2

- N/A

Reflection 3

- N/A

Reflection 4

- Did a trip to Morocco, completely new culture
- Enjoyed meeting people, met a woman from Austria
- Big challenges are related transportation, learned problem-solving skills
- Hard to do schoolwork, wants to travel every weekend
- Doesn't feel at home in her apartment

Reflection 5

- Iconic experience of traveling in Naples and Pompeii, the remains there were evocative
- Saw the Acropolis, appreciates the value of learning about other cultures
- Says overall the program has had a big effect on her gaining cultural awareness and learning she enjoys intercultural experiences

Reflection 6

- Wants to keep up going on walks and taking breaks from work
- Global engineers understand the impact of engineering on different people, technical and cultural

Reflection 7

- Highlights of seeing the bridges in the group trip, history of Rome, culture of Morocco
- Difficulties were homesickness and the unfamiliarity of the environment
- Difficult to communicate, especially with a food allergy
- Differences in usage of infrastructure, beauty in Vienna, trip to Budapest
- More interested in career in structures, possibility of living abroad

C.2.4 Elizabeth

Pre-Interview

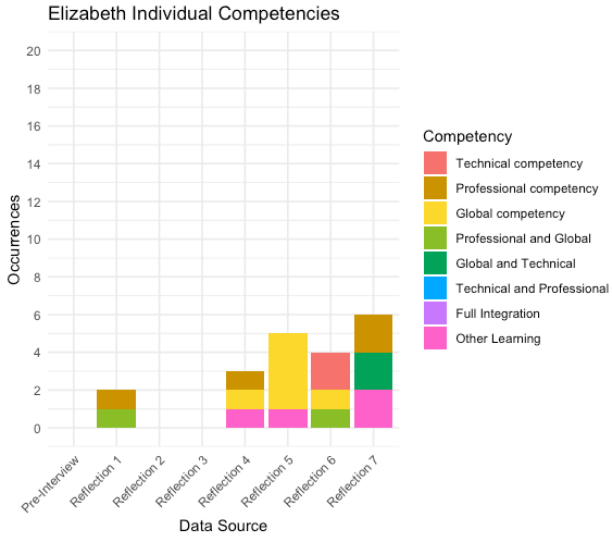


Figure C.19: Elizabeth competencies

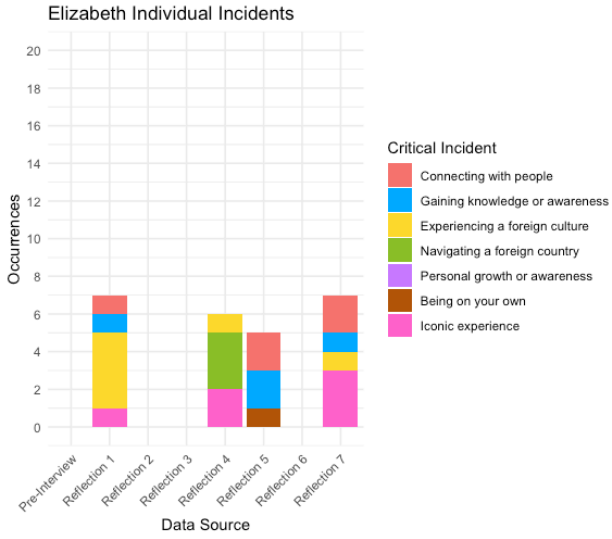


Figure C.20: Elizabeth incidents

- N/A

Reflection 1

- Born in Europe but did not live there long
- Global foods class visit to a vineyard led to learning about the science of wine-making
- Discussed difference in education systems, including explanations for kids going home for lunch
- Learned about cultural impacts on professionalism
- Significance of having small class sizes for asking questions and collaborating

Reflection 2

- N/A

Reflection 3

- N/A

Reflection 4

- Went to Formula 1, which she's a big fan of.
- Found it easy to travel, has learned how to travel with trains
- Had difficulty communicating in Germany, had more travel difficulties
- Had a trip to Ireland and enjoyed connecting with people

- Learning to balance travel and schoolwork

Reflection 5

- Birthday during the program trip to Rome
- Hotel staff sang for her birthday, she enjoyed talking to the staff about living in the moment and taking advantage of opportunities
- Talked about being away from home
- Met a local restaurant owner because of the food class, discussed culture and preserving history of her business
- Learned she is easygoing

Reflection 6

- Has been busy studying recently
- Adapted to eating without distractions like the local culture
- Focused on technical competency for defining a global engineer, then adds cultural openness
- Understands more about the field of engineering and similarities across cultures

Reflection 7

- Favorite parts of the semester were traveling
- Challenged by studying in close quarters, adapted

- Connected with International staff and [Swiss University] taught about cultural differences, met students
- Said that she learned differences in engineering standards by country
- Would work abroad someday
- Said she was immersed in the culture but the town is small

C.2.5 Sam

Pre-Interview

- Has traveled extensively, including a short-term study abroad and family trips
- Feels comfortable working cross-culturally
- Defines a global engineer as someone who works across cultures and benefits needs
- Is prepared to be flexible

Reflection 1

- Views Swiss culture as stricter and cleaner than the United States
- Engineers should design based on culture
- Observes infrastructure differences such as the roads being small
- So far it has been easy to keep up with work
- Took a trip to Cinque Terre, impressed by the ease of travel by train
- Met some Europeans and heard their opinions on Americans

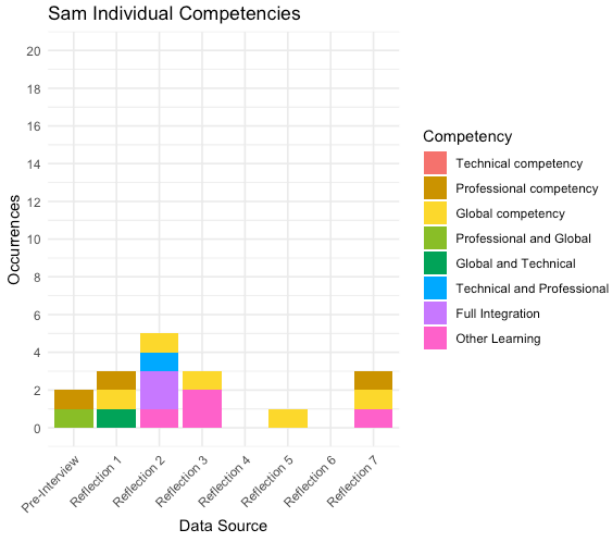


Figure C.21: Sam competencies

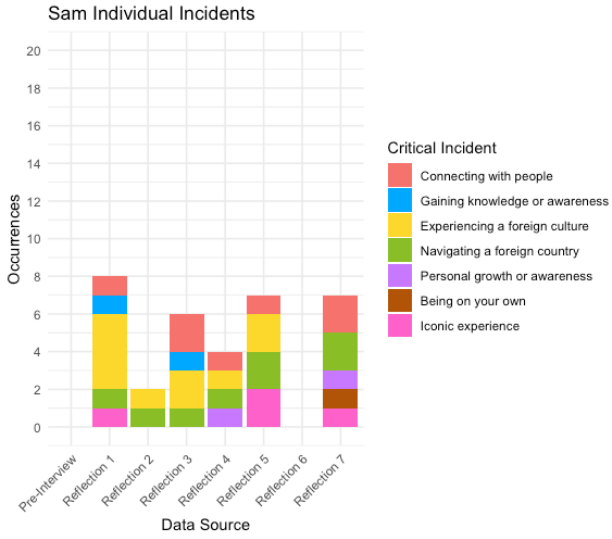


Figure C.22: Sam incidents

Reflection 2

- Gave a fully integrated definition of global engineering, including working in teams to design for other cultures
- Learned that he learns better in the smaller and experiential coursework
- Took a trip to Venice but disappointed by the over-tourism
- Learned about adapting to travel setbacks and cultural differences in timeliness

Reflection 3

- Met students in Europe, compared education systems
- More cultural differences within Europe
- Went to Oktoberfest, found the Germans they talked to nicer than Italians
- Learned to be flexible and go with the flow

Reflection 4

- Goal is to visit more countries
- Went to Dublin, still had culture shock with accents
- Emphasizes transportation issues
- Met with the professor, mentioned again that he feels more comfortable with small classes at the International Center

Reflection 5

- Impressed with history and sites of Rome, had a disagreement with a peer about non-religious views on the Vatican
- Learned about discounts for architecture students

Reflection 6

- N/A

Reflection 7

- Most significant experience is interacting with the professor, improved grades
- Spent Thanksgiving in Prague, saw local spots based on recommendations, became familiar with the city
- Overcoming travel challenges while staying calm, problem-solving
- Has become more confident, leadership
- Learned from overcoming language barriers

