Understanding the Dimensions of International Engineering Programs in Higher Education: A Qualitative Study with Faculty and Students

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ABSTRACT

Universities across the United States have integrated international experiences into their engineering students' education. International engineering programs provide learning and professional opportunities for participating faculty and students while aiding international partners in their own efforts. These programs are unique from traditional engineering courses and projects and generate outcomes desired for engineers entering the workforce including professional skills, critical thinking skills, and a strong understanding of their target audiences. While individual programs have explored the impacts of their programs on their students and their resulting project outcomes, there are significant gaps when considering the following: 1) how are programs structured, 2) what are the intended learning outcomes, 3) why do faculty participate in these programs, 4) how are relationships formed and maintained with international partners, and 5) what barriers exist that limit international engineering programs? To address these gaps, I interviewed 25 program faculty and 40 students. Through qualitative analysis of these interviews, I found that programs shared a common consideration for the program's focus on student learning or achieving international partner goals. Programs approached both structure and learning outcomes with either more emphasis on one or the other; balancing these two goals was a challenge for most programs. Faculty were motivated to participate in international engineering programs by their own intrinsic values, however, many felt limited when in traditional tenure track positions. Students tended to reflect more deeply and from a systems perspective the more exposure and time in a program. Students who engaged in either multiple programs or longer participation within a program tended to reflect their experiences contributed more to their current and future career plans. Partners were typically developed initially through personal relationships of the faculty members or through third-party organizations that specialize in international work. Maintaining relationships was highly varied between programs, but a common deficit among programs was the ability to evaluate project outcomes with partners in a numerical way. The examination of these questions about international engineering programs provides a foundation of knowledge for future programs to build on and for existing programs to compare their approaches to. This is a critical step to implementing these types of programs in a more widespread and intentional way.

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GENERAL AUDIENCE ABSTRACT

Universities across the United States have added international experiences into their engineering students' education. International engineering programs provide learning and professional opportunities for participating faculty and students while aiding international partners in their own efforts. These programs are unique from traditional engineering courses and projects and help students learn professional skills, critical thinking skills, and a strong understanding of their target audiences to prepare them for jobs. While individual programs have explored the impacts of their programs on their students and their resulting project outcomes, we don't know the following: 1) how are programs structured, 2) what are the intended learning outcomes, 3) why do faculty participate in these programs, 4) how are relationships formed and maintained with international partners, and 5) what barriers exist that limit international engineering programs? To answer these questions, I interviewed 25 program faculty and 40 students. I transcribed and used qualitative coding to analyze the data from faculty and students. Through these interviews, I found that programs shared a common consideration for the program's focus on student learning or achieving international partner goals. Each primary focus leverages different aspects of program design, learning, and participation outcomes to achieve those goals. Faculty were motivated to participate in international engineering programs by their own personal and moral values, however many felt limited when they held traditional tenure track positions. Students tended to reflect more deeply and from a systems perspective the more exposure that they had to a program in terms of length. While participation one time led to valuable learning and reflected learning, those that engaged in either multiple programs or longer programs tended to consider more components of their experiences as it affected their current and future plans. Partners were typically developed initially through personal relationships of the faculty members or through third party organizations who specialize in international work. Maintaining relationships was highly varied between programs, but a common deficit among programs was the ability to evaluate project outcomes with partners in a numerical way. These answers help future programs to strategically build programs and helps existing programs compare their program to others.

DEDICATION

I am dedicating this work to the future international engineering programs—I hope that this work helps faculty, students, and community partners to find value in their experiences.

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CHAPTER I: INTRODUCTION

1.1 International Programs in Engineering Education

International programs bring together faculty, international partners, and students to tackle real-world global challenges. As the engineering discipline becomes more globalized and employers are demanding more workplace-related skillsets, engineering students are required to leave their undergraduate education with the ability to operate within international settings, understand the global context, and have the skills to work on real-world problems.

As the field becomes more globalized, engineering students simultaneously are becoming increasingly interested in participating in international experiences. In fact, over 87,000 STEM students studied abroad in academic year 2019-20 [1]. While the pandemic drastically reduced these numbers, there has been consistent increases in international experiences for students over the last decade. The engineering workforce is continuing to become more globalized, requiring globally competent graduates to fill these roles [2]. International programs can bridge these two phenomenon, and it has emerged as a response to incorporate civic education and globalized topics in engineering undergraduate curricula throughout the United States [3].

International projects allow students to learn complex, global skills while utilizing humanitarian engineering principles to provide technology and services to partners abroad. However, there is much to learn about the impacts and learning outcomes of these programs for students, faculty, and international partners. While international courses exist within a number of different universities, there is not a standard method of evaluating or comparing different programs [4]–[7]. For example, some courses focus on alignment with ABET criteria [4], while others focus on non-technical skills [5]. International partnerships vary between institutions in ways that shape the program structure and outcomes [4], [5], [8]–[10]. Faculty perspectives are largely ignored in these program outcomes. Additionally, as existing programs often evaluate different traits that are relevant to their desired outcomes and goals, there are not always comparative results for different student outcomes between programs.

1.2 Objective

International program experiences provide numerous positive outcomes for students. International programs operate across multiple disciplines in higher education. However, we have a limited

understanding of how programs are structured, how students and faculty perceive the impacts of the students' experiences to be, and how the connection between programs/courses and international partners are formed and maintained. My objective with this research is to address these gaps in knowledge.

The main objective of this work is threefold: (1) create a baseline of knowledge for existing international programs and courses in the United States for future faculty and program directors to collaborate and build future programs; (2) capture perspectives of international programs, specifically perspectives of faculty leading these programs and students reflecting on their experiences; (3) strengthen the argument and understanding of value for building formal international programs in engineering programs and colleges.

1.3 Outline of Chapters

The dissertation is organized into five chapters. The first chapter was an introduction to the topic and provides the motivation of the study. Chapter 2 describes the current literature available and highlights the departure point for this dissertation. Chapter 3 describes the methods that I used to gather and analyze the data. Chapter 4 includes my results for each research question and the supporting discussion. Finally, Chapter 5 concludes this dissertation and presents some broader impacts and reflections along with proposed future work.

CHAPTER 2: LITERATURE REVIEW

2.1 International Engineering Opportunities are Important for Engineering Education

International Engineering Opportunities provide students experiences with real-world projects, connect them to international partners, and provide them opportunities to strengthen skills that may not be a primary focus of traditional engineering courses.

The discipline of engineering is, at its core, designed to aid humanity [11]. However, participation in formal coursework that promotes service or aid of humanity is not always included or mandatory in engineering student's plan of study. The goals of higher education tend to focus on discipline-specific skills such as math and science that aid students in their future careers without fully demonstrating the effects of their careers on humanity. This focus is necessary to ensure that students can enter the workforce effectively upon graduation. However, employers seek graduates with global skills, intercultural understanding, and the ability to think critically about complex, real world problems. These skills are a primary focus within international programs for engineers [4], [12], [13]. These international programs provide students experiences with real-world projects while working to strengthen professional and global skills [14]–[17].

Skills gained in international programs are not only useful for students pursuing international careers; domestic and traditional engineering employers find these skills to be valuable [2], [18], [19]. Trends in globalization of the workplace have placed an added emphasis on the ability for engineers to apply their skills in globalized settings [20]. However, data shows that engineering education largely focuses on the acquisition of knowledge which allots very little time for opportunities for deep learning experiences that mimic professional practice and real-world problem solving [21]. Sheppard et al. [21] described four principles to modify engineering education to mitigate this gap:

1) provide opportunities for students to play an active role in engineering projects,

2) teach concepts for application,

3) integrate identity, knowledge, and skills through approximations to practice, and

4) place engineering in the world and encourage students to draw connections.

International programs provide students with access to each of these four principles by integrating project-based or research-based learning with global perspectives. These programs utilize different structural components and learning outcomes to achieve these four principles.

In addition to student learning, international programs provide the opportunity for students and faculty to connect with international partners to provide value in the global space. In some cases, these programs aim to provide value to specific communities or organizations, while others aim to create products or services that benefit large ranges of populations. In a similar manner to how students provide value to companies through internships and work experiences, participation in international partners' efforts can give organizations more support through technical, financial, and physical support [22].

2.2 Types of International Programs

International programs for engineers exist within and outside of engineering departments and formal and informal courses. There are several types of international programs that engineers participate in including international service learning, service learning and transformative experiences, humanitarian engineering, and global engineering. While service learning and transformative experiences are not always international, several international programs include a domestic arm, and understanding these programs can help understand how international programs are framed. Due to the variances in program terminologies and types, there is limited prior comparison across the types. In this study, I included each of these program types to capture a wide range of program perspectives within international programs. Each are described in the following sections.

2.2.1 International Service Learning

International Service Learning (ISL) provides opportunities for students to work on international projects geared to meeting partner needs through a lense of service. The goal of ISL programs is to strengthen student skills from a technical and global perspective by engaging in meaningful service. Bringle and Hatcher define international service learning as, "A structured academic experience in another country in which students a) participate in an organized service activity that addresses identified community needs; b) learn from direct interaction and cross cultural dialogue with others; and c) reflect on the experience in such a way as to gain further understanding of course content, a deeper appreciation of the host country and the discipline, and an enhanced sense of their own responsibilities as citizens, local and globally" [23].

There are a host of disciplines that integrate international service learning in higher education. Some disciplines use the term “global service learning” instead of ISL to explain and categorize their programs. The predominant areas that publish research about ISL experiences are rooted in the medical field, business, education, and in faith-based programs. Within other fields, like engineering, the primary learning outcomes tend to investigate global citizenship, ethics, competency development, professional development, and area-specific skills [24], [25].

The health field often describes the effects and impacts of international, or global, service-learning experiences related to student perceptions of self-efficacy, cultural competence, and attitudes. ISL research in health related fields predominantly apply qualitative research methods such as reflection data coding [25]–[28], case studies [29], interviews [30], and pre/post testing [31].

Many studies aim to confirm a goal known as culturally congruent care [32]. Culturally congruent care encompasses professional, personal, and cultural outcomes in professional practice and could be compared to the engineer’s creed ISL provided the experiences that would help build culturally congruent care [29]. Several other studies echoed the benefit of ISL on student outcomes related to culturally congruent care [30], [31]. Typical evaluation methods to measure cultural competencies and related outcomes primarily utilized pre and post-test quantitative evaluation and qualitative evaluation through interviews

Research International service learning has been included in business programs and is shown to provide similar learning experiences to those in engineering cocurricular experiences. Established professionals participate in international service learning programs to improve global skills related to areas of business [13], [33]. Programs evaluate these global skills using interviews and data coding. A comparative study of six ISL business programs compared learning outcomes and found that technical skills were heightened across programs [33]. Additionally, Isl business programs found that changing cultural environments impacted the student learning outcomes related to global skills depending on how different the culture was from their own [34].

ISL has been used within both existing and standalone engineering programs and standalone programs. The integration of these projects into student education was described as “bridging the ‘valley of death’ between academia and real-world applications [35]”. Students involved with international engineering capstone projects showed improved cultural growth over their traditional project counterparts [4]. Other universities have developed programs dedicated to ISL [8], [9], [36]. Students engaged with these

programs reported improved understanding of community engagement and using altered approaches to problem solving [37]. Others described strengthened technical and professional skills [5]. Research into these programs shows impact for students, however it lacks comparison across program types and structures.

2.2.2 Service Learning and Transformative Experiences

Both service-learning and transformative experiences provide insights into some aspects which are underexplored across global engineering programs. Service-learning programs often have a similar project-based approach, while transformative experiences, such as study abroad or living learning communities, tend to emphasize cross-cultural and interpersonal skills. Both types of experiences are important to understand in these relevant areas.

Service learning is defined as, "an educational approach that combines learning objectives with community service to provide a pragmatic, progressive learning experience while meeting societal needs" [38]. Service learning, without the international aspect, tends to include domestic service projects. The missing international component creates a stark difference between ISL and service-learning projects on the level of focus on cultural and global considerations, however the real-world project aspect remains.

Service-learning experiences have many positive student learning outcomes and improve retention in higher education but could be dampened by poorly designed courses. Service-learning participation can help retain students in higher education [39] [40]. Tinto's model of student attrition has been the foundation of much of this research which aims to address student retention through student's confidence in social integration—similar to agency measures described by Godwin [41]. Many of these studies investigate topics such as academic ability, cultural consideration, and professional skills. Additionally, service learning enhances academic development, personal development and civil responsibility [42]. Across 42 institutions with service learning programs, students' perception of their learning was positively affected by service learning [42]. Service learning also caused the largest increase of student perceptions of their learning than any of the other five high-impact practices including first year seminars, learning communities, undergraduate research, and capstone experiences [43]. However, poorly designed courses could have negative effects, such as increased stereotyping or a lack of understanding of how service is related to their disciplines [39], [43], [44].

Transformative experiences can improve cross-cultural and interpersonal skills. Study abroad experiences have a strong impact on students' cultural competence along with identity development, content knowledge, and social responsibility [15], [45], [46]. It is also a significant positive indicator of intercultural effectiveness [45]. Compared to global engineering programs, study abroad often lacks the focus on applied technical and professional skills. Learning communities can positively affect student's intercultural effectiveness and are a predictor for student's likelihood for lifelong learning [45]. Additionally, they can positively affect student's academic performance and civic engagement [47]. Learning communities can improve student's critical thinking [48], which aligns with improved academic performance.

2.2.3 Humanitarian Engineering

Humanitarian engineering is described as, an engineering specialization that focuses on the design of products, systems, or services to support the sustainable development of resource-constrained communities [53], [54], [55]. Humanitarian engineering specifies only that the projects are being implemented somewhere other than the native land of those designing the solution. It stemmed from the inception and growth of humanitarianism in the 1970's alongside the context dependency of engineering [50]. In short, humanitarian engineering creates solutions that help people but draws criticism due to misunderstanding of cultural values, imposing solutions on communities that do not want them, and failing to understand the long-term impact of the work [52]–[55].

Combating historical missteps in community involvement in humanitarian engineering, recent projects have led to the development of community adaptation and integration models. These models allow engineers to make more educated decisions in future humanitarian engineering and community development projects. For example, Kenny and Connors developed a model which outlines relevant elements for community development alongside questions that both community and outside participants should consider [56]. One example in their work is the element of authenticity. The associated characteristic is people's own knowledge and viewpoints and the relevant question to consider is "what do the people think about the project?". The goal of this characteristic is to consider the authenticity of the work from the perspective of the end user.

2.2.4 Global Engineering

Global Engineering is broadly focused on creating engineers who can address global challenges and work in globalized settings. There are some variations on the formal definition of global engineering. Some highlight the humanitarian nature of global work, while others consider it more broadly. Thomas describes, "Global Engineering envisions a world where everyone has safe water, sanitation, energy, food, shelter, and infrastructure, and can live in health, dignity, and prosperity [57]. On the other hand, Giovannelli and Sandekian describe, "A global engineer is someone who practices engineering in the following way: 1) with a forethought of its far-reaching consequences, both physical and social; 2) with an appreciation of international colleagues and/or in international offices; and 3) with cultural sensitivity, so that personal interactions are both pleasant and effective." [58]. Global engineering does not always imply the use of "real world" projects to achieve the program goals which differs from international engineering programs.

2.2.5 International Project Co-Curricular Opportunities

Outside of the formal curricula in higher education, students can become involved in both co-curricular groups and independent volunteer or internship experiences. Both types of experiences include opportunities for international service-learning projects and work.

Co-curricular experiences include participation in groups like Engineers Without Borders (EWB) or Bridges to Prosperity. These programs, while both addressing ISL projects, are wildly different in structure and support. Additionally, these are just a few examples of the types of co-curricular groups that exist. Co-curricular international service learning opportunities in EWB have been extensively investigated through the work of Litchfield [6], [14], [59], [60]. International service learning improved students' perception of their own technical and professional skills along with their sense of engineering agency and identity [6], [14], [60]. While these results are promising, they do not necessarily carry over directly to international service-learning experiences within formal engineering course work, as those participating in co-curricular opportunities often have higher motivation for the subject and are willing to donate their time to participating. In addition, due to the differing structures and involvement, it is difficult to extrapolate those experiences to other ISL programs.

Unlike co-curricular experiences, volunteer and internship opportunities often exist outside of higher education. NGOs and similar organizations offer direct volunteer and internship opportunities to students.

However, as described in relation to co-curricular programs, these opportunities vary widely, and there is no real data that supports our broad understanding of these programs on student learning.

For both co-curricular and opportunities outside of higher education, some common gaps exist including the lack of formal education for participating students and the variation in structure within and between organizations create difficulties in examining the impact on students broadly.