C.2.6 Conner

Pre-Interview

- N/A

Reflection 1

- N/A

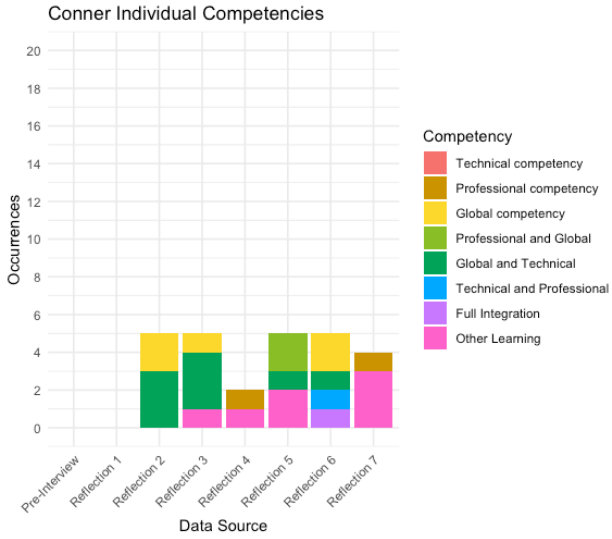


Figure C.23: Conner competencies

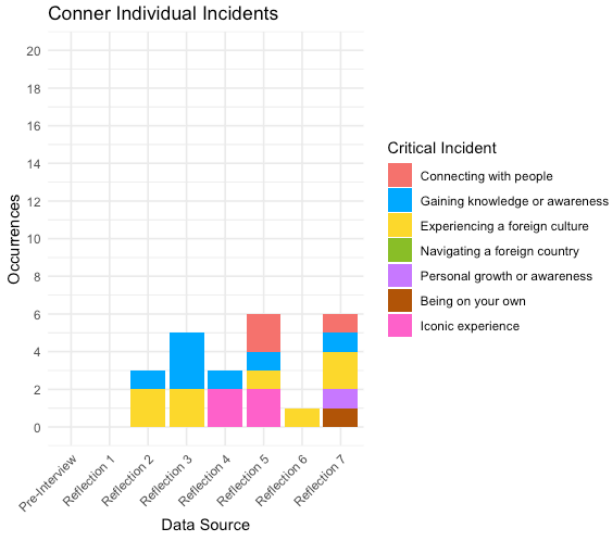


Figure C.24: Conner incidents

Reflection 2

- Defines a global engineer as someone who cares about global impact and sustainability
- Observed how trains in Switzerland demonstrate differences in culture and engineering compared to the United States, also compared road structures and biking
- Critical incident with trying to take food to go from cafeteria at International Center, cultural value of food
- Identifies as open to new cultures

Reflection 3

- Viewed bridges on the course excursion and differences in design
- Wants to be an engineer who makes a positive impact
- Visited another Swiss university, saw differences in education process and more interdisciplinary program
- Went to Barcelona and Budapest, observed cultural differences in each

Reflection 4

- Highlight was an art museum in Vienna
- Enjoyed spending time on the lake in Lugano
- Trying to grow personally and be less impulsive and manage time better

Reflection 5

- Observed engineering sites in Rome, how they were built
- Visited his aunt in Spain, did cliff diving, learned from her setting her own path
- Wants to see more of the world and make international friends
- Personally has become more observant, goes with the flow, has trouble focusing
- Liked recording the reflections

Reflection 6

- Wants to take life slowly, not about efficiency and achievement based on cultural differences
- Global engineering is integrating multiple perspectives and making global connections
- Wants to incorporate creativity with problem-solving and engineering, not imitating what has come before

Reflection 7

- In hindsight, glad he was able to reflect during these recordings
- Increased interest in bridge architecture and engineering after the excursions
- Learned about differences in other cultures from meeting British and Australians
- Wants to travel more in the future

C.2.7 Jackson

Pre-Interview

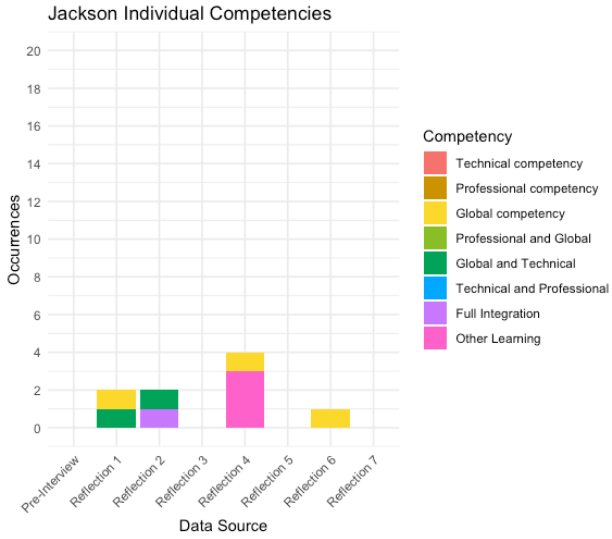


Figure C.25: Jackson competencies

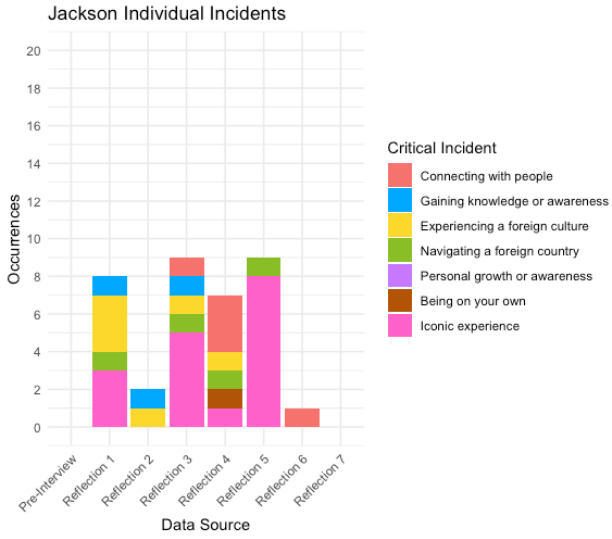


Figure C.26: Jackson incidents

- N/A

Reflection 1

- Traveled to Cinque Terre, new cultural experience with Airbnb host, favorite experience was iconic hike
- Cultural differences are that everything in the local town is closed on Sunday and there is little small talk
- Learn from class that building process and speed of engineering projects are different in Switzerland

Reflection 2

- Defines a global engineer with all three dimensions
- Cultural differences in bridge designs, more about aesthetic than cost in Switzerland
- Traveled to F1

Reflection 3

- Course excursion to see bridges, described what he saw but not what he learned
- The group got tired of one another and had some conflict
- Spent the rest of the week in Budapest
- Also traveled to Prague, learned about travel difficulty with strikes

Reflection 4

- Favorite aspect is meeting people during personal travel and at the International Center, previously came from a more homogeneous area and is in Greek Life at [U.S. Institution]
- Traveled in Spain
- Observed that nightlife is similar throughout Europe, not as heavy drinking as United States
- Biggest challenge is navigating travel
- Sad to miss events at [U.S. Institution] but lucky to be at the International Center

Reflection 5

- Went on program excursion to Rome, Pompeii, and Sorrento, then traveled to Greece
- Described itinerary, not learning

Reflection 6

- Describes how he eats and works out, observed differences in diet
- Talked about courses, not a fan of lectures

Reflection 7

- N/A

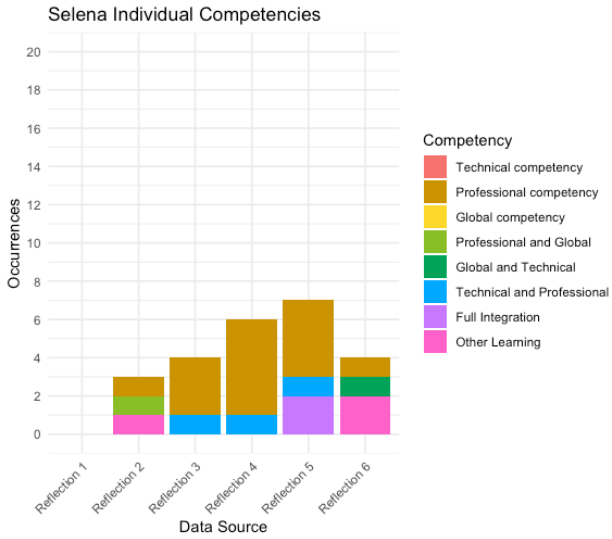


Figure C.27: Selena competencies

C.3 COIL Case

C.3.1 Selena

Reflection 1

- Goals of becoming a better software engineer by learning about global differences and to integrate that knowledge into her future work

Reflection 2

- Project is creating a hub of information for students studying abroad at the International Center (with Willow)
- Met with stakeholders, pivoted to focus on an internal app
- First time studying abroad
- Wants her engineering work to always have a positive impact