2.2.6 Programs Share Similarities

The research around international engineering programs is somewhat disjointed because of the definitions and program types used. Each of the program types described above approach project work from slightly different perspectives, but all include the same major components: participation of engineering students, student education, and international partner assistance. These variations yield different program approaches and objectives. For example, humanitarian engineering is often focused on community benefit over potential learning gains of the engineering student [52]. On the other hand, international service learning often focuses primarily on student learning. While humanitarian engineering and international service learning within engineering education vary on the role of and emphasis on stakeholders, they share many of the same goals and applications. Similarly, service learning and international service-learning focus on similar service-oriented goals, but international service-learning emphasizes skills like global citizenship in addition to shared skills such as social responsibility.

Each of these subsets of international experiences use different terminology and objectives to achieve student education and partner assistance goals. Within international programs, each provide insights into relevant programs structures and can give insights into student education, faculty perspectives, and development of international partner relationship.

2.3 International Engineering Programs in Engineering Education Are Not Compared

International engineering programs are included in many universities, however programs are not designed and implemented uniformly across universities. There are no comparisons across these varying program types. However, many types of international engineering programs including senior design or capstone programs, standalone courses, and large programs have published literature on their own programs through project publications and program evaluations. [4], [8], [9], [36], [61]. Each type of program findings is described below.

International projects have been integrated into senior design or capstone courses at several universities across the United States. Prior research compares the learning outcomes from these projects against ABET requirements [7]. Each respective study shows improvement towards ABET criteria and requirements [4], [62], [63]. For example, Budny distributed surveys across civil engineering senior design teams at the University of Pittsburgh (total sample n= 45, international team members n=6) to measure the student's perceived benefit from their projects. The research team measured the difference in perceived benefits between international teams and traditional capstone project teams. Overall, students on the international team responded more positively in their confidence in all (7) categories: ethics, communication, global/society, contemporary issues, constraints, overall education, and altruism.

Stand-alone courses tend to focus on outcomes directly related to the international experiences such as social responsibility or global communication in addition to relevant engineering skills [10]. For example, the University of Colorado at Boulder's focus of their global engineering minor is to "expand students' understanding of how to operate within an international context from an engineering perspective and to understand the impact of engineering solutions in a global, economic, environmental, and societal context" [64]. Another program at the University of Michigan focuses equally on technical and non-technical learning outcomes defined specifically for the course [65].

Capstone experiences often integrate projects which can help faculty meet ABET criteria. For example, Budny and Gradoville describe student learning relevant to ABET criteria through an international service learning capstone experience [4]. Students worked in small teams to complete their senior capstone project and were able to travel to their target community upon completion of the course to implement their technology. Through the work, the authors outline how the project helped to meet ABET criteria for student learning.

2.3.1 Program structures are widely varied and lack comparison

International programs vary widely across a number of factors including the types of programs, the size and structure of programs, student participants, and international partner relationships. As described extensively above, the terminologies used to describe programs and drive development have separated the programs from one another in the literature. This leads to gaps in potential comparisons of programs to understand international programs as a whole. In addition to terminology differences, programs evaluate different skillsets in students. Some programs focus on evaluating technical skills [4], while others focus

on professional growth [36] While these differences exist, all of these international programs address student learning and providing value to their international partners.

Existing programs vary in size and student demographics. Capstone courses often are limited to small teams, 3-6, while standalone courses offer space for more students to participate [4], [8]. Programs or degree paths allow students to participate over several years. These variations lead to different numbers of international projects and student participation. These differences may influence or be influenced by the structures of the programs. Across programs, it is not well understood how these structures are determined or what key components are in place for international programs.

Additionally, while many programs have published on the output projects from their programs [66]–[68], little is understood about the number or types of partnerships, or how they relate to the structure of programs. Capstone programs tend to complete one project during their academic schedule [4] while larger programs can run a number of programs simultaneously [69]. However, there is limited understanding about the nature of relationship formation or how these relationships are managed.

2.3.2 Faculty motivation for participating in these programs are not well understood

Within international programs, faculty motivation for participation is widely unknown. Faculty publish about programs and student learning, however there is limited understanding on their own experiences. While understanding of faculty motivation in international programs is limited, this phenomenon has been investigated within higher education more broadly.

Numerous frameworks exist to describe motivation [70]–[73]. Each framework aims to address a different aspect of faculty motivation. For example, the achievement goal theory tends to focus on what goals faculty aim to achieve, while the control-value theory of emotions explores how one's sense of control and value for their work leads to positive or negative emotions and activations [70], [73]. The most applicable framework related to this work, though was the self-determination theory.

Self-determination theory (SDT) suggests that motivation includes both autonomous and controlled motivation. Autonomous motivation is related to intrinsic goals or outcomes while controlled motivation reflects on external factors [72], [74]. SDT evaluations in faculty motivation have shown that autonomous motivation led to improved educational efforts from faculty and it was shown to have a more significant effect on faculty motivation than controlled motivation [72]. Personal traits such as recognition,

achievement, and responsibility relate to faculty's perceived identities and agencies within their roles. In fact, engineering agency and identity have been shown as a motivation for career choice [75], [76]. Within faculty motivation, engineering agency was shown to strengthen when faculty worked to develop innovative curriculum components such as problem-based learning opportunities [77].

Autonomous or intrinsic motivation is shown to have a more significant effect on faculty motivation than controlled motivation [72]. Personal traits such as recognition, achievement, and responsibility relate to faculty's perceived identities and agencies within their roles. In fact, engineering agency and identity have been shown as a motivation for career choice [75], [76]. Within faculty motivation, engineering agency was shown to strengthen when faculty worked to develop innovative curriculum components such as problem-based learning opportunities [77].

Gender was shown to not play a role in motivations for educators [78]. Research showed that faculty engage in two types of motivation: personal and professional, when considering employment within Hispanic-serving institutions [79]. Faculty personal motivations are also described similarly as intrinsic motivations which include themes like "personal characteristics" or "values", while professional or extrinsic motivations are described through effective education [80]. This mix of personal and professional motivations is consistent across disciplines.

Faculty motivations for including aspects of internationalization in their education curriculum is similar to general motivations for education. One study found that individual motivation, specifically individual efficacy and competency, played an important role in faculty developing international components of their curriculum [81]. Faculty's motivation to include international components aligned specifically with personal motivations that fit into their institutional frameworks. [82] These personal motivations were closely linked to the work itself, their responsibility to their students, and the value of the material. Other faculty were also motivated to include more international components in their curricula through a mix of both intrinsic and extrinsic factors similar to those described above [83].

The Two Factor Theory of Motivation highlights some potential barriers to motivation through the hygiene factors. The two-factor theory proposes that there are motivating factors such as achievement, recognition, fulfilling work, or responsibility and that there are hygiene (aspects that could produce dissatisfaction) factors such as relationships, company policies, or security [84]. These hygiene factors include:

1. Interpersonal relationships
2. Salary
3. Policies and administration
4. Supervision
5. Working Conditions

Faculty motivation within higher education to include international aspects in their course ties closely to personal and professional motivators. Similar to the SDT, intrinsic or autonomous motivation strongly impact faculty motivation. Additionally, faculty's sense of agency increased when implementing problem-based learning opportunities within their course [77]. These faculty also described their care for their students, innovation in their pedagogy, and their efforts in professional learning as their major factors for increased agency. Therefore, I expect perspectives of faculty participating in international programs to be motivated by both professional and personal factors similarly to motivations in general education and internationalization of existing curricula. Given the potential for factors that can cause dissatisfaction and work against motivation, I will consider the hygiene aspects of the Two Factor Theory of Motivation when evaluating faculty motivation.

2.3.3 There is not a Comparison of Student Learning Outcomes Against Program Types

While student learning evaluation is a key component of international programs, it has not been considered in terms of program structure or project types. This research aims to build on existing literature from international programs while considering these other factors in student's perceived learning outcomes.

Student learning is a cornerstone of programs in higher education, however learning objectives vary across programs [4], [14], [51], [60]. Some programs aim to evaluate technical skills, professional skills, or global skills [5], [14], [85]–[87], while others investigate career choice and engineering agency and identity [6], [59], [60]. These studies generally show positive correlation between participation in the international project and the specifically measured student skills. However, these studies are typically small in sample size, or have a biased sample population. Additionally, they fail to capture the effect that the program type or structure has on the student's perceived learning.

The structure of the program can impact student learning. In a small study across multiple service learning courses, student tended to achieve the program learning objectives more effectively based on structural components of the programs including integration of service material into the course and the use of teamwork [88]. More generally, literature shows that student learning is significantly impacted by various structural components of programs [89]. The structures included in courses including organization, tutoring, and assessment impacts the student's learning.

Student learning can be influenced by the type of work that they participate in within a course or program. For example, project-based learning has significant impacts on student learning outside of the general course structure [17], [90]. Project based learning impacts more than just technical and professional skills; it has been shown to improve student's self-efficacy and motivation in engineering [91]. Given the project-based nature of many international programs, student learning is likely to be impacted by the projects that they work on in addition to the program structures.

In addition to the impact that the project-based learning approach has on students, team dynamics and relationships with others may impact student learning. While teamwork generally improves student learning across traditional learning objectives [92], there are negative outcomes that can arise from teamwork as well [93]. These team dynamics are another aspect to capture in student learning. While student learning has been evaluated within programs or across similar ones, we do not understand how different program types affect student learning.

2.3.4 Relationship formation and maintenance with international partners has not been well explored

Very few studies exist that investigate the relationships of international programs with partnering communities or how these partnerships are formed. The lack of publications in this area is an opportunity for improvement. A 2010 program review found less than five relevant studies that addressed community impact [3]. These studies were all small and specific to program relationships within one institution. One of these studies evaluated service-learning courses from the perspective of four stakeholders: students, faculty, community, and the institution and found that community partners often found their relationships valuable but that expectations needed to be clearly explained. A second study included the experiences of 99 community partners across California through focus groups to capture the community voice [22]. This study made it clear that local partnerships are not one-way, and in fact community partners value the reciprocal relationships formed through academic institutions. The findings of this work outline the

difference between what community partners deemed important (project efficacy, consistent communication, understood expectations) for these projects compared to what the university actors deemed important (student learning). A third study focused on community partner's perceived consequences of hosting students participating in service learning opportunities [3]. The studies seem to agree that the community partners in the studies found that the experiences were overall valuable, but some negative consequences existed such as ineffective communication and sub-par project outcomes [27], [28], [29]. None of the previous studies examine the impact on community partners in an international context or how these partnerships were formed. Measurement of this type can be difficult due to language, cultural, and geographical barriers for communication.

Outside of service learning, programs tend to focus on specific project efficacy instead of project formation and relationship maintenance [66]–[68], [97], [98]. In these instances, it is rarely discussed what the long-term efficacy was, but instead focused on the project's immediate feasibility to solve a specific technical problem with social implications. These investigations arise as a result of formed partnerships, which are not explained within these works. Understanding the specific partnerships in place may affect the implications of the work or help future programs understand how to best solve these engineering challenges.

Partnership formation has been widely investigated in other areas such as cooperative relationships and local community partnerships. Cooperative relationships include an initial 'bond' between the parties that is only valid if there is a limited amount of uncertainty in the long-term value of the relationship [99]. While this is most commonly applied to business relationships, it highlights two critical components: the bond between parties and the level of certainty in the relationship's value. This concept of a bond is discussed in community partnership literature through the community partner's perceptions of relationships with academic institutions [22]. Relationship formation is foundational to the success of the partnership. Bringle and Hatcher propose that in service learning, there are four phases of relationships: 1) initiation, 2) development, 3) maintenance, and 4) dissolution [100].

For my study, I focus on the initiation, development, and maintenance of relationships. Relationships can form in a number of ways, both intentionally and unintentionally. This intentional or unintentional relationship formation is a focus of this study. Once identified, a critical component of relationship formation is deciding if there is a convergence of interests [101]. A key component of this is discovering

if the parties are a good fit for the other's objectives. One international program described their approach to developing and maintaining partnerships through an ethical engagement framework described through three principles: partnership approach, community empowerment, and humility [102]. The framework provides best practices to help practitioners decide if the proposed partner is a good fit for their program. This is a fundamental consideration within international programs that is not often discussed in the literature.

Relationship development and maintenance vary by program and goals. However, for those aiming for long-term relationships, closeness of relationships and the types of outputs are critical evaluations [100]. Relationships vary and have different intended outcomes, so it is difficult to quantify effective outcomes across programs. However, understanding how partners perceive value in their outcomes helps to understand how or why relationships are maintained. Relationships are also adaptive. In community engagement settings, this is described by the adaptation of relationships to tackle new challenges [103]. As needs of both the academic institution and community partner change, the relationship must adapt to accommodate those changes.

A common critique in the "campus/community" relationship space is the lack of alignment between university programs and partners [104]. There is a strong need in these relationships to obtain a strong understanding of the community and have adequate representation of these partners. In international work more broadly, this is also a commonly expressed sentiment [105]–[107]. While these perspectives are not directly related to international programs in higher education, any work that includes western institutions collaborating with international organizations or vulnerable populations should use caution and be intentional with these relationship building efforts.

My dissertation aimed to investigate international partnerships, which would be comparable to these local community partnerships in the needs of relationship formation. I expect these values for community partnerships to be transferrable to forming and maintaining international partnerships. Additionally, I aim to capture how programs intentionally build partnerships.

2.4 Research Questions

To address these gaps in research, I proposed five research questions for this dissertation. These questions aimed to understand the types of international programs in the US, understand the structures of programs and connections to community partners, and capture faculty and student perspectives from their experiences.

RQ1: How are International Engineering programs structured in the US?

RQ2: What are the expected learning outcomes associated with International Engineering Programs?

- *i.* What structural components (e.g. number of courses, credit) influence these learning outcomes?
- *ii.* How do student participants describe the structure of their program and their learning outcomes?

RQ3: What motivates faculty members to participate in International Engineering Programs?

RQ4: How are international partner relationships built and maintained?

RQ5: What are the barriers that persist to forming and maintaining International Engineering Programs?

CHAPTER 3: METHODOLOGY

My study is a qualitative analysis of international engineering programs across the United States. To conduct this study, I gathered information on existing programs and recruited both faculty and students to participate in my study. My methods for the study are described in the following sections beginning with how I identified programs to include. This is followed by how I collected my data and analyzed the interviews to develop results.

3.1 Program Identification and Faculty Recruitment

To address my research questions, I first identified programs at U.S. universities that facilitated international coursework. This included standalone courses, international programs, and degree-granting pathways. I did not limit the university demographics by location, size, or type (private or public). However, I did limit the study to four-year institutions. It bears mentioning that there are numerous terms that are included in this category of international programs. For the purposes of this research, international programs for engineers are operationalized by four key components:

1. Provides tangible outcomes for a community, group, or organization
2. Provides students with the opportunity to work on "real world" problems in a global context
3. Includes a partnership with a global community or institution
4. Offered to engineering students

To identify the programs to include, I first investigated publications on international courses through journal outlets including the *International Journal of Service Learning and Community Engagement* and the *International Journal of Engineering Education*. I then conducted searches on the internet to identify four-year institutions that offered international courses or programs. Through these methods, I identified 33 relevant programs. Finally, I used the snowball method to identify additional programs by asking interviewing faculty if they knew of other programs that I should contact for participation. Through this method, I added six additional programs to my contact list. Of the total 39 programs, six programs did not fit into the definition of this study, reducing the pool to 33 programs. Of the 33, 8 did not participate in the study. A total of 25 programs and their associated faculty members were included in this study. This resulted in a participation rate of 75% for programs recruited that met the criteria of the study. Schools were distributed across the United States, 52% (13) were public research institutions, 36% (9) were private

research institutions, and 12% (3) were private non-research institutions. In total, 36% (9) of participating universities had a religious affiliation, and 24% (6) of them were land grant institutions.

The participating faculty ranged in position type as well. Positions include program director, tenure track faculty positions, and professor of practice. Table 2 shows the distribution of institution location and type, faculty position and gender, the project locations, and program type and length.

Table 1: Included institution types, location and faculty characteristics

Characteristic	Type	Quantity	Percentage
Institution	Public Research	13	52
	Private Research	9	36
	Private Religious	3	12
	Private (total)	12	48
	Land-grant	6	24
	Religious	9	36
Location	North	5	20
	South	5	20
	East	5	20
	West	4	16
	Central	6	24
Position	Program Director	11	44
	Tenure Track	11	44
	Professor of Practice	3	12
Gender	Male	14	56
	Female	11	44
Program Type	Single Discipline	4	16
	Interdisciplinary	21	84
Length	Single Course	15	60
	Multi-Course	10	40
Combined Program	Interdisciplinary Multi	10	48

	Interdisciplinary Single	11	52
Partner Location	Central and South America	14	-
	Asia	8	-
	Africa	12	-
	Europe	3	-
	North America	3	-

3.2 Student Recruitment

To better understand the student perspective, I recruited students who participated in the international courses or programs listed above. I asked them to share their experiences through a semi structured interview. I included students in this study who had participated in an international program experience in the past five years, and I did not limit my sample to those who had or had not participated in any travel experiences as part of the program.