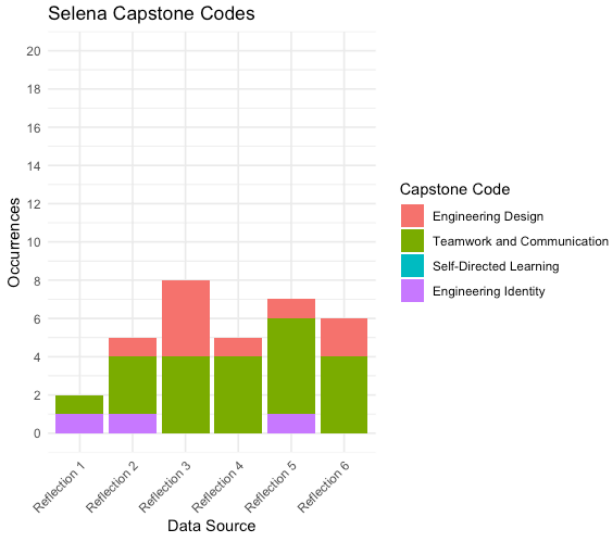


Figure C.28: Selena capstone codes

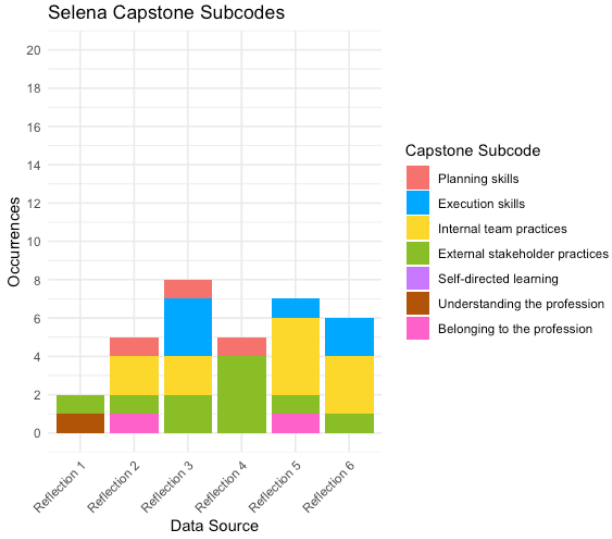


Figure C.29: Selena capstone subcodes

- Team is quick to communicate on Discord
- Deciding on splitting up tasks

Reflection 3

- Difficult to pivot the project's direction based on stakeholder's feedback and implement the project
- More challenges with time zones and prioritizing work
- Learned about iterating and changing projects and the importance of communication
- Feels a little behind on the project and wishes she had met with stakeholders more frequently

Reflection 4

- Significant experience: first meeting with stakeholders (previously discussed), learned the value of designing for users' needs
- Significant experience: demonstration to the professor where they were behind on their goals, learned to work more collaboratively instead of splitting up the project and working alone

Reflection 5

- Biggest challenge was coordinating a unified vision for the project but pleased that it was possible to coordinate internationally. It was vital that everyone was motivated
- Observed cultural differences in the field and appreciated the real-world skills of coordinating with a client

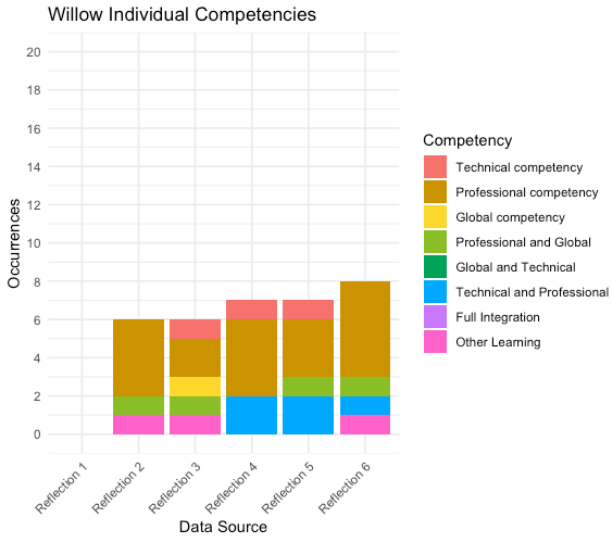


Figure C.30: Willow competencies

Reflection 6

- Highlight of travel portion was meeting the group and building relationships, becoming friends and working together
- In the future, she would meet group members more frequently and review code for one another

C.3.2 Willow

Reflection 1

- Goals of working with a diverse team
- In prior experiences, she has not coordinated with people of diverse countries of origin. There is a large portion of students at [U.S. Institution] from a wealthy part of the state

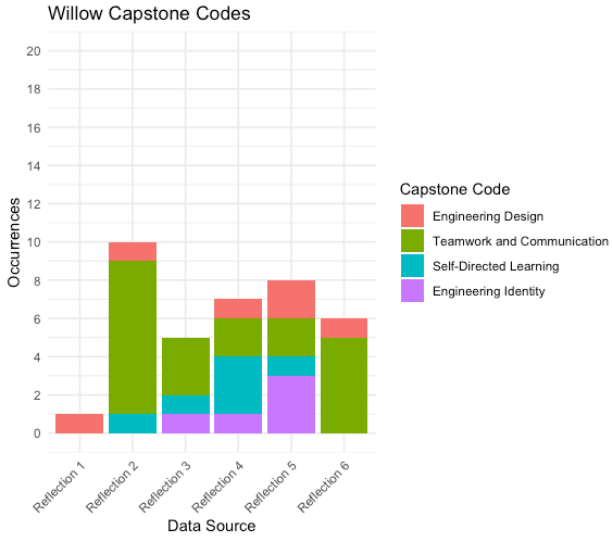


Figure C.31: Willow capstone codes

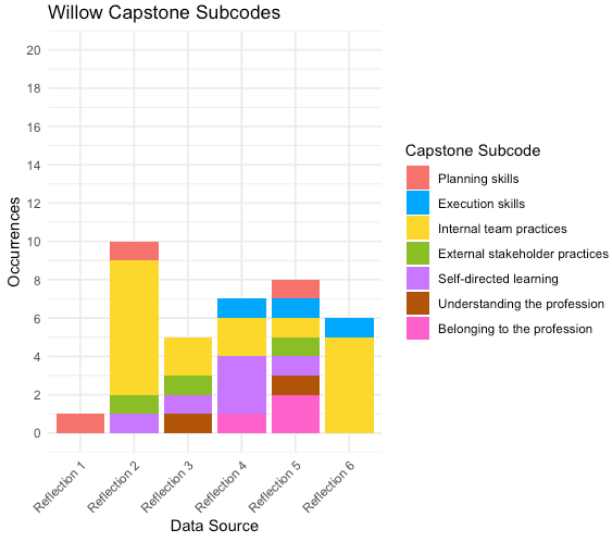


Figure C.32: Willow capstone subcodes

- Wants to travel and possibly work abroad in the future

Reflection 2

- Project is an app to gather data about students coming to the International center to help the employees, met with stakeholders
- Friendly relationships within group, want to have fun
- Group has strengths in technical areas and communication
- Talked about splitting up tasks based on skills and working across time zones

Reflection 3

- Biggest challenge is communication and finding a time to meet
- Difficult to manage time
- Learned about applying Agile skills
- Glad to take away international friendships and learn about cultural differences
- Looking forward to advancing technical skills, reconnecting with stakeholders, and continuing friendships

Reflection 4

- Significant experience: regularly meeting with a team to plan a large project
- Significant experience: self-directed learning to familiarize herself with Android Studio
- Enjoys self-pacing and integration of technical and professional

Reflection 5

- The biggest challenge was coordinating internationally for a large project-based learning assignment with multiple technical aspects
- Difficult to take into account holidays and calendars
- Liked learning Agile methods and app development
- Similar ideas about the field as before the course but happy to see that software engineering is open-ended and interdisciplinary
- Views herself as more capable to complete the project due to hard work from the whole team
- Identified differences between stakeholders and customers

Reflection 6

- Learned about collaborating and taking into account different viewpoints
- Enjoyed seeing Europe
- Easier to work in-person relationally and technically
- Takes away friendships, would communicate more in the future

C.3.3 Michael

Reflection 1

- Has learned previously that design skills are vital for engineers

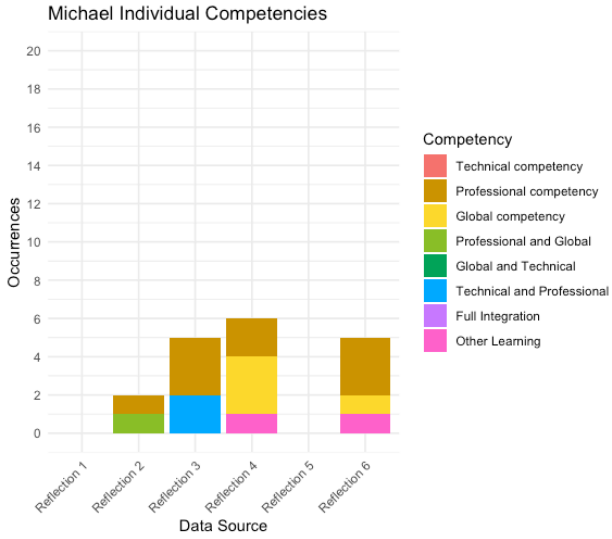


Figure C.33: Michael competencies

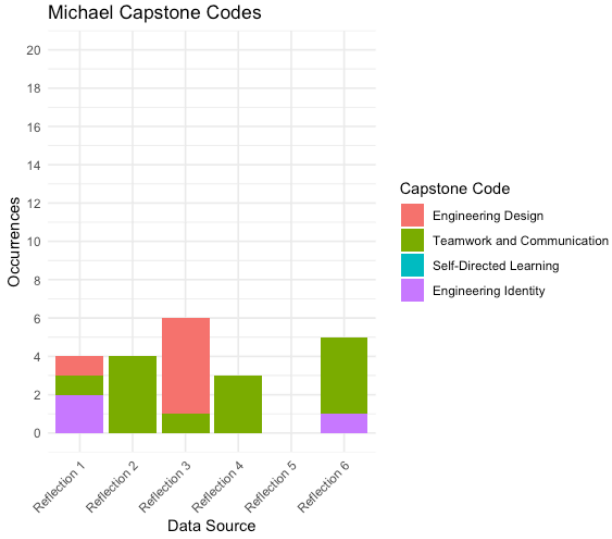


Figure C.34: Michael capstone codes

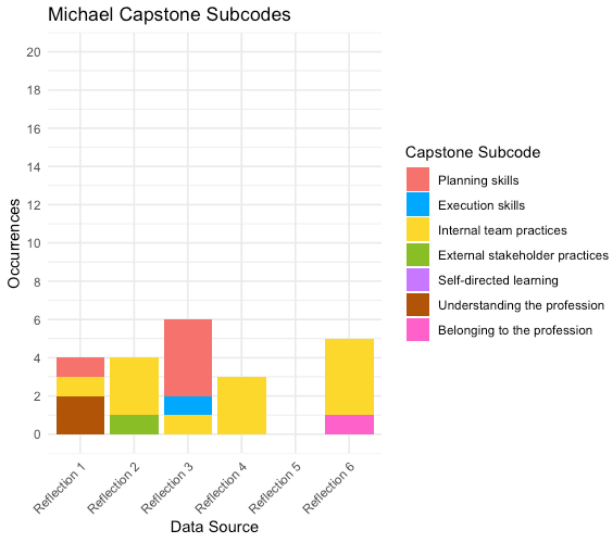


Figure C.35: Michael capstone subcodes

- Hoping to work with a diverse team to solve a problem, similar to professional work

Reflection 2

- Creating a math education game for kids
- One team member has dropped out
- The remaining members have set expectations and talked about problem-solving with their team, coordinating across schedules

Reflection 3

- Collaboration has been going well, the biggest challenge is planning and breaking down the components of the project and splitting work up while still collaborating
- Learned about project planning tools and requirements analysis
- Found it is important stay focused on users' perspectives and not only technical aspects

- Benefits of experiential learning instead of memorization

Reflection 4

- Significant experience: pre-trip presentation about Swiss culture and international travel, preparing for culture shock (only student to mention this)
- Issues with game engine but received help from team members
- Significant experience: Group has tried playing games together to get more comfortable and learn about one another

Reflection 5

- N/A

Reflection 6

- Favorite experiences were going to [Swiss University] and learning about their university and meeting the team
- The stakeholder said that they would implement the students' project
- Easier to understand body language and subtext in person
- Shared experience with the students from Egypt of going to a new country
- Would spend more time creating personal connections in the future

C.3.4 Lila

Reflection 1

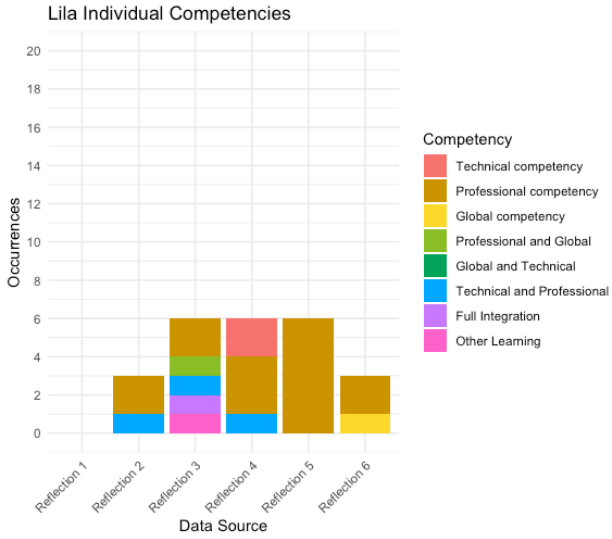


Figure C.36: Lila competencies

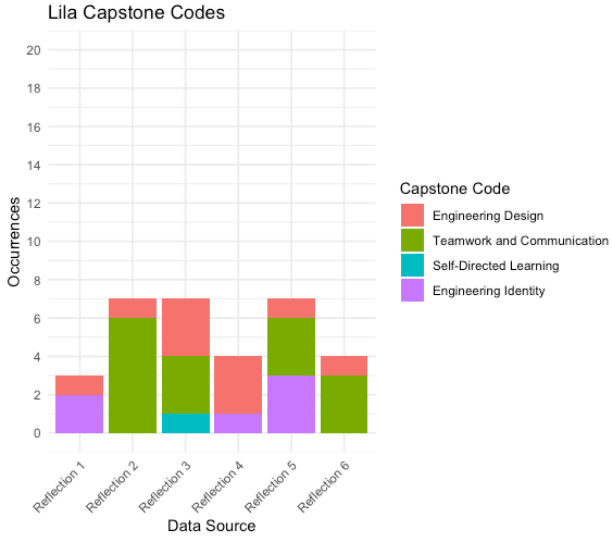


Figure C.37: Lila capstone codes

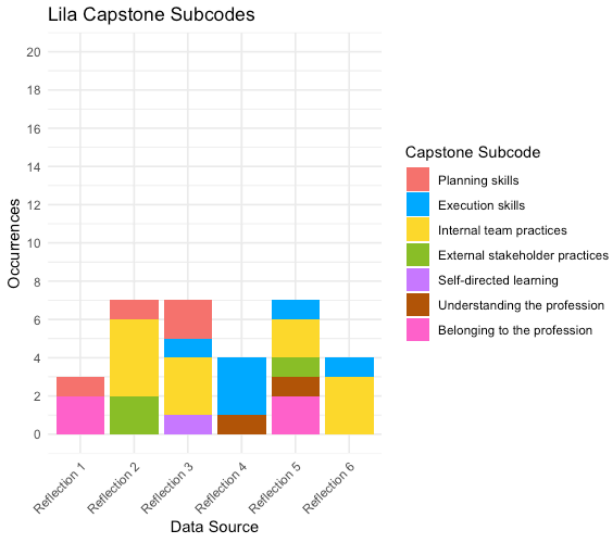


Figure C.38: Lila capstone subcodes

- Looking forward to creating a software project from the ground up, does not yet feel like she has the skills to do it
- The project seems overwhelming so she is hoping that this is a good experiential learning opportunity in a low-stakes environment

Reflection 2

- Same project as Michael, thought about what stakeholders want and created user stories
- Good interactions with the team but the members are busy, all are interested in the project space
- Gives specific strengths of her team members
- Has learned about measuring the contributions of other team members and picking up the slack for one another

Reflection 3

- When planning the project, her group realized that they have some misalignment in technical expectations. She learned that sometimes it is difficult to realize you have different expectations
- Learning technical and professional skills of designing a product, such as personas and user stories
- Likes accomplishing this large project (ties back to first reflection) with her team
- Enjoys bonding time with the team
- Splitting up tasks based on time zones

Reflection 4

- Gaining technical experience with game engines and programming in a new language, new experiences with game design and UI
- Significant experience: She was in charge of writing the tutorial, gained experience in taking on users' perspectives
- Significant experience: Pivoting and making changes with the Agile framework, learned professional competency of flexibility

Reflection 5

- This experience changed her perceptions on teamwork from a previous bad internship
- Her goal from Reflection 1 of taking on a big project was achieved by checking in with teammates and adapting

- Now she thinks of computer science as more flexible and she is not afraid to ask questions
- In the future, she would start programming while finishing planning instead of doing all the planning first
- Now feels like big projects are more manageable and can be accomplished during personal time

Reflection 6

- Highlight was dinner the first day, having fun
- Learned about Italian and Egyptian culture such as phrases
- Said being in person isn't too different, more convenient and could communicate non-verbally
- The project came together in the last few weeks
- Would do more team building in the future

C.3.5 Andrew

Reflection 1

- Interested in the course's global context and collaboration skills that are broadly applicable
- Wants to learn how to design end-to-end software, particularly with backend and AI/ML