To recruit students, I asked faculty for student contact information and specifically asked for students who best represented their programs. Then, I distributed a recruitment email through the faculty or directly to students with their consent. Students that agreed to participate in interviews received an IRB consent form (Appendix A), and we scheduled video conference meetings to conduct the interviews. I also employed the snowball method and asked students to refer others to grow my data pool. The resulting data included 40 students from both public and private institutions (52% public, 48% private) and was nearly evenly distributed by gender (55% male, 45% female). Students ranged from second year university students to graduate students and covered the engineering disciplines: mechanical, chemical, civil, electrical and computer, biomedical, and aerospace engineering. International experience ranged from one-time experiences to multi-year experiences.

3.3 Data Collection

Prior to data collection, the study was approved by the IRB at Virginia Tech (IRB #:19-719). I conducted all of the interviews for this study, and I was responsible for the coding of the resulting data. A single-coder approach was taken in this work to allow for a deeper reflection of the data to be used instead of

relying on high-level codes. I have a deep personal understanding of both participating in and operating international engineering programs and including a second coder without that depth of knowledge on the topic could have led to widely different interpretations of the faculty and student perspectives. To minimize bias in my coding, I employed reflexivity practices such as asking myself during the coding process "has this been my own experience in operating international engineering programs?" and made careful effort during the interviews to remove my personal experiences from the conversations. Am I employing my own feelings into reading this passage?" In addition, I emailed some participating faculty and students to validate that I was properly understanding the meaning of their responses to questions.

Faculty Interviews

I recruited faculty members to participate in my study via email. (Appendix B). Each interview I conducted ranged between 45 minutes to two hours over video conference. The interviews were semi-structured guided by three main groups of questions. The first group of questions aimed to provide information on the quantitative metrics of the program including participant demographics, program size, learning objectives, and course structures. There are five questions that guided this portion of the interview:

1. Can you describe your course(s) to me?
2. Can you describe the major goals of your course?
3. Are there key skills that you want students to leave your course with? (Such as social responsibility, teamwork, sustainable design, etc)
4. What are some of the major educational methods you try to use in your course? (Such as problem-based learning, lectures, reflection)
5. If you could improve one aspect of your course structure or outcomes, what would it be?

The following semi-structured questions focused on the international partners of their program or course. These questions aimed to understand how faculty develop and maintain relationships with their partners:

1. How did you choose your partner?
2. How long have you worked with this partner?
    - How often do you talk to your partner?
    - How many projects have you done in the past?
3. Is there a monitoring and evaluation structure for the service project after your course ends?

The final section of the semi-structured interview focused on faculty motivation and their perceived impact of the program or course. These questions were intended to capture faculty's thoughts behind why they do the work that they do, and what they perceive the impact to be for others and themselves:

1. Why do you teach this course?
2. What challenges do you face teaching this course?
3. Can you give me examples of the impact that your course has had on (1) students and (2) your community partner?
4. What do you think that the legacy of your course will be?

At the end of each faculty interview, I transcribed the audio file using a transcription service. I assigned each interview a number and removed all identifying information from the faculty data to ensure the privacy of the participants. I then used these transcriptions for my qualitative analysis to answer my research question about faculty perspectives, course structures, and partnership relationships.

Student Interviews

After receiving consent forms from student participants, I conducted a semi-structured interview with each participant ranging from 45 minutes to 2.5 hours. I used semi-structured interview questions to guide the conversations. I included 10 questions in my interview protocol:

1. Can you tell me about yourself? What did you study? What drew you to [Program]? (*Broad background question aiming to understand the student's academic experience and what drew them to their program*)
2. Prior to this course, did you have experiences with international work? (*Understanding student's prior exposure to international engineering practices and principles*)
3. Can you describe the structure of the course/program you participated in? (*This question is to compare with the faculty perspective of the course program. Used to understand the student's perspective of their program.*)
4. Why did you participate in this international program? (*Used to understand motivation*)
    a. If mandatory, would you opt to take it if given the choice?

5. I understand that your program looked like this: XXX. How do you think that shaped the experience that you had in the program? (*Using their response to question 3, this question compares their perceived program structure to their experience in the program*)
    a. Were there specific aspects of the program that you found most impactful?
    b. What was the most difficult part of your experience?
        i. How has that experience impacted future decisions?
    c. How did you interact with others in your program (students, faculty, partners)? How did these interactions shape your project and your experience?
6. Do you feel like you had a meaningful experience in your program? How do you define it? (*Use the student's description of meaningful to understand what they expected to get out of the program*)
7. Are there skills that you gained from this course that you feel you didn't get from your traditional engineering courses? (*Used to understand perceived engineering skills*)
    a. Can you give me an example?
8. Tell me about your current role: are you a student or are you employed? (*Used to understand effects on career choic*e)
    a. What do you want to do when you graduate?
    b. What is your job?
    c. Did your experience in XX shape your career or personal goals?
    d. How does your experience shape your work now?
    e. Do you think the structure of the program shaped these career goals?
9. Would you describe yourself as an engineer? Why or why not? (*Used to understand the impact that the program had their engineering agency and identity*)
    a. Do you feel like your international program experience helped you to understand your role as an engineer?
    b. Do you think your international engineering experience influenced you as an engineer? Did you feel like an engineer during your international experience?
    c. If you had to pick, what are the most important qualities of an engineer for the modern world?
    d. Do you think that your experience helped you to be a better engineer?

10. Outside of coursework or your career, have you continued to engage in service opportunities? (*Understand continued involvement or lack thereof*)

At the end of each student interview, I transcribed the audio file using a transcription service. I assigned each interview a number and removed all identifying information from the data to ensure the privacy of the participants. I then used these student transcriptions for my qualitative analysis to understand student perceptions related to their international experiences.

3.4 Qualitative Analysis

I answered each research question using a qualitative approach. I first developed a list of questions using existing literature and then developed a list of a priori codes using the relevant literature. I conducted pilot interviews with a faculty member and several undergraduate students to ensure both face and content validity. Using these interviews, I coded these interviews to verify that my list of a priori codes were captured the data. I used a priori codes for three of my research questions, and an exploratory approach for the other two, which had less available information through prior literature. For the research questions that used an a priori approach, I included emergent codes from the data that had not been captured in the codebook prior to analysis. I used a semi-structured interview approach for each interview conducted to capture both faculty members' and students' unique experiences in an effort to ensure that their interviews provided complete and accurate descriptions of their experiences. I describe how I answered each research question below.

Research Question 1: How are international engineering courses and programs structured in the US?

To answer this research question, I developed a list of a priori codes using prior literature about course structures [4], [8], [9] and learning frameworks [3], [17], [91], [108], [109], technical skills [61], [110], [111], [112, p.], [113]–[116], professional skills [86], [91], [117]–[120], and the ethics of global work [11], [86], [121]–[130]. These codes represent specific terms from each of the three categories aimed at capturing the structure and learning outcomes of the courses and programs. The a priori codes are shown in Appendix C. Using these a priori codes, I anticipated that programs and courses include structural components of student size and number of projects in addition to considering specific educational structures like team-based learning or didactic learning. In addition to these a priori codes, several emergent codes arose from the coded transcripts. A group of emergent codes focused on the timeframe of courses and programs including "multi-year" and "one semester". While this was not an initial

consideration of the a priori codes from the literature, these conditions about the structure of the courses and programs were emphasized in the data across all interviewees.

To answer my research question, I primarily focused on responses from questions 1, 2, 4 and 5 from the faculty interviews. These questions are focused on the course structure and aim to gain an understanding of the types of educational methods, the goals of the course, and a general description of the course. In the general description faculty described the age of the program, credits, structure of the program, along with the student demographics. These questions were:

1. Can you describe your course(s) to me?
2. Can you describe the major goals of your course?
3. What are some of the major educational methods you try to use in your course? (Such as problem-based learning, lectures, reflection)
4. If you could improve one aspect of your course structure or outcomes, what would it be?

An example of my a priori coding is a subcode "career preparation" to the parent code "professional skills". I coded the following quote as career preparation: "We run this program like a business. I want students to learn professional skills that they can market to future employers. Our students have a 100% job placement after participating in the program. It's because of our structure. They have a strong LinkedIn presence; they have strong presentation skills; their professional skills are well documented."

As an example of an emergent code, I coded the following quote to "multi-year" as a subcode to "program timeline": "Students come into the program as sophomores and participate in a different course each year until their senior year is complete" (4). The number of semesters or instances that students are able to participate varied between programs, and it became clear that it was important to capture those distinctions through the coding.

Research Question 2: What are the expected learning outcomes of programs across the United States?

Learning outcomes are closely tied to course structures. The given structure of a course tends to focus on the material that drives learning outcomes. Because of this relationship, I used the same a priori codes to analyze intended learning outcomes of international programs as in research question one. The specific codes that I included to understand the program learning outcomes include technical skills [61], [110],

[111], [112, p.], [113]–[116], professional skills [86], [91], [117]–[120], and the ethics of global work [11], [86], [121]–[130].

I developed and included emergent codes that arose from the data around other areas of learning outcomes. Emergent codes were unanticipated learning outcomes that emerged from the coded transcriptions. Two of the most prominent emergent codes were “transferable skills” and “soft skills”. “Transferable skills” focused on the idea that concepts learned through their international engineering experiences can directly impact and improve their skillset for traditional or non-engineering roles. “Soft skills”, unlike my other professional skills code, tended to emphasize student’s abilities to connect and communicate effectively across demographics. These codes had not been discussed in literature as an impact of experiences on students.

To answer this research question, I primarily focused on responses from questions 1-5 from the faculty interviews:

5. Can you describe your course(s) to me?
6. Can you describe the major goals of your course?
7. Are there key skills that you want students to leave your course with? (Such as social responsibility, teamwork, sustainable design, etc)
8. What are some of the major educational methods you try to use in your course? (Such as problem-based learning, lectures, reflection)
9. If you could improve one aspect of your course structure or outcomes, what would it be?

In addition, I analyzed student responses using emergent coding. I coded responses across 11 emergent dimensions (program type, trip structure, project type, language fluency, team dynamic, expectation of experience, partner relationship, aftermath of experience, motivation for participation, strongest impact, skills gained) to understand how students described their experiences. The questions used were:

1. Can you describe the structure of the course/program you participated in?
2. Prior to this course, did you have experiences in international engineering?
3. Why did you participate in this course?
    a. If mandatory, would you opt to take it if given the choice? (*Added to understand motivation*)

4. I understand that your program looked like this: XXX. How do you think that shaped the experience that you had in the program?
    a. Were there specific aspects of the program that you found most impactful?
    b. What was the most difficult part of your experience?
    c. How has that experience impacted future decisions?
5. How did you interact with others in your program (students, faculty, partners)? How did these interactions shape your project and your experience?
6. What skills did you gain from this course that you feel you didn't get from your traditional engineering courses?
    a. Can you give me an example?
7. Tell me about your current role: are you a student or are you employed?
    a. What do you want to do when you graduate? (*Added to understand effects on career choice*)
    b. What is your job?
    c. How do you think your experience in XX shaped your career and personal goals?
    d. How does your experience shape your work now?
    e. Do you think the structure of the program shaped these career goals?
8. Would you describe yourself as an engineer? Why or why not? (*Litchfield, 2015*)
    a. Do you feel like your experience helped you to understand your role as an engineer?
    b. Do you think your experience influenced you as an engineer?
    c. If you had to pick, what are the most important qualities of an engineer for the modern world? Do you think that your experience helped you to be a better engineer?
9. Outside of coursework or your career, have you continued to engage in service opportunities? (*Litchfield, 2015*)

I grouped the coded student responses to explore how they differ based on the interdisciplinary nature of the program. I also captured descriptions of the trip structure including the size of the groups, and the relation of the project to the student's area of study as related, tangential, or unrelated entirely. I grouped the coded responses based on the relationships between team members and with the international partner to understand the collaboration that the student had with others. The last grouping that I explored was related to the project itself. I considered whether responses differed based on the student's language

fluency within their partner location. I did this to establish the level of collaboration and communication. Outside of specific project and program aspects, I categorized a number of student expectations about their experiences both before participation and after. Prior to participation focused on expectations including why they pursued the experience and what they expected to gain from the experience. After participation perspectives were grouped into perceived learned skills, most notable impact of the experience, and how it impacted them afterwards.

Research Question 3: What motivates faculty members to participate in International Engineering Programs?

I used an exploratory approach to answer this research question. Through broad questions (like what do you think the legacy of this program will have for students and the university?) and open-ended questions (like how did you start teaching in the international engineering space? Why do you continue to work in the space?) I captured a range of data and coded it based on emergent themes. Three primary categories of codes emerged from the data. The most prevalent theme was the motivation to help others. One example of this is shown through the following quote: "I want to educate students to do this work". I coded this quote to "educating students" which falls inside of the primary code "helping others."

Research Question 4: How are community partner relationships built and maintained?

There is very little exploration into the formation and maintenance of international partner relationships within higher education. I intended to explore this phenomenon to create a baseline understanding of how various programs approach this aspect of international engineering work. I used the work of those who investigated international work inside of and outside of higher education to build a set of a priori codes to answer this question. These codes are focused on elements of partner relationship such as the length, interactions between groups, and intended impact [3], [126], [131]–[133].

To answer this research question, I used the following questions:

1. How did you choose your partner?
2. How long have you worked with this partner?
    - How often do you talk to your partner?
    - How many projects have you done in the past?
3. Is there a monitoring and evaluation structure for the service project after your course ends?

These three questions aimed to understand the formation of partnerships, how they are maintained (communication styles and participants), and how long these partnerships last (long-term commitments versus individual projects). Finally, I aimed to understand how programs evaluate their relationships with partners.

As an example of an a priori code, I used the code "travel length" as a primary code. I coded the following quote "our students spend a year developing relationships with their partners, and then are required to do a full summer's work with their host organization" (12) to "semester-long experience".

A consideration of the programs included is the location of their partnerships. A majority of the programs included in this work establish partnerships in the Global South with a handful of partnerships operating in the United States and Europe. As a note, local programs were not included in this work, so that limits the included number of US based projects as compared to what is truly available for students in US institutions. Those included are primarily on Native American reservations, which faculty established as culturally different from the surrounding communities in a way that provides similar educational opportunities for students. However, with the majority of projects occurring in the Global South, considerations of power is critical for these programs. Power can be an unexpected shift in the balance of power between these different groups, even when those with power are making an effort to do something helpful or "good" [105], [107]. A critical consideration for programs with this power imbalance is the flipped model of project development. This consideration of the power imbalance was either directly or indirectly addressed by every faculty member interviewed in this study. However, a gap in this research is the perspective from the international partners.

Research Question 5: What are the barriers that persist to starting and running international courses and programs?

As I answered research questions 1-4, numerous barriers emerged through the data that tended to crosscut program type. I used emergent codes to identify these barriers. While these barriers seemed to be common knowledge to the faculty that participate in these programs, there is little published data to build codes about prior barriers. I looked at responses from all the interview questions, but I specifically referred to three questions. These questions captured faculty perspectives on the challenges of the program or course they teach along with the areas that they most feel could be improved.

1. Why do you teach this course?
2. What challenges do you face teaching this course?
3. If you could improve one aspect of your course structure or outcomes, what would it be?

One emergent code that arose from the data was “tenure track process”. I captured data for this code by looking at references to barriers surrounding the tenure track process. One example of this is “so that's pretty much why I think we continue to do this against our best interests professionally, because it does not align with the incentives. I think that's one thing that your work has to acknowledge. There are zero incentives to do this work.” (17). Another example comes from a faculty’s experience looking from the outside of the tenure process, “so the number one thing that you're going to fight in getting faculty involved in this is the concept of scholarship for most universities. For the tenure track and promotion components, they only look at the scholarship of discovery. So, they put their blinders on [to this work].” (20). I coded both of these quotes as a “tenure track barrier”.

CHAPTER 4: RESULTS AND DISCUSSION

This section answers all five of the proposed research questions. There are numerous aspects to consider in the dimensions of international engineering programs, ranging from the individuals included (faculty, students, partners) to the outcomes intended from different program stages. The following figure aims to describe these key aspects as they relate to the program creation, implementation, and outcomes.