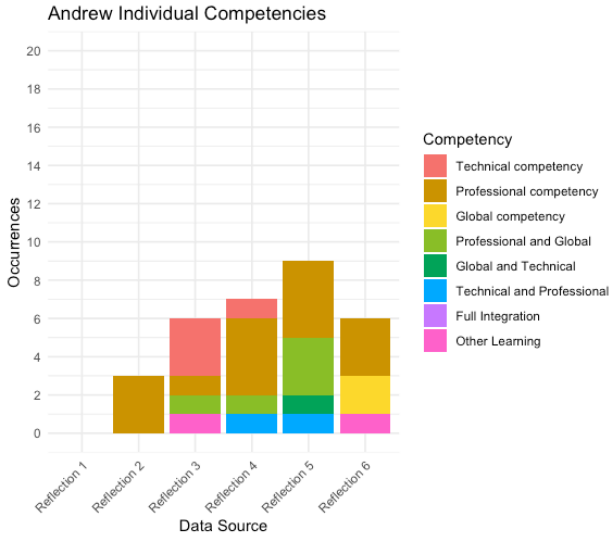


Figure C.39: Andrew competencies

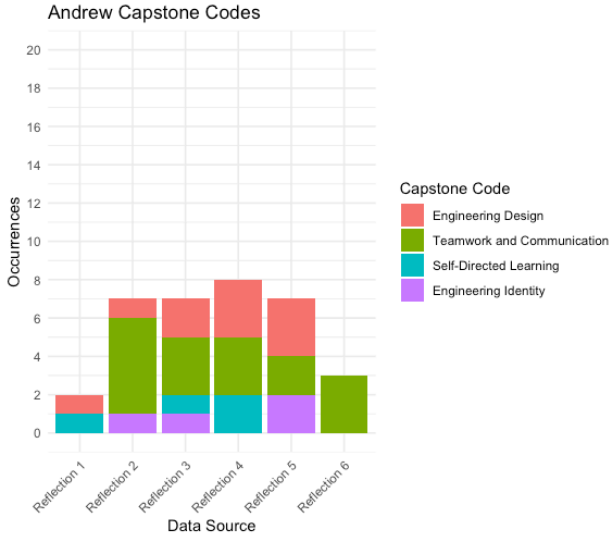
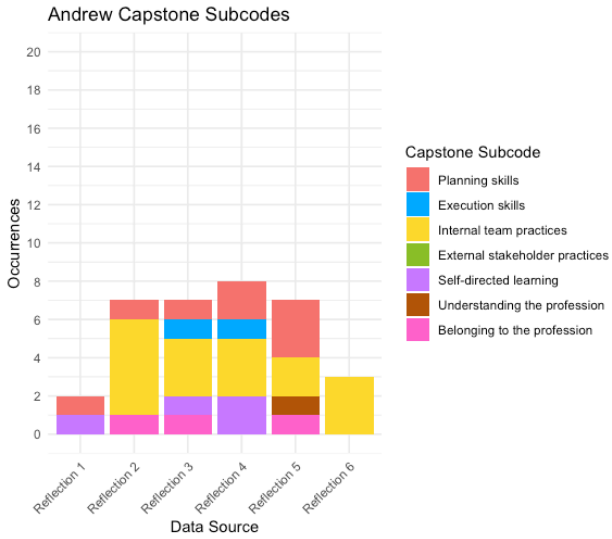


Figure C.40: Andrew capstone codes



Reflection 2

- The group has interest in AI so they selected the Lego computer vision project with the goal of gaining skills on the technical side. He also has prior experience with robotics competitions
- The other projects were more web-based
- So far the team has been timely, respectful, and cohesive. Speaks to their technical strengths and the importance of listening

Reflection 3

- The biggest challenge is technical: training the AI on the dataset. Learned how to augment it and tested multiple approaches
- Unique element of working remotely online
- Wants lasting friendships
- Gaining skills on app development

Reflection 4

- Significant experience: Distributing tasks among teammates so that people can achieve the tasks and learn. They had to iterate their plan and gained professional skills
- Switched to a more collaborative model (similar to Selena even though they are on different teams)
- Significant experience: training with the data set, gained help from their teammates to automate the process and learn about new resources (self-directed learning and technical)

Reflection 5

- Biggest challenge was the international coordination and not slowing one another's progress
- Divided tasks by time zone (grouped Switzerland and Egypt)
- Learned about cultural backgrounds and international project management (especially with time zones)
- Says this experience has helped with professional development
- Sees how much is left to learn as a computer scientist

Reflection 6

- Wanted to strengthen group relationships and was able by spending time together in person
- Admired the scenery in Switzerland

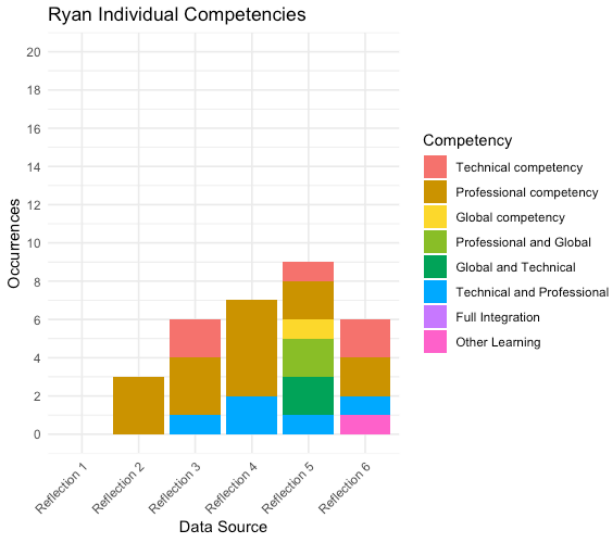


Figure C.41: Ryan competencies

- Mentioned learning about culture but did not say what he learned specifically
- Had better interactions in person, but his understanding of teammates and project did not change
- Says that meeting in person is required for friendship for him
- Important to connect and understand culture in the future, knowing what questions to ask

C.3.6 Ryan

Reflection 1

- Wants to see how cultural influences software design and the impact of speaking different languages
- Hopes that future projects are useful internationally

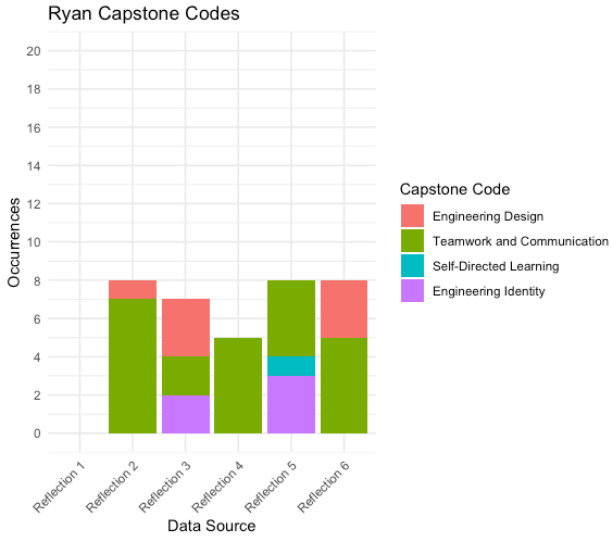


Figure C.42: Ryan capstone codes

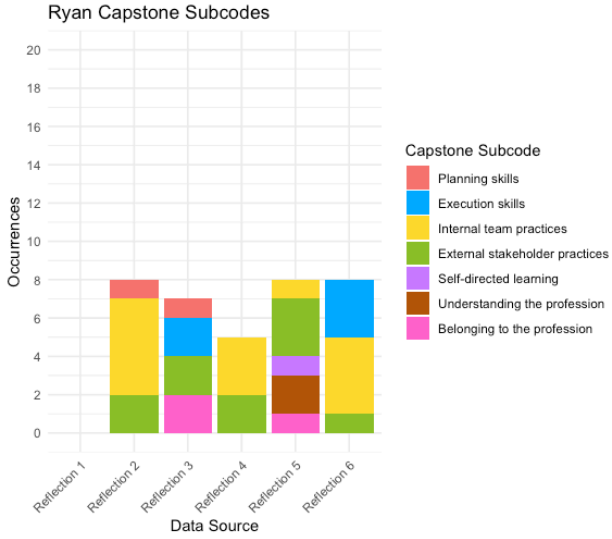


Figure C.43: Ryan capstone subcodes

- Wants to improve engineering skills by learning different methods

Reflection 2

- Lego AI project. No one on the team has programmed an Android app yet, learned from meeting with stakeholder which features are important and which to remove
- Ryan masterminded picking AI-interested people for his team
- Wants their project to help robotics teams, which were influential to him
- Swiss students have been very busy but mentions good professional and technical skills of teammates

Reflection 3

- Biggest challenge is technical app development, which is primarily his responsibility
- Has had fun learning something new
- Learned project management skills and professional such as Agile
- Wishes they had spent more time planning the UI before programming, needs to get approval from stakeholder

Reflection 4

- Significant experience: meeting with professor, surprised that it is a client meeting and not a sprint update. They presented specific code instead of having a working example, which the faculty wanted
- Significant experience: Swiss student dropping the class and reorganizing the team without his skills

- Glad for the experience of overcoming challenges and learned the importance of having contingency plans

Reflection 5

- Biggest challenge is time zones, tried to split up work based on time zones and to have some aspects of the project always being worked on
- Found that programming is not very different around the world, but universal because of the same programs and languages so anyone can communicate through code
- Confident about making a product from scratch and making an app
- Prepared for future cultural differences with stakeholders and teammates

Reflection 6

- Liked seeing the Alps and meeting the teammates (has them in the video), joking with one another in the reflection
- Had better collaboration with teammates and stakeholder in person, tested the app with the product
- Stayed up all night working
- Would use GitHub to merge code better in the future, they accidentally repeated work

C.3.7 Joshua

Reflection 1

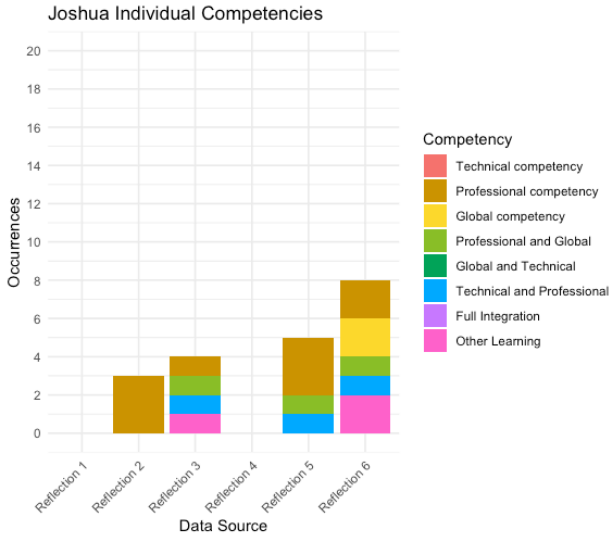


Figure C.44: Joshua competencies

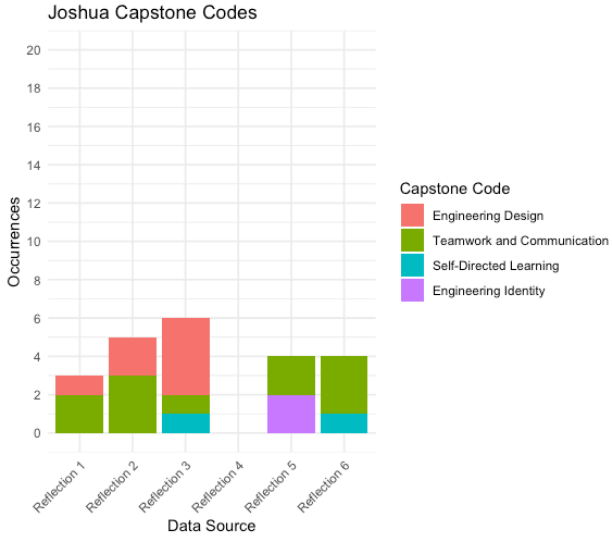


Figure C.45: Joshua capstone codes

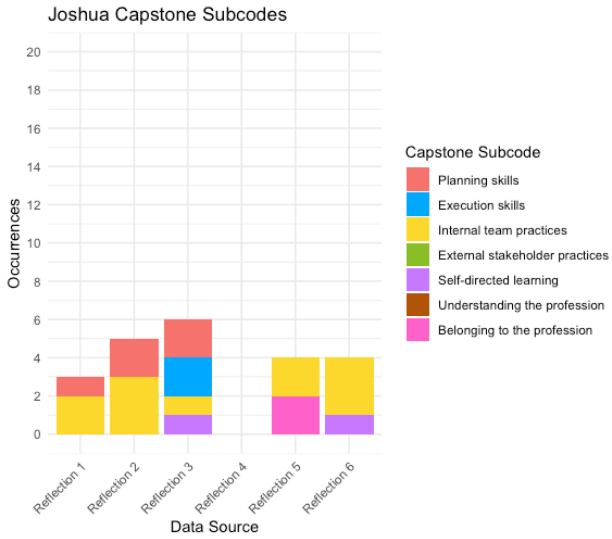


Figure C.46: Joshua capstone subcodes

- Wants to learn how to work with a team
- Hopes everyone focuses on planning and writes scalable enterprise software

Reflection 2

- Spoke to the client about features for an AI chatbot that can be added to service industry websites
- Joshua is comfortable with back-end programming, teammates are more front end
- Team uses multiple communication platforms, good communication but hasn't learned anything new yet
- Open to new ideas and disagreeing

Reflection 3

- Biggest issue is moving from the guidelines to the actual project creation

- Implementing professional planning tools like Agile and story descriptions
- Is trying to make decisions about travel
- Looking forward to overcoming conflicts in a truly remote team
- Impact of cultural holidays and differences for workplace collaboration

Reflection 4

- N/A

Reflection 5

- Struggling to distribute the work instead of dividing it and completing it individually
- Impact of time zones
- Did not change his view of computer science
- For himself, he is aware of what he does not know, has gained a little more technical skill but wishes he had even done other courses on front-end development
- University symposium bonded the U.S. students, which helps before they go abroad
- They are already finished with their project and just have to present abroad

Reflection 6

- Observed abroad that the culture is slower and differences in food
- Easier to communicate and understand each other, much more efficient working with the team in person

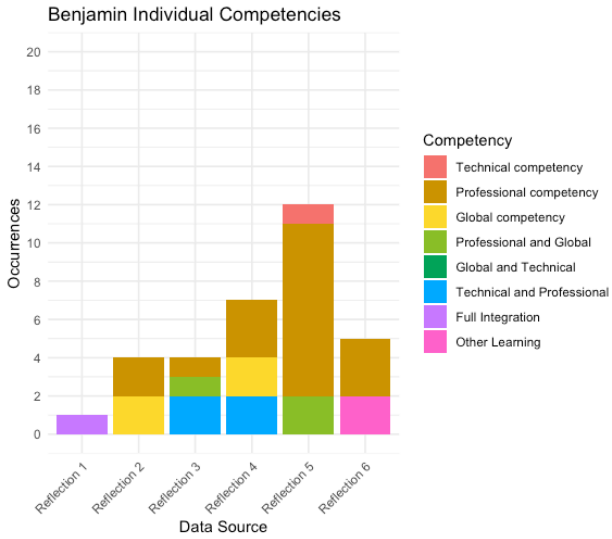


Figure C.47: Benjamin competencies

- Everyone is friends during the trip abroad
- Eye contact and learning from teammates is easier in person
- Needs to have better understanding of the technology before working remotely in the future, wishes he could've helped more but impressed by his teammates' skills

C.3.8 Benjamin

Reflection 1

- Wants to learn about cultural differences in code development, differences in problem-solving
- Wants to gain experience in working with people internationally
- Potentially wants to live abroad

Reflection 2

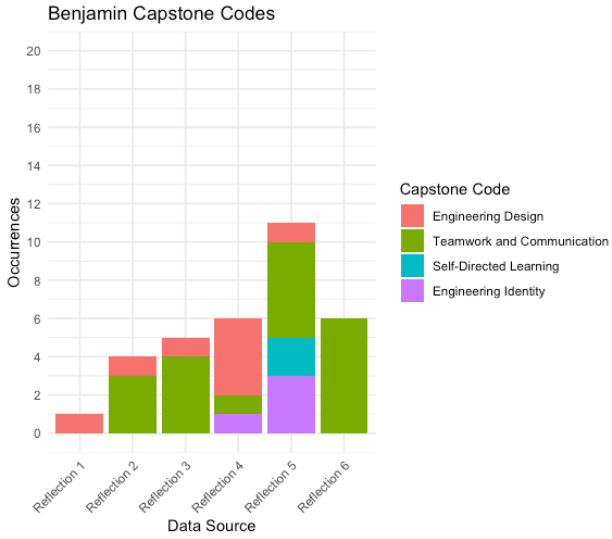


Figure C.48: Benjamin capstone codes

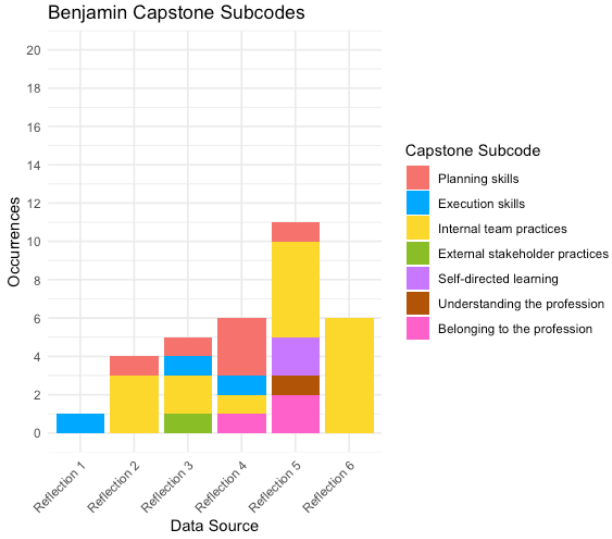


Figure C.49: Benjamin capstone subcodes

- Same project as Joshua, deployable chatbot for websites
- Wants to do this project because of the importance of AI for the field
- Impact of time zones, strengths of the team are clear communication and technical skills

Reflection 3

- Difficult to coordinate times to meet between classes
- Most important learning is about communication and ensuring that everyone is on the same page on the project's direction through listening
- Meeting with the stakeholder helped clarify things

Reflection 4

- Significant experience: learning about team members' backgrounds and what it is like to live in Egypt and Switzerland
- Found he has similar hobbies to his international teammates
- Significant experience: structured workflow for team projects, Agile method, personas and taking on user perspectives