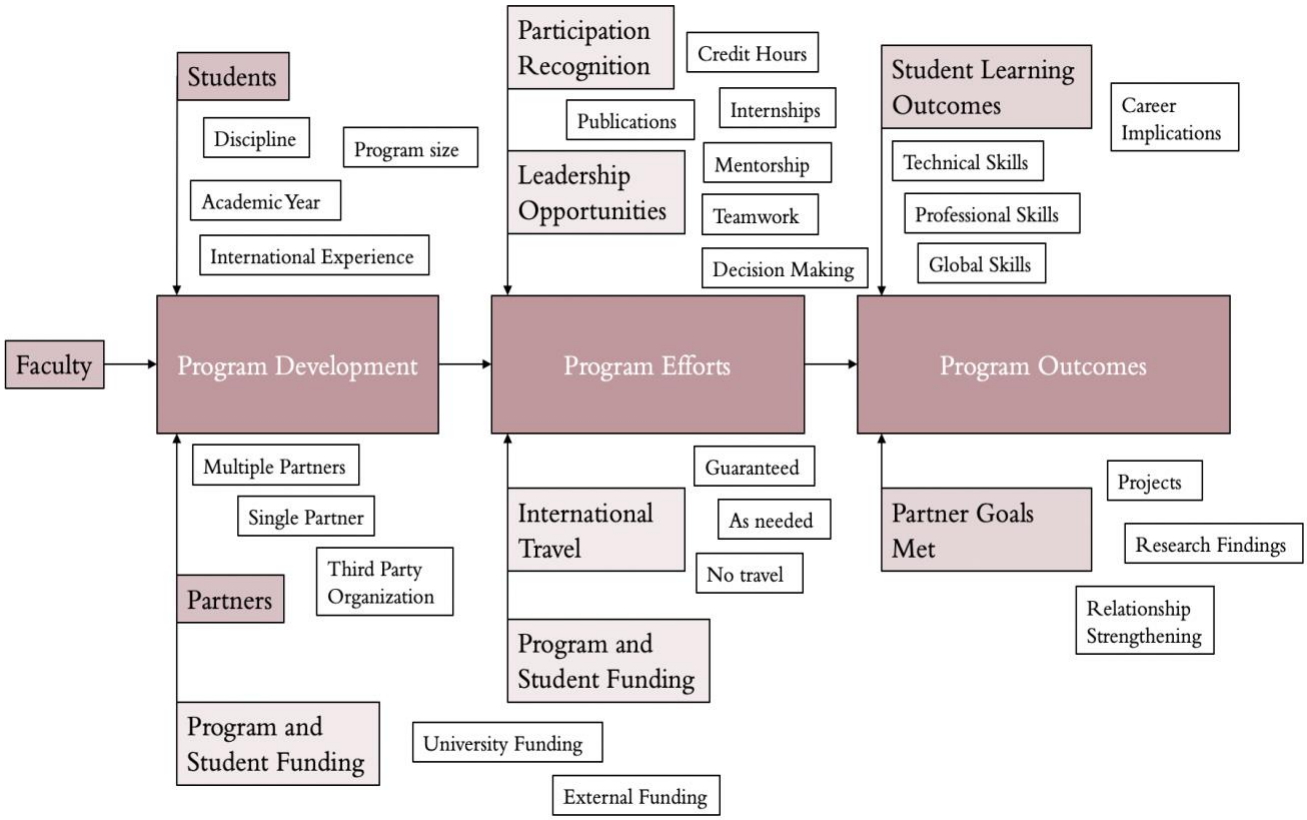

Figure 1: An overall perspective of the stakeholders and components of international engineering programs

Throughout my results I report estimated frequencies of both faculty and student perspectives. While frequency is not necessarily an indicator of importance, it does show the similarities between both faculty and student perceptions and experiences across their programs and suggests a similar perception.

4.1 Research Question 1: How are International Engineering programs structured in the US?

All programs, regardless of discipline, university, region, or program type held two primary objectives: to educate students and to provide value to their international partners. While all programs aimed to achieve both of these objectives, one was almost always elevated over the other. This tended to influence decisions about program structures. These objectives were also not rigidly defined across programs. For example, educating students included a range of learning outcomes, including technical, professional, and global skills. These varied between program type.

Faculty described three international engineering program types which allowed for different levels of structural and content influence. These three types were: embedded programs, independent research-based programs, and independent project-based programs. Embedded programs tended to conform to the structures of the existing course or program that it was conducted within. For example, capstone programs had specific structures and included pre-set students, and faculty used international projects as a mechanism similar to how other, non-international projects were included. On the other hand, independent programs were designed with the international research or projects as a critical consideration for creating the program structure. For independent programs, the faculty and program directors had more control over the program structure. Figure 1 shows the organization of these three program types.

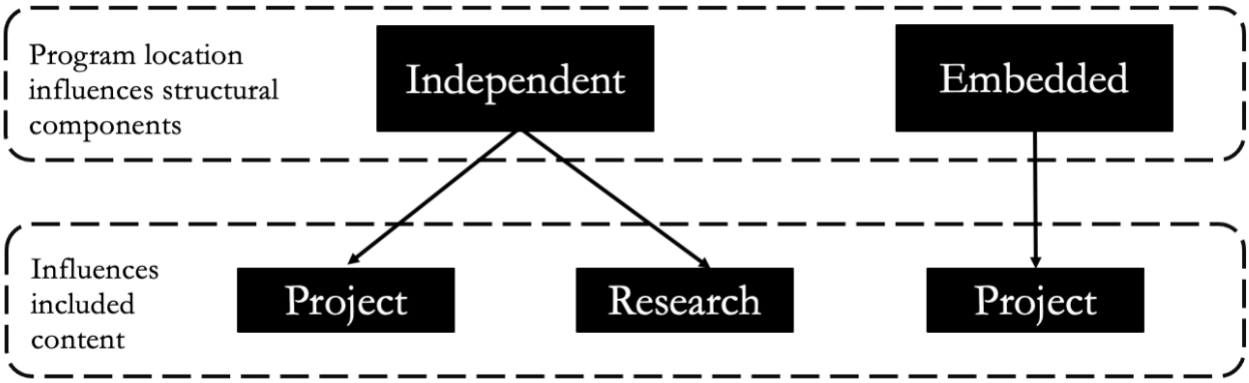

Figure 2: Program Type Organization

While all programs had the same two primary objectives (educating students and helping partners achieve goals), the weight placed on each objective varied by program. In many cases, achieving these two objectives was a balancing act. Structural components that created easier paths to achieve student learning

were often at odds with structures that could best support the value add for international partners. Some programs integrated structures in an effort to balance these goals. In many ways, I think of each of these objectives as a weight on a scale. Figure 2 shows this mechanism.

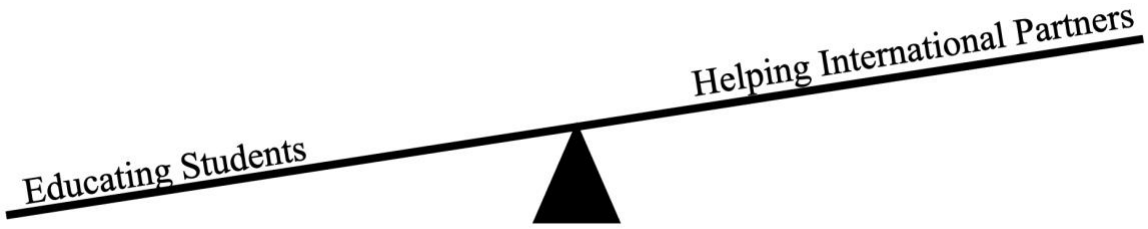

Figure 3: Balancing student learning and helping international partners

There were five major structural components that supported student learning and helping international partners. These components were critical to all programs and were important to consider when creating new program structures:

1. Student Demographics
2. Recognition of Participation
3. Organization of Student Roles
4. Travel and Partner Relationships
5. Funding Sources

Each of the five components either helped to determine the types of students and projects that could be included in the program or how the programs operated within their place in higher education. Across higher education institutions, it has been shown that there is a wide degree of variability across programs inside of each institution [134]. However, for decades researchers have investigated general "good practices" when developing structures. Several directly related to those investigated in this work [135], [136]. Considerations for interactive teaching and learning, diverse participation, out of class activities, collaborative learning, and active learning are a few that directly relate to those primarily focused on in this work. A major departure from traditional structure considerations is the accessibility to funding and frequency of travel as it relates to student work and partner relationships.

4.1.1 Student Demographics

Faculty described that students of different academic years and disciplines (both within and outside of engineering) were included or excluded from programs to achieve student learning objectives and/or partner goals. Student demographics were important for faculty to consider to achieve program goals. Faculty described that programs focused on student learning tended to tailor their student demographics for their specific learning outcomes, while those focused on achieving partner goals often used different student demographics. Of the programs in this study, 24% focused on partner goals as the primary objective, while 76% focused on student learning objectives.

Interdisciplinary vs single discipline

The number of disciplines included in programs affected the learning outcomes included in the program. A majority, 84%, of faculty described their programs as interdisciplinary – meaning the faculty's program included multiple majors. The remaining 16% were discipline specific programs. While faculty in single discipline courses and programs aimed to achieve discipline-specific goals, faculty in interdisciplinary programs aimed to integrate a number of disciplines to leverage learning opportunities and create diverse solutions to partner goals [137].

Faculty described that single discipline programs aimed to achieve discipline-specific learning outcomes. Some allowed students from other disciplines to participate when the course was considered introductory to those learning outcome topics. These included capstone courses primarily but extended to other discipline specific courses as well. The most common discipline specific outcomes were associated with ABET. Faculty described the need for students to demonstrate a certain level of technical, discipline specific expertise while working on the project because of ABET requirements. One faculty member involved with a single-discipline, senior-level program that included both international and traditional engineering projects described this as, "[the program] is meant to give students the opportunity to demonstrate all of their learning across their years at [the institution]. We are able to use these international projects to support those ABET goals, just like the [non-international] projects do." (4) An example of a single-discipline course was a capstone engineering program. In general, capstone courses have widely varied structures and can be multi-discipline [138], [139]. However, those included in this study were primarily single discipline (90%). For these capstone courses, the primary objective was to provide students with a chance to demonstrate the culmination of their learning throughout their university time. Students used their international projects to achieve these program goals, while faculty aimed to align the capstone project metrics with their partner's needs. In this case, a single discipline approach allowed the

students to demonstrate their engineering skills most effectively for the purposes of ABET accreditation and achieving their degrees (4). One faculty member described, “the purpose is to give [mechanical engineering] students [an experience] to apply everything they learned in their previous time at [the university].” (6) These international capstones were structurally very similar to traditional engineering capstone projects [139], [140]. The major structural differences between interdisciplinary programs and single discipline programs tended to include student recognition and student demographics

The independent programs frequently included a wider range of engineering disciplines and non-engineering disciplines than embedded programs. These programs were not always housed in engineering colleges but included engineers in the program. Interdisciplinary program goals included creating wider ranges of ideas and perspectives from student participants (1, 11, 22). Interdisciplinary non-international programs have similar motivations [137]. Faculty felt that this tended to enhance the quality of the projects within the program. This in turn provided benefits to the international partners. However, it sometimes proved to be difficult to provide students with formalized opportunities to further their degree programs in these interdisciplinary settings.

One of the biggest challenges faculty described was establishing credits or recognitions that were honored across disciplines. The location of the program (i.e., within a specific engineering discipline department or independent) had an effect on this challenge. For example, a faculty member involved in a program housed within a specific engineering discipline described their credit recognition as, “[the course] counts for the [in discipline] students as part of their core elective requirements or core curriculum requirements, [but may not count for credit for other disciplines], so that I think does help in terms of recruiting those [in-discipline] students [over other students] (7”). Another described their program’s location across colleges as beneficial, describing their interdisciplinary recruiting as, “we obviously strive to have interdisciplinary teams [and it] is a pretty easy affair because we have all majors [in our program]. When I put out the call for the next semester, we get everyone from global studies to nursing to global health language [to engineers] (9)”.

All faculty in interdisciplinary programs have worked to address the challenges of formal credit either by creating alignment between participating disciplines, providing additional learning opportunities such as field or international work, and more recently leveraging shared facilities and living arrangements like those in living-learning communities [141]–[147]. These alternative recognition types such as internships

and shared facilities may help international programs provide formal recognition for students across disciplines. About half of the faculty in interdisciplinary programs have implemented one or more of these alternative recognition strategies into their programs. These are discussed in detail in future sections.

Alternatively, some faculty described circumventing credit recognition through establishing a minor degree pathway for their program. This allows all students to achieve formal credit recognition for their course participation through the minor. One faculty member working in a minor degree-granting program stated, "it counts towards the minor for curricular requirements...So, I do have quite a few students that are pursuing the minor. We also in the College of Engineering have 14 different majors within the college that all require technical electives. And so, this course would be approved as a technical elective [in addition to the minor]. So, I also have some third- or fourth-year students that are taking this as one of their options as a technical elective." (13) The establishment of the minor pathway allowed for non-engineers to gain credit towards the minor where technical electives were not an option.

Academic Year

International programs included students ranging from freshmen to graduate students. The faculty described the decision of what academic years to include was often made to either improve the quality of the projects produced through the program or to improve the students' learning experiences based on the intended learning outcomes. Programs focused on creating strong projects or those that included more formal travel for project work tended to leverage older students while those with a stronger emphasis on student learning tended to include a wider range of academic year.

Faculty described student education differently by the academic years included in the project teams. For example, faculty in programs which included only senior level students or graduate students tended to emphasize implementation of prior knowledge (5, 6). One faculty member describes this expectation as they transitioned from having younger students participate on projects to only seniors, "I just said this would be so much better if I was dealing with seniors, because they've already gone through that whole transition [of learning and maturing]. I remember when I used to work at [another university], I ran their senior design [course] and I said these international projects look a lot like what we used to do for senior design" (8).

For programs described by faculty as integrating a number of academic years, there was a wider range of technical education included. For example, one faculty member described their technical learning outcomes as wide-reaching and not limited to certain levels of academic years, stating,

> The big thing that comes out of our data is teamwork and leadership, the ability to work with diverse teams. Most of our students have some type of leadership experience if they've been in the program for multiple semester. The ability to communicate orally and written with diverse audiences. The ability to manage projects and plan there is adaptability. The ability of students to apply their knowledge to design is a big piece. The awareness of an ability to work within diverse communities and setting is another important value and of course, we get into ethics. I want to note we elicit learning as we go through [the course]. There were years we tried to say, OK, week 13 is Ethics Week and it just doesn't work. But when you say over the semester, we want to have an ethics conversation, wow, here's a great time to have it. That's really where it's [effective]. But it is the same for all of our students, that's why it works better than [creating a specific schedule of topics]. (14)

This range of topics was common across faculty descriptions of programs. Additionally, this faculty member notes that the flexible nature of the intended learning topics allowed for adjustments to the course as the projects progress and students experience relevant activities through project or research work. This was an intentional design to allow students of all academic levels and program experience to learn.

About half of the faculty members across different program and university types believed the project quality was not influenced by the academic years of students. A faculty member in a large public university program that accepted all undergraduate levels described the academic year of team members as a much less of a factor for success compared to their level of involvement with the program. They stated, "the productivity of a student in their first semester [of the program] compared to their second or third semester is incredibly different and almost has nothing to do with what year they are in school. So, if they're a first-year student, first time student [in the program], their ability to perform in the [program] environment is about the same as a junior first semester student. I always found that super interesting (1)." Another faculty member at a private research institution described their decision to include all undergraduate academic

levels in their program as a way to increase the range of ideas that were not bound to limitations perceived through increased education (15).

Some faculty justified limiting the academic years that they accepted students to improve project quality. For example, several faculty described that their programs did not accept first-year students because of the travel component of the program. Two faculty members, one from a large east coast university and one from a north eastern university, believed that the travel component was too overwhelming for younger students and they lacked technical background to make the trip effective (6, 8). While the students may learn a lot in this instance, the prior research aligns with their rationale that maturity and preparedness of young students can strongly impact both the project success and travel team dynamics in ineffective ways. In general, students of lower academic years tended to have higher levels of creativity but a lower sense of engineering agency and self-efficacy [148]–[150]. For the international partners, these students may not provide as effective final projects. However, students of lower academic years may become more confident in their engineering capabilities through project-based experiences [59], [151].These considerations can help faculty decide what level of students to accept into international programs.

Student's prior international experience

Faculty that considered prior international experience of students when admitting to their program or assigning particular roles within the program described that they believed prior international experience was a determining factor in future project quality and often helped lead to better mentorship of other students. Of the programs included in this study, few strictly or mostly required prior international experience to participate, however, programs with graduate students tended to have a higher expectation of students with prior international experience (15, 5). One faculty member described, "their experience helps the partners and the projects" (5). Similarly, general engineering programs use this concept of prerequisite experience to ensure proper quality and content delivery within relevant courses [152]. The idea of prerequisite experience ensures that all participating students begin from the same level of understanding.

At the undergraduate level, though, there was more lenient requirements for international experience. This is, in part, due to the goal of providing students access to learning about international work. Similar to the considerations for implementing a prerequisite, programs that aim to provide "ground up" education on international projects have less need to require students have prior experiences. However, undergraduate

students with multiple semesters of participation in programs tended to be utilized in similar manners to those students with prior experience outside of the program. One faculty member described, “I asked [a returning student] to run this project, because I knew that she could deliver. I gave her the tools that she needed to operate on a tight timeframe, and they knocked it out of the park (1).”

Whether students are gaining multiple iterations of experience from within the program, expected to arrive with a foundation in international work, or require no prior education about international projects helps to shape the structure and content delivered within a program. For example, a program with all first-time participants in international work have a duty to cover fundamental considerations and practices with their students, while those who recruit students with prior experience may move on to more complex, higher-level work. This relationship can be related to engineering design courses. Lower level courses cover fundamentals [153] while upper level design courses focus on culminations of information [139].