Reflection 5

- Challenge is working internationally, solved by working individually and communicating online
- Saw the benefits of good organization skills and working towards the same goals, increased productivity

- Learned that you can never know everything about computer science but it is important to be curious and keep learning
- He has increased confidence for teamwork skills and new technology
- If he could do it again, he would not put so much pressure on himself

Reflection 6

- Friends with Andrew, visited Zurich together after arriving and tried new things
- Ate new food, beautiful train ride
- Fun to see team members in person, communicated and collaborated better
- Resolidified their team's direction and goal for the project when they met in person
- View of teammates didn't change, they were always communicative and helpful
- Would do more informal meetings in the future to become friends

C.3.9 Alessandra

Reflection 1

- Hoping to learn about designing projects from scratch
- Also wants to see the global perspectives and backgrounds of team members

Reflection 2

- Developing the website for an inn in Switzerland with reservations, events, and a chatbot

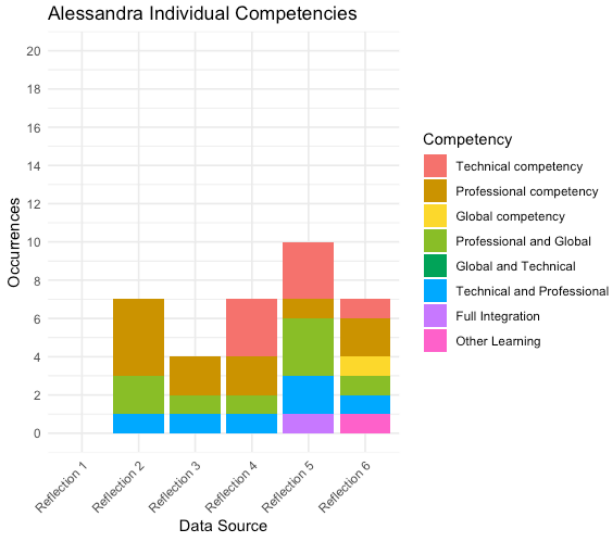


Figure C.50: Alessandra competencies

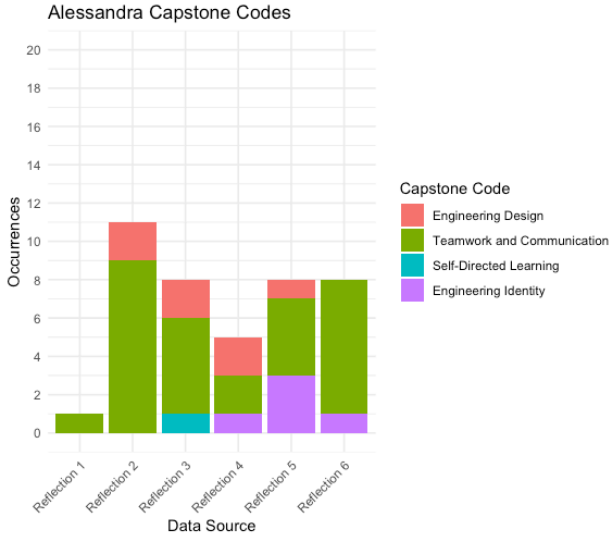


Figure C.51: Alessandra capstone codes

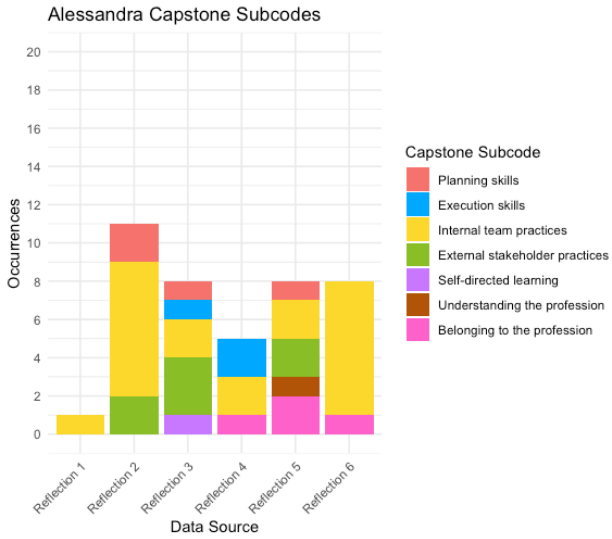


Figure C.52: Alessandra capstone subcodes

- They picked a project they have some skills for but also want to learn from but making a rating system in their group
- One student from Switzerland dropped the course
- The remaining team members are communicating and meeting during class time
- Everyone is contributing
- Described professional skills of her teammates and the importance of communication across time zones

Reflection 3

- Her team had difficulty coordinating with the stakeholder because of an email issue
- Once they met the stakeholder, they learned about her ideas for the project and adapted their plan

- One student is not contributing as much but they are messaging them to keep them in the loop
- Best thing she's learned is communicating and collaborating across diverse backgrounds and time zones, playing to each other's strengths
- Learned about professional competencies such as Agile and point estimation
- Wants to improve her development abilities for websites and presentation skills

Reflection 4

- Significant experience: coordinating across time zones by using the Agile process
- Divided up the tasks based on strengths, focused on keeping everyone updated
- Significant experience: gaining technical skills with React and TypeScript, enjoyed learning new knowledge
- Also learned about GitHub and how to make her work easier for other people to use
- Wants to create something useful

Reflection 5

- Biggest challenge was meeting up across time zones for the team members and stakeholders
- Working on the same code base with merge conflicts was also difficult, tried to avoid affecting others' code
- Most valuable learning was communication and technical skills

- Learned that software projects can have an international impact
- Improved as a well-rounded computer scientist with full stack development abilities
- Recognized the importance of working early in a team so that people can give feedback
- Would have liked more stakeholder meetings
- Overall learned about large-scale projects

Reflection 6

- Easier to collaborate in person, learned about culture
- She thought Switzerland was pretty
- Overall learned technical competencies
- Collaborated better in person
- The project felt more real after visiting the site
- Built more relationships with the team outside of work during the in-person portion
- Happy that the project worked
- Would do more coordination with video calls in the future

C.3.10 Zara

Reflection 1

- Goal in the course is to learn about different cultures and collaborating with a diverse group, not similar people she already knows well

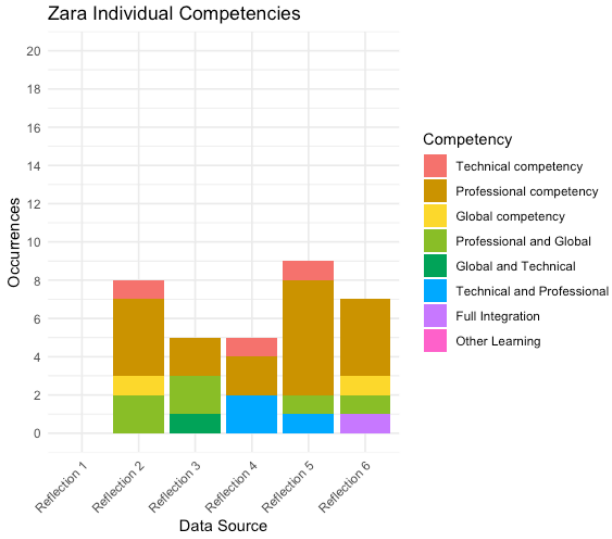


Figure C.53: Zara competencies

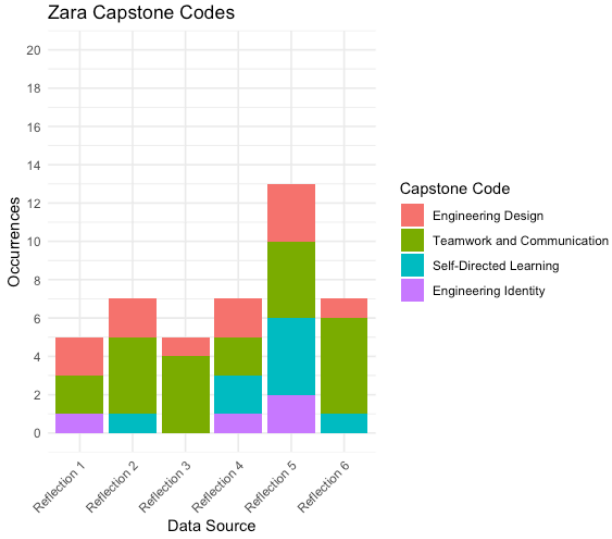


Figure C.54: Zara capstone codes

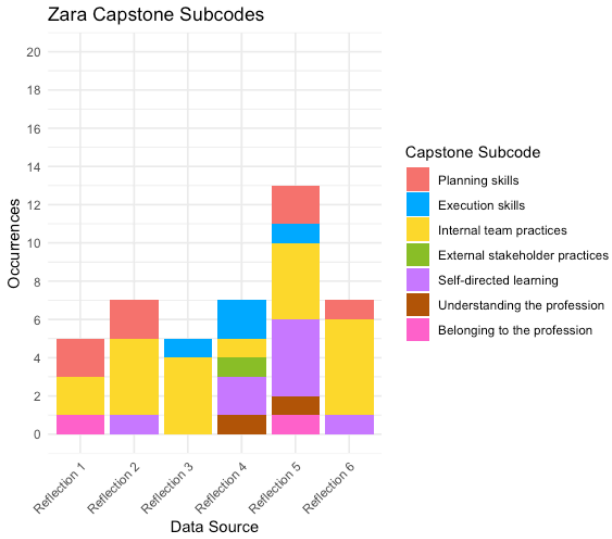


Figure C.55: Zara capstone subcodes

- Wants to see different perspectives and advance her technical skills

Reflection 2

- Same project as Alessandra
- Wanted to apply her knowledge to something useful and advance LLM and ML/AI skills
- The group wanted a project that they were confident in some aspects and would stretch them in other ways
- Appreciates the aspect of interacting with a real-world client
- Some communication issues with Swiss students, divided up based on what makes sense to her group, such as the U.S. students submitting the assignments
- Experiencing working across cultures and time zones, listed strengths of teamwork and professional skills and working asynchronously