Number of student participants each year

There are several factors that impact the number of student participants, including: number of courses, number of faculty, number of projects, and travel requirements. Student participation has largely been used as a program descriptor [4], [8], [102] along with the other notable aspects of programs, yet the number of student participants tends to change the structure of the program itself. In fact, it can help drive program objectives when considered during program development.

Faculty members who taught single courses included a much lower number of student participants compared to programs with multiple course offerings. In the programs included in this study, as the number of courses increased, the number of students and faculty participants tended to increase as well. For example, a program that included 6 courses averaged 10-15 students per course, totaling 60-90 participants, accommodated significantly more students than a standalone course accommodating the same numbers.

More than half of the faculty described limiting the number of student participants by the number of projects across all programs and was a critical factor in the number or size of projects within the program. Faculty that ran more projects simultaneously were able to accommodate a higher number of students as opposed to those who ran one or two projects simultaneously. In practice, there tended to be a limit of how many students could effectively work together on a single project. Team based literature suggests that teams of 4-7 are most effective to leverage student learning [154]. On average across all programs

included in this study, this number tended to fall around 5-10 students per project. In some cases, student teams were significantly bigger and in others there were only 1-2 per team. The range tends to lie on the specific project topic or the organization of student participants.

All faculty echoed the sentiment that smaller teams were limited in the amount of work that they could complete, while larger teams, greater than 10, often pursued larger scale projects that could be broken down into smaller components allowing for small teams to focus on the smaller project parts. For example, one faculty member, from a large east coast research university, described the number of participating students as, "We usually include anywhere from 10-15 students," and described their projects as, "infrastructure projects [like]...a greenhouse, water sanitation systems, or schoolhouses...and students work on parts of it in smaller groups (6)." While another faculty member, from a small southern university, who described the number of student participants per project team as, "one to two students per client" described the project work as, "limited to more supporting work but is more flexible for students to help support existing 'intern-type' operations within the organization...and the students have to really own their projects since there are only two of them on site (13)." To create optimal project teams across university and program types, programs should ensure that between 4-7 students have direct impact on a portion of or a full project. These project sizes allowed students to be fully engaged.

The ability to travel was another component that influenced the number of student participants in a given academic year. For programs that required all students to travel, there tended to be a smaller number of students in the program due to the resources and coordination required with international travel. One prior investigation on short term study abroad describes the decision for the number of student participants in part as a result of the trip leader's tolerance for chaos, meaning their ability to effectively coordinate complicated schedules and needs among student participants [155]. When considering the level of coordination required to conduct a classroom course and a related study abroad, faculty described several limiting factors which were heightened by increasing the number of student participants. A faculty member described an example of recruiting enough participants to participate in semester-embedded travel. The faculty described this as a limitation for recruiting enough students to allow their program to run. As a solution to this, they developed alternative travel dates to accommodate more student schedules. They stated, "We travel in the winter and summer semesters to allow students with compact schedules the opportunity to participate in the program" (6). This decisions allowed the program to accept enough students to allow the course to run and to effectively create project solutions.

Ten faculty described that their programs included fully or partially funded student travel, while others required the students to fund themselves. The availability of funding influenced the number and type of students who participated in the programs. One faculty from a large research university described their motivation to fund students to travel as, "an opportunity for students of all backgrounds to participate (7)." However, another faculty member described that requiring students to partially fund their travel, "gives them a stronger sense of commitment (13)." Self-funded programs tended to be smaller, while university supported programs with funding tended to include larger student teams. Programs that require students to fund themselves should be conscious of the demographic limitations that their program may face with inclusion and recruitment.

Faculty selected their program's student demographics based off the consideration of the level and type of education and personal maturity of the student to achieve the course objectives. The included student demographics that faculty described for their programs directly supported their intended goals for student education or supporting international partner goals. A majority of faculty felt that interdisciplinary programs were highly beneficial for their program success. However, faculty were split on the inclusion of all or limited academic years in their programs. Faculty tended to decide the included academic years directly based off of their ability to meet course objectives and effectively travel where appropriate. Student's prior international experience was not important to most faculty.

4.1.2 Recognition of participation

University students were, at the core, using these opportunities to build their resumes and experience to better prepare them for life after university. Recognizing their participation in international programs helped them achieve this objective. Recognition for participation included traditional course options like credit hours or more professionally driven recognition like research, internship, or mentorship opportunities. Each of these provided value to the students' credentials upon completion of their degree. It also better helped them to convey their experiences to others in a way that is transferrable. Additionally, some programs created mechanisms to keep students formally involved to improve retention and to help students build additional formal experiences.

Credit hours

Compensation for student participation in international projects varied widely and included options like technical elective credit, general credit, and internships. Within these options, the amounts also varied.

For some programs, courses offered one credit, while others offered up to 30 or more credits. Faculty described using of credit hours as an incentive for student participation, a mechanism to fit within rigid engineering course loads, or a way to provide resume-tailored experiences for students. While credit hours are not required to provide educational and developmental opportunities for students, the value added for students participating in degree granting pathways is significant towards their future goals [156], [157].

Of the programs included in this study, 40% required multiple course participation. Some of the single course programs included the option to repeat the course over several semesters each for credit. In total, 72% of the faculty in this study described their programs allowing for multiple iterations of participation. This increased the total credit load to add to the student's transcript. While this provided formal recognition of participation, many engineering students perceive their course loads to be more strenuous than other disciplines [158], [159]. The use of iterative courses was a solution for this and aimed to allow students to participate in the program as it fit their schedule (1). One faculty member noted that the highest performing and most invested students are often involved with several other groups or activities on campus, therefore their time was stretched (1). They stated, "so it tends to be the junior year that some of our students who've been with us for semesters, they start their junior year and they're like, 'I can't do this anymore because it's just too much.' So, part of the problem is that we get these really elite students in their junior year who all sort of drop off and sometimes they come back and sometimes they don't (1)." Additionally, certain years of the engineering curriculum limited non-degree path credit hour space for students in those years and semesters. The flexible course offering allowed for these types of students to return to the program when their schedules allow it. Iterative courses in higher education have grown in popularity in disciplines like software engineering and have aimed to increase the flexibility in traditional course design [160]. In a similar manner, these iterations create multiple opportunities for learning and participation without bogging down schedules.

A majority (64%) of programs required less than four formal credit hours for participation. Table 3 shows the categorization of programs based on required credit hours. Programs that utilized iterative options within a single course are captured as a three-credit hour option here as the additional iterations of the course are optional, not mandatory. The programs who fell into the +10-credit hour category are established minors or degree granting programs. Those that fell in the 4-9 credit hour range offered a handful of required courses and were often supplemented by additional optional options.

Categorization of programs by required credits. Note: iterative courses with one course listing are counted as a single course offering.

Table 2: Categorization of programs by required credits. Note: iterative courses with one course listing are counted as a single course offering.

Number of Credits	1-3 credit	4<x<10 credit	+10 credit
Number of Programs	16	3	6

The distribution of credit hours supported the notion that credit hours within an engineering curriculum are limited and courses tend to compete for space on student's calendar. While the engineering curriculum, in practice, is not heavier than other majors in terms of credit load, a majority of this perspective arises from the additional program components that students participate in, such as the related out-of-class time required for courses [158]. An example of this would be a lab course. Labs courses are often one credit hour but require a significant time commitment for students to complete the projects and tasks related to the relevant credits outside the classroom. One faculty member echoed this sentiment and described that compared to traditional lectures, their one credit course overwhelmed the other in terms of workload (1). So, while the credit load itself was not significantly impacted by adding these additional credits, the additional project component could increase student load when done alongside other engineering requirements.

Publications

Faculty described that student publications were utilized in both research-based programs and professional development-focused programs (19, 20). 48% of faculty described a publication requirement for their students. Faculty aimed to use publications to disseminate the work that is being done while providing students with a professional achievement that can be shared with others (2, 19, 20). Many of these programs focused on publications also encouraged students to participate in conferences and other professional opportunities to share their work with the academic and local communities. One faculty member described the value added from publications as, "an opportunity for the students to show off their experiences within the program in a formal and professional way" (20). 20% of the faculty in participating programs in this study required students to produce publications from their work. In general, research and publication experience while in undergraduate degree programs have shown to strengthen students'

perspectives of personal and professional growth [161]–[163]. As outcomes of many international programs, adding in this publication component has helped strengthen student skills.

Internships or Work Experience

Faculty in 32% of programs included opportunities for internship experiences or framed the time that students spent in their partner countries as a work experience. This typically includes a formal arrangement with the international organization. This formal work experience, according to faculty implementing the experiences, lent more credit to the student's international experience and helped to elevate it above a study abroad experience on their resumes. Internships are valuable for students' career preparation and are a prominent feature on resumes to show potential employers [164]. One faculty described how students used these experiences professionally by, "helping them to understand where to put it on their resumes. We ask what skills they learned that are applicable. What formal experiences should be included here?" (12). Additionally, by framing the experience as a job, the international partner gains some control over the work conducted. Faculty who implemented internship and work experiences explained that the framing of the experience shifted from an external project to complete to the student becoming part of the international team (5, 12). A faculty member described the type of work that students are able to do in this structure as, "if they go in the fall, they're going for 15 weeks full time to the site. So, they might work on several project, they might work on one project, they might work with one aspect of the organization, or they might work with several...so they can fully support the needs of our partner organizations (12)."

Formal Mentorship

Programs integrate mentorship in one of three ways: peer mentorship, graduate student led mentorship, and professional led mentorship. Each type of mentorship aims to achieve different objectives within the program. A common goal across programs with mentorship was providing value for participating students through personal, professional, and educational opportunities. Each type of mentorship is described below.

Peer to peer mentorship was most commonly included in faculty descriptions when the peer mentor had taken more formal courses or participated in more projects than those that they mentored (1). Faculty described that the goal of this style of mentorship was to provide the mentor with a formal experience to lead a project while giving newer students access to a deeper level of information (1). Peer to peer mentoring was widely used across higher education [165]–[168]. However, while peer mentorship is applied across various uses, this style of peer mentorship is most closely tied to project-based learning

principles research [90]. The mentoring student may only have a year or two of experience through the program, and therefore their primary objective in mentorship was described as guiding newer students through the learning process for the projects within the program. For instance, a faculty member described the value of this style of mentorship as, “students with more experience work alongside newer students to help them understand our design and project principles” (1). Another described peer to peer mentoring networks as, “[highly structured] to ensure that one leader only has at most 3-4 students under them... this allows for them to guide the work quality effectively” (20).

Faculty who used graduate student mentors described that these students were leveraged to promote undergraduate student learning through their extensive international project experience prior to joining the program. One faculty at an independent project program describes specifically recruiting graduate students with formal international experiences to mentor undergraduate students (15). The faculty member described the use of graduate student mentors as an effort to provide the undergraduate students with the opportunity to learn from mentors with real-world international project involvement. This lends a major focus on the nature of international collaboration and cross-cultural exposure. A faculty member described their graduate student mentors as, “the difference between a good program and a great program...these students bring real-world experience to the table and are able to share it with undergraduate students” (15). For some graduate students, though, this can place a significant level of pressure on them to provide specific engineering feedback on projects that is less familiar to them. For instance, one student described pressure in their current mentorship role, “I am not a subject matter expert in this, so I feel a little underprepared to handle the role sometimes” (12S).

A small number of faculty described that their program integrated professional mentorship into their programs. The motivation for including industry professionals was more complex than using other students as mentors. For the industry professional, faculty described that mentorship provided them the opportunity to network with potential future hires while giving them exposure to humanitarian or international work that may be different than their typical day-to-day engineering duties. [169]. Faculty described the value to students, on the other hand, as getting contextualized experiences and perspectives of engineering work in action [170]. In addition to mentorship from someone who is a subject matter expert on the engineering aspect of their projects, faculty using professional mentors described opportunities for students to network for future career opportunities. This type of mentorship more closely focused on professional networking and access to technical experts over mentorship in cultural

considerations. One faculty involved with an independent project program at a small private school described this as, “a huge value to our program. The professional mentors are able to connect with students to network and show them what real engineering could look like...however [the mentors] don’t always have experience with international projects, but the topic of the project itself” (22). To accommodate the lack of mentorship in cultural considerations, course material must supplement these lessons.

Most (76%) of faculty stated that their program implemented one or more recognition method besides credit hours. Faculty described the use of internships, publications, and mentorship as a way to bolster student experiences both academically and professionally.

4.1.3 Organization of student roles

Program organization and leadership typically fell into one of two categories: faculty-led or student-led. Each program’s organizational structure aimed to support the same two objectives of helping international partners and educating students but often utilized different approaches. Considerations for cohesion between academic calendar years, communication with international partners, and guiding student learning were the primary focus for both strategies.

Faculty described that in programs emphasizing a student-led approach, students often took the lead for project development and international partner communications. Student led opportunities such as these are an innovative type of active learning that gives students control over their experiences [171]. Programs that utilized this approach tended to lean on students’ efforts to support partner relations and to give the students the opportunity to “drive” projects (20). This allowed students to gain significant experience working with real-world customer constraints and communications. For example, one program director of an independent project program described their intentions in developing a fully student-led program as highly beneficial to student learning. They described a specific representative case of this during presentation sessions as:

> I'll say that we have some of the best presenters at the university bar. And we're brutal but, we set the bar high, and we don't reduce that bar. So, if you're a freshman literally hours from high school you get treated the same way as if you are a graduate student. I don't care. You know, everyone operates to the same bar. I was meeting with some of the students yesterday and these two students--one was a sophomore and one freshman--gave their presentation and I literally was standing up clapping when they were done, and I

> don't do that, OK? But that was the first time they'd ever presented before the class. and they nailed it. And to present for the first time in front of this group and as tough as we are, it takes a lot of preparation. But they're learning from other students. They're not learning from a faculty member. It seems to be more effective learning from students than from faculty because students in their mind will sit there and they prejudged themselves, 'Oh, the faculty can do this, but I can't. I'm a student. I don't have the same capabilities.' But if a student gets up there and does it now, well, you're safe, you can do that too. And so that's one of the reasons why we really think having this mix of, you know, fresh students who haven't been exposed to this, working with veterans who have done this, they develop many times faster, so they go from baseline to boom, operating very quickly and then they start growing from there. (20)

For programs that utilize a multi-year approach, this student-led structure often allowed students with multiple years of experience to act as mentors or leaders for newer, less experienced students (1, 20). The student-led model was most often used when students could participate in the program for more than one iteration (1, 18, 20). Faculty described exposing students to more "seasoned" peers helped promote confidence and peer-to-peer learning. A limitation of the student-led model was the length of participation that students have with the program. Student-led models required the students to maintain control and ownership of projects [172], which created long-term sustainability issues for programs with predominantly one-semester participants. Programs should consider this relationship when establishing educational structures for their program.

Faculty described programs that used a faculty-led model aimed to prevent the loss of project knowledge through attrition due to the academic calendar. Faculty described that these programs often put a heavy focus on the value of knowledge sharing and cohesion between iterations of instruction, not to mention the deep creativity and understanding that faculty carry about their course and program topics [173]. Most of these programs described by faculty did not require students to participate in more than one iteration, and therefore aim to capture knowledge of the projects and relationships through faculty. For instance, in a single-iteration course, the faculty described, "We use lectures and hands-on learning activities for students to learn [the technical skills associated with the learning outcomes], and we submit these to ABET through their coursework" (7). For educating students, these programs aim to place the faculty member in the forefront to guide the student learning through the project development. Many of these programs

lack experienced students and therefore aim to include much more formal learning. One faculty member described, “we, [the faculty members] aim to educate students in topics that they may never see in other courses. They are all new to the ideas that we work to build on.” (10) Programs utilizing faculty-led models work to create consistent learning in specific topics primarily for students with limited backgrounds in the topic.

Some faculty described programs that integrated these two models to create a hybrid model where there were formal lectures that are faculty-led paired with student-led design time to encourage students to include their formalized learning in their team-based learning time. These faculty tried to balance the intentions of both models to create a knowledge base that could be maintained from year to year independent from the student participants while giving the students the opportunity to guide their own learning. One faculty member described the necessity of continuity of knowledge in the projects as, “the key reason that we keep faculty members heavily involved with the projects and partnerships (22).”

4.1.4 Travel opportunities

Programs utilized travel differently to support their program goals. Considerations of the number of students to travel, frequency of travel, the purpose of the travel, types of communication involved, and the project creation on site all contributed to the overall program goals. This component is unique to international project/research programs because the travel requirement can be a secondary component of program outcomes instead of a primary focus. This is unlike study abroad programs which aim to use travel as a primary component of their program outcomes [174].