- Has gained patience

Reflection 3

- Difficulty for the team of reaching a unified vision and collaborating to achieve that
- Some conflict of people not doing enough work and not being able to meet together
- Seeing have inconsistencies in their work
- Learned more communication skills
- Knows completing programming tasks internationally will be harder than the written assignments

Reflection 4

- Significant experience: first stakeholder meeting and learning about expectations. First experience of a real project instead of classwork
- Significant experience: receiving the code base for the website. The code was not what they expected so the team had to adapt and come up with a new plan. They decided and implemented it as a team

Reflection 5

- Biggest challenge is communicating, splitting up the project, and time management
- Everyone was busy
- Learned active communication for virtual collaboration
- Created a project from scratch instead of existing files

- Created a framework and deployed it
- Feels less confident to start a job, overwhelmed but excited

Reflection 6

- Learned about other cultures and perspectives about computer science
- Saw different specializations of her teammates
- In-person coordination was better, no time zone differences, more collaborative ideas
- More fun and interest in the project when working in person, not overwhelming
- Egyptian and U.S. students got to experience a new culture together
- Communication is the most important to succeed in global projects
- In the future, would have more than two communication channels. She would also prioritize planning and having internal deadlines

Appendix D

Fourth Appendix: High-Level Program Takeaways

D.1 IRES

The NSF funds International Research Experiences for Students (IRES), during which students travel to a partner university abroad to collaborate on an engineering research project. This iteration centered around six weeks of work at a U.K. university. The case characteristics and their impact are in Table D.1.

Highest impact experiences: cross-cultural relationships built in the workplace that informed research decisions and professional learning.

Most effective competencies: integrated Professional and Global (transferable to in-person work) and fully integrated.

Competency that could be further developed: Global. An experience that could improve this competency is if there was an activity to see local sites and learn about the history and impact on culture.

Table D.1: IRES case characterization and impact

Categorization	**IRES**	**Level of impact on competency development**
Program type	Research abroad	**High:** students gained both fundamental research skills and learned global workplace skills that were beyond what they would achieve domestically
Mode of program delivery	Host institution	**High:** students experienced mentorship a new professional setting with different practices and priorities
Duration	Summer (6 weeks)	**Low:** students felt rushed to complete their projects and may have gained global skills in an extended program
Entry target-language competence	N/A	N/A
Coursework language	English	N/A
Academic work context	Local research group	**High:** students built connections with their mentors and peers, which taught them how to collaborate internationally
Housing	Local dorms	**Low:** students had to purchase items for their dorms but did not discuss it otherwise
Provisions for cultural interactions	Direct contact via research	**High:** students saw how researchers and participants differed in the new cultural context
Provisions for experiential learning	Engineering research	**High:** research projects were a learning setting to gain professional and technical skills
Guided reflection	Orientation program, initial and some ongoing	**Medium:** students appreciated the support and were prepared for the transition to the international university

D.2 International Center

International study abroad centers are located abroad and owned by U.S. universities that send faculty to teach the same courses as are offered domestically. The current case was a semester-long civil engineering program at an international center in Switzerland. Group field trips connected engineering to local sites and students spent significant time traveling by themselves. The program characteristics and impact are in Table 5.1.

Highest impact experiences: free time for students to travel and group travel that connected coursework on engineering differences with real-world examples.

Most effective competencies: Global and integrated Global and Technical

Competency that could be further developed: integrated Professional and Global. An activity that could improve this competency is a hands-on engineering design project done in collaboration with students from the local Swiss university. This could be a short-term project.

D.3 COIL

Collaborative Online International Learning (COIL) experiences involve a global coursework (typically project-based) cooperation. The current case included students from the United States, Egypt, and Switzerland working together on open-ended software engineering projects for a capstone course. Following the semester, all students traveled to Switzerland to finalize and present their projects. Table D.3 focuses on the characteristics of the online program and their impact.

Highest impact experiences: overcoming technical and project management challenges

Table D.2: International Center case characterization and impact

Categorization	**International Center**	**Level of impact on competency development**
Program type	Study abroad	**High:** students were able to explore day-to-day aspects of life in different parts of Europe
Mode of program delivery	Home institution	**Low:** institutional coordination was convenient for students but did not seem to impact learning
Duration	Semester	**High:** Significant other learning and personal growth was described in the final reflections during the program, and it was long enough for students to experience and recover from homesickness
Entry target-language competence	Elementary	**Medium:** students had some learning from cross-language communication
Coursework language	English and one target language	**Low:** students did not discuss their language course
Academic work context	Home institution taught	**Medium:** Home instructors were able to impart targeted learning outcomes
Housing	International center dorms and apartments	**Medium:** students got to know the multi-national staff and learned from them
Provisions for cultural interactions	Occasional lab course contact	**Low:** this was infrequently mentioned
Provisions for experiential learning	N/A	N/A
Guided reflection	Orientation program, ongoing informal mentorship from program leaders	**Medium:** students appreciated the mentorship from program leaders and were able to learn about technical and global aspects

Table D.3: COIL case characterization and impact

Categorization	**COIL: Online**	**Level of impact on competency development**
Program type	COIL	**High:** as a virtual program, the COIL was the basis for the international contact in this program.
Mode of program delivery	Faculty-directed	**Medium:** students received technical guidance from the faculty
Duration	Semester	**High:** the scope of the project necessitated a full semester of work to advance technical and professional skills.
Entry target-language competence	N/A	N/A
Coursework language	English	N/A
Academic work context	Home institution with online international collaboration	**Medium:** students learned about virtual engineering collaborations, including communication and merging code.
Housing	N/A	N/A
Provisions for cultural interactions	Direct contact via capstone project	**Medium:** students built relationships and enjoyed working with teammates, but they said these connections were stronger in-person
Provisions for experiential learning	Capstone project	**High:** students applied and advance their previous engineering learning and design skills
Guided reflection	Cultural contact coursework	**Low:** students expressed limited learning about culture and cultural practices during the semester

in collaboration with international peers.

Most effective competencies: Technical, Professional, integrated Professional and Global (for virtual work), and integrated Technical and Professional.

Competency that could be further developed: Global. Based on students' insights of what they would have done differently during the semester, they could be encouraged to have more frequent, video calls with casual team-building activities. This could have helped them to could further understand the culture of their teammates.

Appendix E

Fifth Appendix: Considerations in International Engineering Program Design

This appendix includes recommendations for stakeholders of the best practices that can be incorporated into international-focused programs that take place domestically or abroad.

Intercultural collaboration

Collaborating on an engineering project with a multinational team is a high-impact, low-cost experience. The work can be done online or in-person, which leads to learning outcomes that are transferable to different professional settings. Open-ended projects provide students the opportunity to develop technical and professional skills, and the international collaborations show students cultural communication methods for the workplace.

Cross-context reinforcement

An effective teaching method is to introduce a cultural difference in coursework, then provide opportunities for students to experience the difference in a real-world setting. This was seen to be effective in imparting cultural workplace differences and in engineering applications.

Importance of relationships

One of the most commonly discussed aspects of every program is the connections with others. Students appreciate the opportunity to connect with faculty in a smaller group and new context. Program-facilitated relationships with international peers are enjoyable and informative, and faculty should encourage students to get to know one another more casually. In longer programs, students should be advised to have cross-cultural contact as they travel because these unexpected encounters can be meaningful.

Assessment

Recorded spoken reflections (video or audio-only) can both reinforce learning for students and provide insights into their experiences, which is useful for assessment. Weekly or bi-weekly reflections with different, relevant prompts each time and giving completion grades was an effective method. I recommend sharing the benefits of reflections with students, which include deepening learning, practicing sharing about experiences, and the recordings serving as reminders of what they learned.

Program differentiation

International program options should be differentiated based on program design and assessment results. For example, programs with collaborative research can reveal to students if they would prefer to work in academia or industry, while immersive programs abroad are a time for personal growth and improving confidence. What students will experience and learn should be presented so that students can enroll in the option that aligns with their goals.