Some programs offered no travel experience for students, while others required all students to participate in an international experience. The justification for these travel requirements resided in the programs’ effort to meet their educational and international partner support goals. The frequency of travel was described as often dictating the type and number of student participants that the program can support. For example, programs that required an entire summer of travel had limited engagement of students focused on gaining internship experiences during that time. A faculty member described this challenge as “engineering students can get internships or coops and make a lot of money. So, it can be hard to convince them to pay money to give up their entire summer [for the program]. So, I think that we get some more privileged students as participants.” (12). On the other hand, travel scheduled for winter or spring breaks, or shorter timeframes become more accessible to students. One faculty member reflected, “We travel over

spring and winter break, usually, to help fit the travel into student's busy schedules." (7) The purpose for travel often influences student's ability to travel. Described by several faculty, if a major outcome of travel was the intent to expose students to other cultures, programs tend to include all students in travel similar to study abroad programs [175]. On the other hand, programs focused on project creation may not have needed to send students abroad to effectively contribute to the project creation. A faculty member in a non-traveling program gave an example of this type of perspective stating, "we don't travel every year. Or every other year for that matter. We only travel when it is necessary, so students are not guaranteed the opportunity...in research or design semesters, there is no need [to send students]." (13)

Programs varied in the frequency of travel to their international partner sites. Some described never traveling, opting for virtual communication instead (8-16% depending on the year). This is particularly effective in projects that are more conceptual in nature. For example, a faculty member described their conceptual project semester communications as, "frequent and very involved...We work virtually with our partners to see the locations, understand needs, and get feedback on our project progress." (13) The use of tools like Zoom and Microsoft Teams were often effective in distributing information between student teams and international partners (12, 13, 20, 1, 14). COVID created a significant pressure on international programs to develop these communication tools (1, 12, 13, 20). For instance, a faculty member described the impact of COVID stating, "we had to get creative in our digital communications...but now these are critical components of our projects. [Virtual communication] has allowed us to connect with our partners year-round instead of on trips." (1) Some programs, approximately 40% on average, travel on an annual or biannual basis. These programs utilize their time in-country to establish stronger relationships with their partners and work on more physical projects. For example, one program described their travel schedule as, "My opportunity to build more projects. We go to work on one, and I work on [building] the next. We get to see what our partners are working on and see where we can help." (8)

4.1.5 Funding sources

Funding is a highly varied aspect of programs, and ranges from complete university support to funding being acquired through external independent mechanisms. Regardless of program, funding is a non-negotiable aspect of programs to allow for project or research development. Every program included in this investigation included a funding mechanism. The availability and types of funds shaped the type of work, the type of student, and the type of partner relationships that the programs could have. Programs harnessed ***internal support*** through university resources and ***external resources*** through funding

mechanisms such as grants, donors, or student-generated funding. In addition to these funding streams, student resources also existed within programs and within the university to help provide financial support for international experiences. In general, faculty involved with programs that were independent and multi-year such as minor programs or multi-year programs tended to perceive having the most robust funding streams while those in stand-alone or integrated programs tended to emphasize relying on existing, separate mechanisms to fund international programs.

Independent programs tended to leverage internal funding or alumni support to fund current students and projects. Internal funding existed to support program goals and objectives such as project development and student travel. These funding streams were, in general, the result of program specific funding that was allocated at the university level. One faculty member described this as, "We have a pool of funds from the university, so we are able to allocate a portion to supporting student travel and projects." (9) This funding provided opportunities for students to travel when necessary and supported international projects. Programs with a significant alumni base utilized external fundraising through alumni as a significant source of program support. One faculty member described, "we have an immense pool of alumni who participated in [our program] ...so we send newsletters and let them know what we are working on, and many support our current students." (1) These funding sources allowed for programs to use funds in a flexible manner for projects, student travel, or other requirements needed to complete projects. There were few limitations on how they could spend the funds.

Faculty from integrated programs tended to describe a lack official funding sources for projects and student travel which increased the pressure on students to secure funding (7, 8, 4). A small number of faculty used student learning-focused funding sources to support students in their programs (7). This creative funding required extra work from the faculty member. They described, "we had to justify that the project was providing educational value to students to apply the funds to their project development. But the money could not be used for the actual project itself (6)." This made the students responsible for securing the funds to travel and produce the project internationally. To secure funding, many students looked for external funding mechanisms like fundraising events, grants, or personal donations. One student described, "I asked for money from all of my family for Christmas for our project. It was all I wanted." (19S) For students responsible for funding their travel and the project costs, university resources like global education offices and department resources helped to identify scholarships or other funding mechanisms to help alleviate the burden on students to financially support the experience. For some

students, funding was a critical barrier to participation. When considering future potential funding challenges a faculty member described,

> "My concern in the future is that funding is going to become more and more of an issue. So, I'm concerned about the impacts [on] students, meaning are we going to need to make students start paying more for these experiences and how that kind of look? Can we offer scholarships for students that absolutely cannot afford to do it?" (12)

This type of independent funding raised concerns of sustainability. For faculty in programs who could not raise enough funds, what happens to the partners? The projects? The fragility of project completion relied on fundraising through immediate need and operated on a short time horizon. Additionally, putting this load on students seemed to limit the types of students who could participate in programs to those who were financially able to afford and fund a project.

Other faculty describe that their programs fund a portion of the experience and require students to fund the rest. One faculty member described this as, "[the program] would arrange all of the logistics and travel and expenses, but the students had to raise or pay one thousand two hundred dollars for their experience. I'm not quite sure the history of where that magic number came from." (12) This was to establish financial buy in from students. Similar to funding mechanisms to create stakeholder buy in and ownership of projects, requiring students to partially fund their experience aimed to generate ownership and commitment from students [176].

In 12% of the programs in this study, there was a required financial commitment from the international partner for the completion of projects. The motivation for this funding was to increase the ownership of the project for the stakeholders responsible for maintenance of the projects, and to alleviate the necessary funding requirements for students. The financial ownership for partners additionally created project ownership for the partners, which is the goal of shifting financial ownership of projects [177]. Additionally, eliminating this burden from students allowed a wider range of students to participate outside of those who were financially able to contribute.

Across programs, faculty described how funding mechanisms were used to support three primary areas of programs: student travel, project development, and project implementation. These directly impacted the type of students, partner relationships, and work that a program could include. Program funding was a

non-negotiable component of international programs, however by intentionally developing funding streams, programs can work to shape their programs' student and partner participation while shaping the type of work that they can do as well.

4.1.6 Final Comments on Course Structures

Three course structures were described by faculty in international engineering programs: independent research programs, independent project programs, and embedded programs. Each structure aims to support specific student learning and partner goals through modification of five dimensions: student demographics, recognition of participation, determined student roles, travel opportunities, and funding streams. For example, a partner-focused program may leverage mid-level students to encourage maturity on in-country trips, while working to include a wide range of disciplines in addition to engineering to yield diverse, innovative solutions. On the other hand, programs focused on student learning first may emphasize student academic levels that meet specific learning outcomes (i.e., all seniors if the learning outcomes require high levels of technical understanding, or a wide range of academic years if the learning outcomes are broader). Credit hours, internships and other participation recognition were utilized to encourage participation from specific types of students while giving them formal experiences to help build their university or professional portfolio. Independent programs tended to have stronger funding streams for student travel and project completion, while embedded programs focus any relevant funding on classroom-related endeavors.

Using the five primary characteristics (student demographics, recognition of participation, organization of student roles, travel and partner relationships, and funding sources), faculty construct the scaffolding which allowed them to reach their goals and intended outcomes. The most important consideration that influences each of these structural characteristics is the program's primary focus between educating students and supporting their international partner. The amount of emphasis a program placed on each of these considerations changed how the structural components were used to support those goals. The exception to this was funding sources, which were more unique to program types as opposed to program goals. The following table describes each characteristic with respect to the two primary program focuses and provides examples of balancing these focuses.

Table 3: Course structures considered for student learning objectives and supporting international partner needs

	Student Learning Objectives	Supporting International Partner Needs	Where These Can Intersect (Examples)
Student Demographics	*Included Disciplines* • Single discipline for discipline-related learning objectives • Interdisciplinary for general global learning objectives *Academic Year* • Academic year varies from freshman up *Participant Size* • Increase or decrease number of projects to support participant size *Prior Experience* • Not required	*Included Disciplines* • Chooses discipline inclusion that best meets partner project needs • Often more interdisciplinary inclusion *Academic Year* • Higher academic year typically included *Participant Size* • Participant size tailored to specific project needs *Prior Experience* • Valued and sometimes required	*Included Disciplines + Academic Year* International partner needs a very technical project solution, program recruits seniors in the corresponding discipline *Participant Size* International partner requests project with multiple components, program chooses to divide across multiple years to achieve project goals with pre-determined student size *Prior Experience* Project utilizes a small number of experienced students along with many inexperienced ones
	Student Learning Objectives	Supporting International Partner Needs	Where These Can Intersect (Examples)

Recognition of participation	*Credit Hours* • Single course participation (approximately 1-3 credit hours) *Publications* • Used internally to show student progress • Encouraged to submit to traditional journals *Internships* • Students tailor experience and skills learned for their professional development and communications *Mentorship* • Allows students to learn from one another and build leadership skills	*Credit Hours* • Numerous credit hours to ensure long-term student participation *Publications* • Focus on open-source publications • Disseminate information broadly *Internships* • Flexible to partner's current and changing needs • May be unrelated to area of study *Mentorship* • Can be used to increase technical expertise or global expertise in projects	*Credit Hours* Iterative courses designed to allow students flexibility to include course over their college career Minor programs designed to formalize student experiences while providing multi-year experiences for partners *Publications* Encourage publication of work to a wide range of mediums *Internships* Provide professional development opportunities for students in combination with focused community work *Mentorship* Inclusion of cultural expert and technical expert to provide engineering and cultural mentorship

Organization of student roles	• Uses faculty-led or student-led experiences to meet specific learning goals	• Utilizes faculty-led experiences to ensure consistency between years • Utilizes student-led experiences to better connect with partners or build effective teams	A multi-year program utilizing student-led approaches to develop professional skills while working on partner-specific projects Split lecture and problem-based learning integration.
	Student Learning Objectives	Supporting International Partner Needs	Where These Can Intersect (Examples)
Travel and partner relationships	• Maintains pre-determined travel components for students • Travel is broad requirement for all student participants	• Travel depends on partner needs • Travel opportunities limited to appropriate number and type of student participants	An international partner that requires an annual visit or an annual project completion that correlates with student semesters where all students can travel
Funding sources	-	-	-

Funding exists external to the goals of programs in some ways because it is dependent on the types of funding streams that are accessible and appropriate through each institution. Understanding university buy-in for funding international programs will help program creators to understand what kind of financial support they can offer for students and partners.

Determining the student demographics to include in a program was described by all faculty members as directly depending on the primary emphasis on student learning or supporting international partner goals. Combining program structures can allow for programs to balance the needs of partners and student education, however it can be difficult when those needs come into conflict. Identifying whether student

learning or partner support is more critical to the program's success can help faculty and future programs effectively choose their participating student demographics. The included types of students impact what kind of projects a program can complete in addition to what relevant learning outcomes the program can effectively include.

4.2 Research Question 2

This section answers Research Question 2 which explored the expected learning outcomes of international programs for engineers and how students reflect on their experiences in their respective programs. I begin by describing the learning outcomes as related to the program's level of programmatic and content level influence. These levels are the same as those described in research question 1: embedded programs, independent research-based programs, and independent project-based programs. Embedded programs aimed to support existing courses or program goals by using international projects. For example, capstone programs were designed to achieve specific ABET criteria, and faculty used international projects as a mechanism to achieve those goals.

On the other hand, all faculty in independent programs described the program as designed with the international research or project as a critical consideration for evaluating learning outcomes. These learning outcomes could be tied to various ABET criteria, or they could be independent. For independent programs, the faculty and program directors had more control in developing learning outcomes. Within each of these levels of programmatic and content level control exist all of the structural considerations discussed in the last chapter. While faculty described that some specific aspects of course structures affect or are influenced by learning outcomes, understanding the motivation for specific sets of learning outcomes is more closely tied to the programmatic and content influence of the programs themselves.

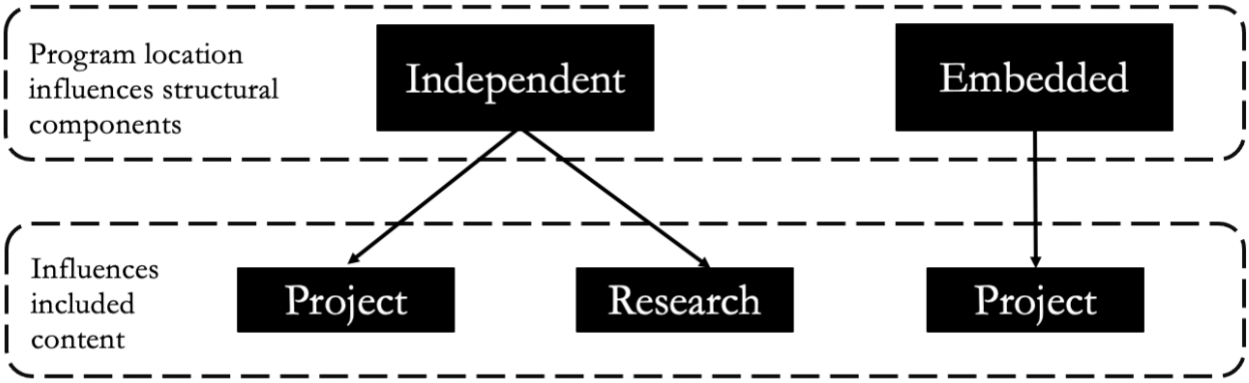

Figure 3: Course levels of programmatic and content influence

With an understanding of the intended learning outcomes of programs, I then describe students' reflections of their experiences in their respective international programs. Student perceptions of their experiences were largely related to motivations and experiences within the program that are outside of the scope or influence of course learning outcomes. Exploring these student reflections led to development of 11 dimensions that capture and explain student experiences. These dimensions aimed to understand how structural components and intended learning outcomes were represented in student perceptions of their experience. These results are discussed after the learning outcomes.

4.2.1 Program Level Learning Outcomes

To understand program-level learning outcomes, I categorized the 25 participating programs by their structure within the university (independently organized or embedded into an existing course or program) and by their primary program deliverable (project or research). Of the programs, 71% were independent project-based programs, 17% were independent research programs, and 13% were embedded programs included in an existing course or program. Independent programs included a wider range of intended learning outcomes and were not linked directly to a discipline-specific set of deliverables such as skills needed for a mechanical engineer. Utilizing a multi-disciplinary approach allowed students to gain critical thinking skills and develop an understanding of relationships between different areas of study [178]. One faculty member in an independent project-based program described their learning outcomes as "we have a laundry list of outcomes that we always get kind of sideways glances from our colleagues because they [say] 'how could you possibly be teaching them all these things?'" (1). In fact, many faculty members described these outcomes as having limited formal measurements but being present throughout the

student's time in the course. These relate to informal learning experiences although it exists inside of a formal education system. Informal education accounts for over 80% of human learning with structured learning activities accounting for the other 20% [179]. Similarly, many of the skills that faculty describe as outcomes are gained through exposure, not through explicitly structured learning exercises and evaluation.

Embedded programs, on the other hand, aim to achieve specific discipline-level goals using international projects. An example of this is a capstone engineering course with an international project. A faculty working in an embedded capstone program described their general learning objectives as, "the purpose is to give students a capstone experiences, as the name implies, to apply everything they have learned in their previous time in [their program] (6)." These types of outcomes often have much more direct measurement opportunities for faculty to evaluate specific skills. In fact, capstone programs across the country use ABET approved curricula to ensure that student leave their programs with specific skill exposure and evaluation [180]. Embedded, non-capstone courses often use learning outcomes to achieve specific discipline-related learning outcomes that are more explicitly measured.

Using these groups, I analyzed the intended learning outcomes of the international programs. All program learning outcomes are included in one of the following three types of skills: technical, professional, and global. The complete codebook used for this analysis is shown in Appendix C. In the following sections, each of the programs is discussed by the skill type. Independent research based, project-based programs, and embedded programs emphasize learning outcomes differently. These differences are especially important to differentiate for a stronger understanding of the program motivations and expectations.

Technical Skills

In this analysis, I captured technical skills that could be applied across disciplines and captured references to specific skillsets that the programs reported related to their host disciplines when applicable. For the different program types, technical skills were framed differently. For integrated programs, these skills tie closely to ABET or the degree-granting pathway objectives. For independent programs with a project focus, these skills include more general technical skills such as systems thinking, design considerations, and rapid failure. Independent programs with a research focus, however, tend to focus on technical skills such as quantitative data analysis or interview protocol development.

Independent research programs' primary formal technical learning outcome objectives were focused on conducting effective research and producing publications to advance their area of focus and solve critical issues. Technical skills focused on areas such as models, experiments, data analysis, understanding the ethics and systems of their work. These research programs have some similar learning objectives as instructional laboratories used to reinforce engineering skills. Within these labs, 13 objectives are used to evaluate student learning, and many overlap those technical skills described for research programs [181]. A technical skill identified in research programs but not laboratory settings was critical thinking. In research programs, critical thinking included considering complex issues in a way that could be simplified to effective research questions. For example, one faculty member describes their goals for student learning as "the primary goal there for the students one is to conduct meaningful research focused on international development challenges. So, it is in all cases their deepening their research skills and capacity in an applied sense." (18).

Independent project-based programs tend to highlight technical skills that cross-cut disciplines. For example, one faculty member described their learning outcomes as: "... [the] primary learning objective there is to actually train them in innovative problem-solving techniques that crosscut the disciplines to secondly help them engage in a meaningful way in a professional consultancy with a partner organization" (16). Another described their learning outcomes by describing their learning approach: "Our approach is human centered design, and that's kind of our umbrella (9)." When considering programs that include multiple disciplines, technical skills are described in ways that cross-cut disciplines. A systematic review described several of these cross-cutting skills such as: interpret data, define constraints, think creatively, make decisions, and take responsibility, and they additionally describe, "problem solving as the core of engineering practice [182]".

Some faculty note that their measurement of specific skills is less concrete due to the nature of the program. There was not a specific task that was pre-created to measure student's learning against. Instead, the project-based nature of the program yields numerous additional learning opportunities. In fact, one faculty described this idea as "So they're going to learn a little bit of [everything]. It's not really a testable learning outcome, but they're going to glean little bits and pieces of lots of [learning] goals." (1). Another faculty member explained that their program's focus was not on specific evaluation of skillsets but looked at learning through the program outcomes.

> So, we focus much more on mindsets like design thinking and systems thinking and ethical decision making...so I can give you very specific examples of the kinds of things that the students do across the program where they develop these skills. Can I assess each one of them and give you a number? It would be incredibly difficult to do. And frankly, I'm not sure whether that would be worth the effort, right? Ultimately, the proof is in the pudding. Show me the publications. Show me the impact. Show me the real stuff that you have done, and the skillsets and mindsets are all in your head! (20)

For others, more specific metrics aimed to measure technical skill learning. For example, one faculty member explained, "since this is a design and construction course, a lot of the skills are related to those aspects of executing a project...so safety, scheduling, estimating. Let's say for example, they'll be doing masonry work. We've had the students build a brick masonry wall in the lab to get a hands-on experience with both the [technical] work and the methods and processes and safety that's involved." (7) The faculty member described that each of these related skills, safety, and the methods, were evaluated using these lab exercises.

In embedded programs an additional emphasis was placed on achieving goals of ABET or their degree granting pathway. To ensure that these goals were met, these programs focus on producing specific examples of students achieving the skills that are mandatory for their host program. Faculty discussed the projects' need to achieve specific discipline-level learning. For example, one faculty member discussed their international projects within various capstone programs:

> Every one of the departments had their own requirements for senior design...so I would propose the projects to the people that were running the senior design. Then I would become the project supervisor, but in the end, whoever was managing the senior design [program] for the department gave the grade. And they set the criteria [for the students]. I don't want anyone to think that these projects are a way of escaping the requirements of a normal senior design project...they have got to be just as thorough as any other project, and if they need to do more analysis then we do it....For example, a couple of places we needed to build utility bridges...but in the end it was just going to be a simple supported beam across a 35 foot span....This is trivial right? So, we said I want you to design me one of the local materials, then do a wood one, then give me a truss design, for example. So,

> for many of the projects the alternative analysis component was the key for the whole senior design. It wasn't necessarily the final project, but it showed the process: how did you arrive? What alternatives did you go through?

Another faculty member also noted that integrating projects into capstone programs sometimes required modifications to either meet ABET-specific requirements or department-level expectations. They described this as being tied to the discipline's implementation of ABET criteria. They said "a lot of it depends on who is in charge of the capstone design course and how traditional that person is or is not on what they consider engineering design to be. So, this is a very subjective call...So depending on how traditional or non-traditional you are as an engineering educator, you are going to open a very narrow window for projects or a wider window for projects (4)"

Technical skills emphasized varied based on the program type, research versus project based, and the range of disciplines included in the program. Embedded programs tended to include technical skills related to the host program that they operated in while independent programs include a wider range of technical skills. This is in some part related the wider range of disciplines included. The more disciplines a program included, the wider and more generalize the technical skills became. This is a common way to evaluate technical skills across disciplines [182].

Professional Skills

Professional skills were included as learning objectives by faculty across all program types. A majority (80%) of faculty described that their program focused on communication and teamwork as their primary professional skills. ABET defines the following professional skill objectives for engineering students:

1. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

2. an ability to communicate effectively with a range of audiences

3. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

4. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives [183].

Those focused on in international engineering programs were broadly similar to those defined by ABET. However, the ways that faculty members integrated professional development varied. In general, engineering programs integrate and evaluate professional skills in widely varied ways [161], [184], [185]. This is similar to the results of this study. However, embedded programs tended to utilize more 'traditional' methods of professional development while independent programs utilized more unique and innovative methods to ensure professional development for their students.

Of the faculty in independent programs, 90% of them had formal professional skills-related learning outcomes. Faculty members in independent programs had more flexibility in creating professional skill development opportunities. For example, one faculty member in an independent program made professional skills the cornerstone of their program structure (20). The entire program was structured to give students experience in developing professional skills such as managing teams, creating professional communication material (either through emails, presentations, or publications) and communicating with their teams and their clients (20). This faculty member described their program as "a corporate organization where we actually have project managers and students reporting to them...we may have more management than normal, but it's because many of [our] students have full course loads, and we need to make sure that they're going to be successful. The other thing we do is we focus heavily on the development of students to get them ready for careers." Each student participated in formal LinkedIn job positions and was required to produce one publication per semester. Their primary learning outcomes included teaching students how to communicate their work experience to employers, producing publications, and working within structured teams (20). Industry role-playing experiences have also been used to build similar professional skills in students, however those role playing simulations provide less authentic professional experiences compared to this program structure [184]. Another independent program developed their entire program based on entrepreneurship ideals. This meant that they emphasized professional skills like grant writing, business planning, and research (25). In this program, professional skills were integrated into lectures, workshops, and fieldwork.

Independent programs also included mentorship as a professional development skill by providing students with opportunities to be mentored either through peers or professionals. Mentorship has been used

similarly in education disciplines in higher education [186]–[188]. One model used by a program in this study integrated graduate and undergraduate students emphasized mentorship as an outcome for graduate students responsible for guiding undergraduate students in their project work (17). A faculty member described their program goals for mentorship through graduate and undergraduate integration as follows.

> The pinnacle of this is a program where we recruit graduate students to attend to do their master's degrees...we recruit graduate students who have prior experience working internationally on humanitarian work and who have cultural and language fluency as well as engineering backgrounds. [Here], they become team leaders for our undergraduate teams...They have this natural mentor ability with undergraduate students and specific contextual awareness of issues in the field that they bring to the table. I think that brings a key differentiator in our overall program...I describe it as the difference between good and great. (17)

About half of the faculty who implemented mentorship described another model focused on building mentorship skills through peer-to-peer undergraduate mentorship. Returning students to the program were given mentorship roles to allow them to gain mentorship skills after having learned the technical and global skills in their first or second course within the program. One faculty member described this mentorship component in their program as resulting for a need for more cross-collaboration across projects (1). Peer to peer mentorship provides students with skill-building opportunities regardless of the type of project or program work that they are involved with [165]. Literature describes mentorship as going hand in hand with leadership development, which is a less-emphasized skill in these programs [189]–[191].

The last mentorship model described by a small number of faculty included professional mentorship from industry professionals. A faculty member described the learning value for this form of mentorship as, "[it's] a great opportunity for the students. If they only see faculty during college...they're very confused about what an engineering career looks like. Getting to work with them, talking to them about their day-to-day life, working on fairly complex designs and seeing how that changes with community feedback. It is vital to the projects that we do (21)." Additionally, connections are made from these mentorship opportunities for career placements.

Professional development learning outcomes for research- based programs primarily included the ability to produce publications. Research programs highly emphasized this aspect, noting that publishing was a valuable way to push knowledge into the public domain and to evaluate the student's learning. Of all the programs included in this study, one major note regarding publications is that faculty publishing in this area noted the importance of free, accessible research. One faculty focused on publishing in free to access journals (19), while another faculty developed a google scholars page with free content for others to access (20). Faculty noted that this also allowed for students to strengthen their professional resumes and display their professional work in a public manner (20).

Embedded programs expected professional skill development included outcomes such as "communication with client" or "work collaboratively with a team". These skills were not specific to their international project but were an intended learning outcome of the program as a whole. These noted skills were closely tied to ABET's descriptions of professional skills [183]. An example of these professional skills was described by a faculty member who taught an embedded, technical elective course as, "a lot of the skills are related to those aspects of executing a project.... things that you would do working in a team and working abroad." (6) Similarly, a capstone instructor described their professional skill learning outcomes as, "the heavy lifting is in the first semester, but the second semester is where they learn the most from their mistakes. But in both they are working in their team and communicating with their 'client' and faculty advisor to report progress and clarify aspects of their designs (7)."

Global Skills

Learning outcomes for global skills described by faculty included the concepts of gaining global perspectives, using empathy, communicating across cultural and time boundaries, and concepts of global citizenship. Faculty across program types found these learning outcomes to be valuable to students. The emphasis of global skills has been permeating into general engineering education for decades [192]–[195]. Bourn [194] describes the phenomenon as leading to recognition of the following:

1. the importance of understanding globalization
2. working in international, multicultural teams
3. engineering means both working in different cultural contexts and understanding the implications for ways of working, language skills, and approaches to resolving problems [196]

4. Recognition that there are different interpretations of what problems are and therefore what skills are needed, and to work effectively with people who define problems differently [197]

5. Recognizing the importance of sustainable development in determining one's actions

While engineering programs work to incorporate these considerations, international engineering programs are designed to include them. Regardless of the program type, faculty emphasized that these skills are critical to their programs. The divergence for these learning outcomes exists in the integration and formal evaluation of global skills within the programs.

Faculty in independent project-based programs described having a strong formal emphasis on global skills. This is in part due to the level of control that programs have over their learning outcomes. These faculty implemented specific global skills opportunities to educate students on global skills (7). For example, one faculty member explained, "We have what's called a senior international educator. I worked with her last year to develop a cultural intelligence workbook...So she comes in an actually leads that piece for us (9)." Another referred to their global skills learning outcomes as strongly tied to a cross-cultural approach. They said, "the third element of it is they're working in cross-cultural teams. So, all the teams are blended with representation from different countries so that you get an indication of what it means like to work as a practitioner across a global context every day as you're working as a team. So, it forces students to embrace different styles of work and cultural nuance and then be able to even manifest different language skills to go in the field and do the work. So that has a lot of learning objectives tied to effective teamwork" (17).

Faculty in independent research programs often reported less formal learning outcomes for global skills due to the nature of the programs. Learning outcomes tended to specifically focus on technical skills and publications. Global skills were emphasized in practice but had a less formal evaluation metric. For example, one faculty member describes their program's global learning objectives by "helping students co-create research with communities in other countries," emphasizing that they "really emphasize working across culture and co-designing with communities closest to the problem (18)."

Within embedded programs, these skills are often extraneous to the formal course evaluation metrics (3). In these integrated programs, faculty often have less flexibility with their evaluations of student learning unless developed in addition to the course metrics. For example, one faculty member leading an

international capstone course described their emphasis on the global component of their projects as a way to provide students with a more effective project team (6). They stated, “if you take our students who have formal training in engineering, and you take the innovators and the leaders from these countries and put them together, you’ve got a great combination.” (6). Another faculty member developed their own learning outcome metrics to measure with respect to their student’s learning (8). Although they are often not formally included in metrics, some faculty used professional skills metrics such as teamwork and communication as a way to consider students learning in the global environment (6). Some faculty, though, considered global skills more of an implicit item when considering learning outcomes. One faculty member described this as implicit learning—meaning that by simply participating in the program that students would be forced to interact with these global skills.

Program Learning Outcomes Vary Primarily by Program Type

Faculty and program directors used the program type to support the intended learning outcomes of the program. The type of international program shaped the focus on specific learning outcomes. Learning outcomes fell into three categories in this study: technical, professional, and global skills. Each participating program aimed to achieve learning outcomes for all three categories either formally or informally. The emphasis on learning outcomes strongly depended on the program’s learning goals. Embedded programs tended to aim to achieve specific ABET or related metrics while independent programs had more flexibility to determine their learning objectives. Embedded programs used more formal evaluation methods to meet these metrics while embedded programs aimed to include a long list of learning outcomes that are less formally captured in course learning outcomes.

4.2.2 Outcomes from the Student Perspective

In general, students did not reflect on their learning differently based on the type of program that they participated in. Instead, students tended to reflect differently on their experiences when they either 1) had leadership experiences, 2) participated in travel, or 3) perhaps most importantly increased the length of participation in programs. Thus, I was unable to compare student learning outcomes to the goals of programs in a direct way. Instead, I aimed to capture student reflections on their experiences by understanding 11 dimensions of their experiences. These dimensions helped to create a clearer picture of student learning expectations and their perceived outcomes from participation in an international project

program by understanding their expected learning, their key experiences during their program participation, and their reflected learning after participation.

Students reflected on their experiences by focusing on three ways: 1) providing descriptive characteristics of their program including what type of program it was and what the structure was like, 2) describing their perceived experiences in the program, and 3) by describing their motivation to participate in international work. Figure 4 shows dimensions related to descriptive program characteristics. Figure 5 shows dimensions relating to student's perceived experiences, and Figure 6 describes dimensions related to their motivations. Each are shown and described below.

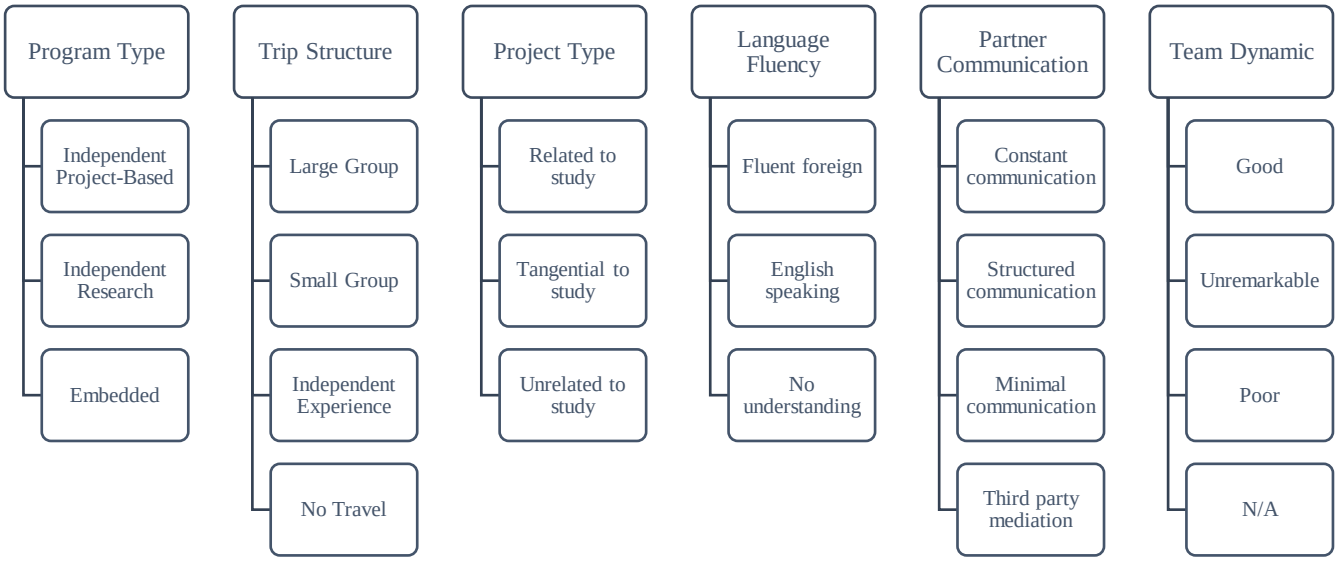

Figure 4: Student-described program characteristics

The program characteristics that students described included the program type, trip structure, the project type, their language fluency, and partner communication in general, and their team dynamics within the program when relevant. Team dynamics and project-based learning have been shown to have an effect on student's perceived learning [90], [92]. Partner communication in projects is also an important component of the project work along with consideration for language barriers [198], [199].

When considering their perceived experiences, students reflected on their expectation of the experience prior to participation, skills gained, and their perceived highest impact experiences. These are shown in Figure 5.

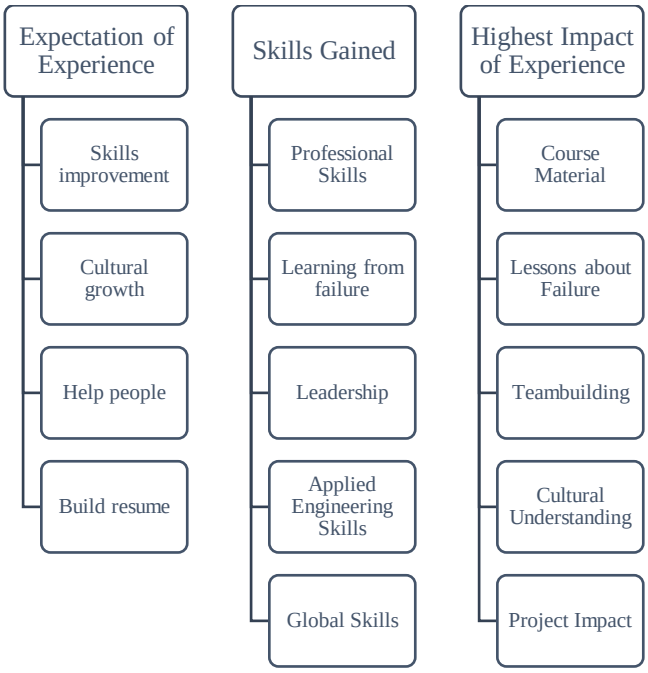

Figure 5: Student's perceived experiences

Finally, students reflected on their motivation to participate in international experiences by directly describing their motivation to pursue international experiences and by describing their post-experience professional directions. This is shown in Figure 6.

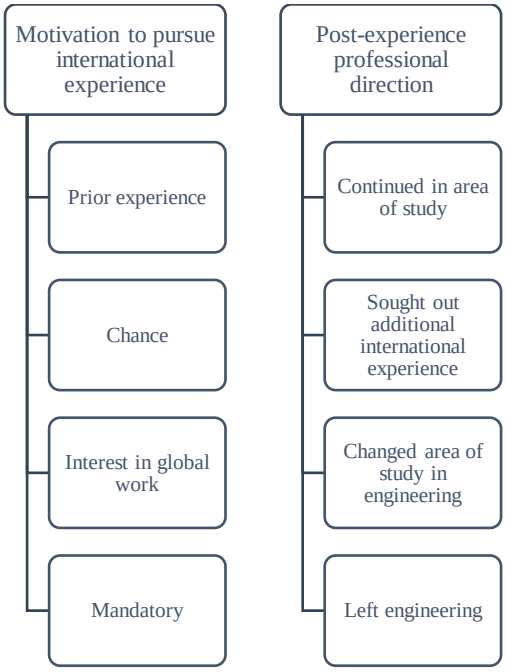

Figure 6: Student reflection on motivation and professional direction

Student experiences were widely varied in this study, and they did not reach consensus of particular experiences within similar program types. One of the reasons for this is that student experiences and motivations are widely varied and personal. Individual motivations for participation had an impact on their reflections after participation. For example, one student explained, "I wanted to help the community" (13S), while another stated, "I wasn't sure what the program entailed...but it sounded interesting." (6S). Additionally, real-world projects are inherently complex and create unique learning opportunities that are not clear cut and linear like case studies or traditional engineering projects [200]. These experiences often altered the student's experiences within the program. For example, one student described the departure of their anticipated project to the realized one as, "definitely really challenging to work through all of those different scenarios with a whole team of people" (4S). In contrast, more structured programs with less room for project variation or limited travel opportunities yielded a widely different experience for students. These variations along with student's individual motivations led to a wide set of student perspectives. However, as students have more experiences in international programs, their perspectives tended to shift. To describe student results, I group them into two categories: (1) students who participated in a single program, (2) students with multiple experiences, who participate in a program multiple times.

Additionally, two specific factors tended to change the focus of the student's reflection of their experience. The first factor was the student's ***participation in travel***. The second was the ***student's involvement in project leadership*** These two factors caused students to reflect on their experiences differently and often led to different discussions of impact from the program on their likelihood to pursue additional international experience either within higher education or in careers. Each are described in detail in the following sections.

Travel impacted the student's experience in the program.

Students that participated in formal travel as a component of their international program made up 85% of those I interviewed for this study. For the remaining 15%, some were in the early years of their program (prior to the allowable travel experience) or participated in a program that did not require travel. This distinction provided a major point of departure for how the student described their program experience. Students that participated in travel rarely referred to their learning in the classroom portion of their program. For example, when considering the most impactful experience in their program or the skills that they gained, students with travel experienced tended to respond with stories from their time internationally

(13S, 5S, 10S) compared to students without travel experience who responded with perspectives more related to their classroom learning (6S, 9S). In general, travel provides numerous educational opportunities and can have significant impact on students [201]. Working across cultures is highly impactful for student learning and consideration of global skills [129], [193], [202], [203]. Students reported similar considerations as a result of travel in this work.

Student's involvement in project leadership altered their reflection on their experience.

The students who engaged with leadership roles reflected on their leadership experiences and learning frequently when considering the impact of the program and the skills that they gained. For example, the primary student leader for their international project reflected on their skills learned describing them as applicable across all aspects of their life in graduate school. They stated, "I take a lot of my experiences from [the program] and how I work with my teammates, how I talk to my superiors, how I email other people or work on group projects for my classes now is very much in a leadership role. [The program] allowed me to take those steps and to work in that capacity." (14S) On the other hand, students without leadership experiences reflected on other aspects of their team experience in a much more limited way, stating things like "we had to make sure that all of our designs and drawings were really clear" (6S) or "we'll sometimes do additional testing behind the scenes or have a meeting with project partners like we have occasional meetings with the partners and Cambodia (2S)." Leadership opportunities have been shown to elevate learning outcomes in other areas [204]–[206]. The impact of leadership opportunities in the international project context is consistent with leadership opportunity outcomes in other areas.

Experiences of single program participants

Students who only participated in programs one time were usually from embedded programs (50%), but also independent research (15%), and independent project (35%). The independent projects were usually related to the students major (65%) or tangential related (15%), but sometimes unrelated (20%). Most of these students did not travel, with only 15% completing formal course-related travel. Some of these students did report travel related to the project that was outside of the formal recognition of their embedded course. Including these students, 40% of students participated in travel. For students who traveled, all were either in small group or independent experiences.

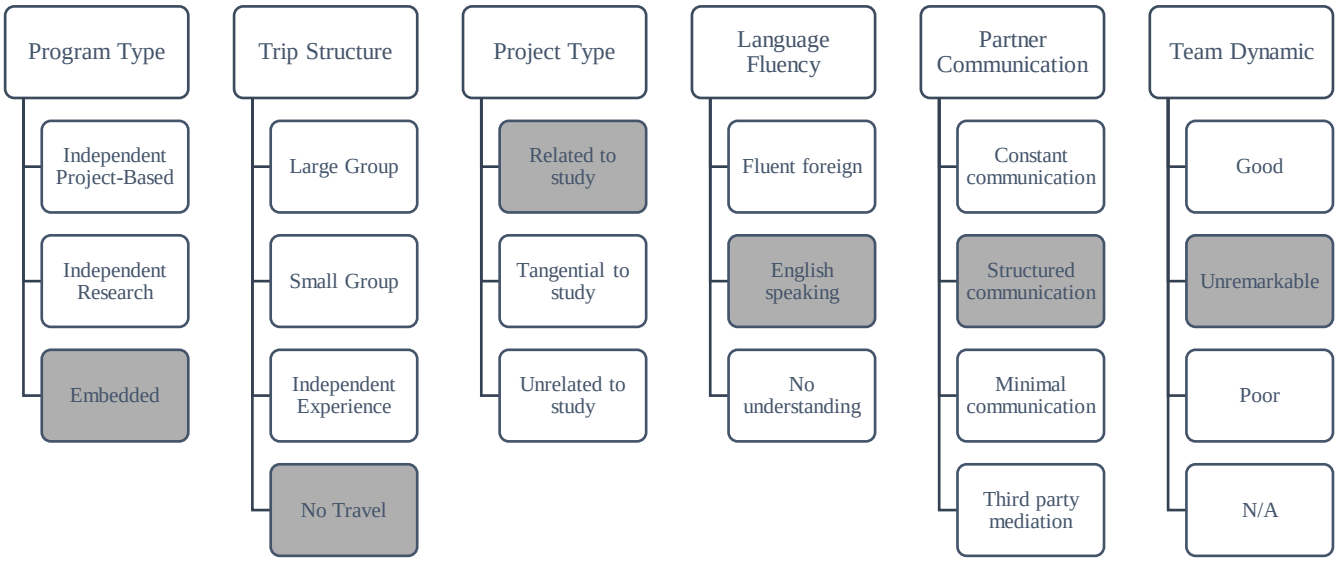

Figure 7: Adam's reflection on program structures

Figure 7 is an example of one student, Adam's, experience, related to the dimensions associated with program structures. Adam was a one-time participant in an embedded program working on a project directly related to his area of study. He described this course as having, "a project that is interesting based on what I like to do in engineering, but with an international component." Another student described, "the project helped me learn about topics that I want to focus on in engineering." Students with a single experience often related the experience directly to their area of study.

There was no associated travel for his program, and they had limited experience with language barriers due to their partner communicating in English. Adam described his team as "generally good", but as a whole not unlike every other project team that they have been a part of in their college career. In most engineering programs, students engage in teamwork that provides numerous learning benefits [92]. These teamwork opportunities in-class were similar to other teamwork experiences integrated into courses.

Partner communication for Adam was structured. Through pre-planned, agenda-driven zoom calls, they connected with their international partner to explain project progression and request feedback. They described it as, "we had a number of Zoom calls with the leaders of this community where we discussed our progress, and they told us what was going on over there for them." For those without travel experience, this type of structured digital communication was common. Students who traveled tended to have much more constant and informal communication. Informal communication can help strengthen personal connections and encourage cross-cultural sharing [207], [208]. Another student, Jesse, described:

> I think that communication was definitely important and learning what they expect and how to communicate it in a way that makes sense to them. And also, I think just learning how to talk with other people get your point across to people that don't necessarily understand what you're [saying or] doing. I mean, some don't even speak English. Getting your point across—whatever it was, whether it was project related or, you know, like hey I am hungry, where do I go to eat?

Jesse participated in a single-experience independent project program with a significant travel component. Like Adam, they refer to the project being related to their area of study, but they had a different experience with partner communications as they were more constant and ranged from formal to informal, and they were part of a two-person team as opposed to a more traditional engineering project team. They referred to their team experience as "good but challenging. It was just us there for 8 weeks, and no one else really spoke English. So, we just had each other. That could be challenging, or really comforting depending on the moment." The implications of the added challenge in team dynamics due to travel was evident for Jesse. The travel environment paired with their small, two-person team added pressure and altered their team relationship compared to what Adam experienced.

Students like Adam who had no travel experience tended to talk about communication through more formal channels, like meetings and design reviews. However, students like Jesse who participated in a travel experience included informal communication experiences in their reflections. Informal communication that includes more personal components can help to better develop aspects of trust [209], and in these projects the face-to-face communication associated with travel helped students to develop these deeper relationships with partners.

The next consideration was student's reflections on their expectations of the experience and what skills they gained. Adam's responses are shown in Figure 8. He highlighted that he expected to gain engineering skills and felt that he left the program gaining those skills. Another student, Jesse, described their expectation as gaining technical skills and helping people. They described, "I thought the program was cool because I could learn [engineering skills] and help other people at the same time."

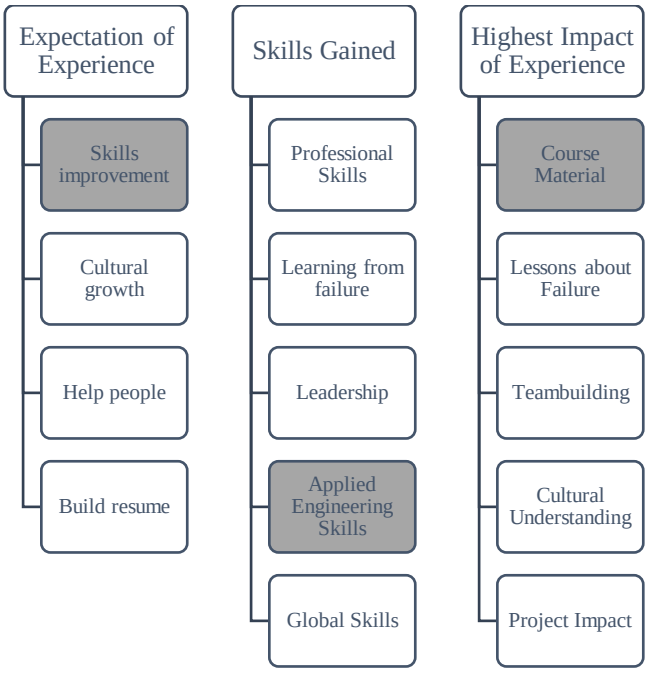

Figure 8: Adam's reflection on perceived learning

Adam described that the technical skills they gained through the course were due to the course materials, and he explained that the project impact was significant for them as an engineer.

> I would say I learned a lot about considering other people in my designs, which it seems like you would do that normally, but it helped me to think about that more deeply than I probably normally would have...I liked when we talked about really doing our research to make sure that we understand what our users want, what our users need, and understanding their circumstances and where they're coming from before just jumping into designing a solution. That was a lot of really good wisdom to gain so young into engineering. It can really benefit me in what I'm doing, but also the people that I'm making stuff for. It's helping me to be a better engineer, and ultimately that means that I'm going to be able to produce work that's of higher quality.... I think the most impactful part of the program was the technical elective I took last spring, because while it's great talking about stuff, in theory, it means nothing if you actually never apply it. So, I liked that I was able to take all the stuff that we were talking about and make it happen and realize that it was really making a difference in someone's life.

Another student described professional skills as their major takeaway. Jesse described," I definitely use some of the skills that I learned in my program every day...It helped me learn how to talk to clients and partners in effective ways." Professional skills are a critical aspect of student learning to prepare them for the workforce after graduation [185]. Project-based learning and real world projects help to build these professional skills [14], [91], [210], [211]. Students from these international engineering programs experienced these professional skill-building opportunities with the added value of cross-cultural collaboration, another skill necessary for global workforces [196].

A primary focus of Adam's reflection was on his ability to apply his engineering skills to a real-world problem. This is the motivation for inclusion of real-world projects in higher education [90]. Students in this group reflected on the real-world nature of their projects like Adam, however, those with travel experience reflected differently about their real-world experience than those who did not travel. For example, one student, Marie explained the engineering skills that she gained included being able to consider on-the-ground project constraints and more specific design skills as opposed to general design principles highlighted by students without travel experience.

> The difficult part of it was whenever we were there, people would obviously ask us what we were doing, and we would talk to them. They were like, 'Oh, we should pave the road with asphalt'. And that's really expensive, and the community that it was in was paying for it. I want to say like 10 percent of it... these people sometimes don't even know where they're getting their next meal from. So, for them to come up with 10 percent of the project budget, we couldn't. It wasn't feasible to put asphalt down, essentially.

The additional difference between students like Marie and Adam was their focus on the course material versus the project and cultural considerations. This change was, again, a result of the travel opportunities. The time in-country working helped students to identify specific project aspects that they had to apply engineering skills to. Those who worked in the classroom on designs referenced design principles from a more general perspective relative to course material.

The final consideration was student's reflection on their motivation to pursue international experiences and what area they expected to pursue professionally. Again, Adam's responses are shown below.

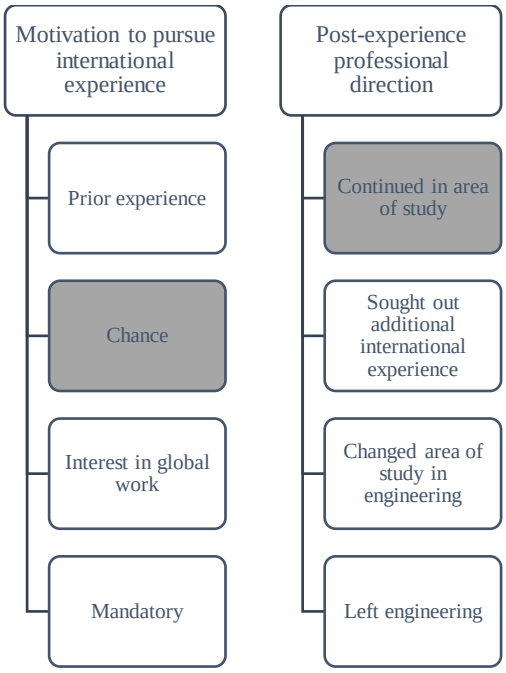

Figure 9: Adam's reflection on motivation and professional direction

Adam described their motivation to pursue their international experience as chance. They had very limited expectations of the program, however those that they had revolved around applying their skills to humanitarian-based engineering projects.

> I first heard about it when I was applying to [my university], it's just part of their application. One of the questions was: are you interested in applying to any of the scholar's programs? And to be honest, I had no idea that [there was a] scholar's programs when I applied. So, I was just like, well, I guess I'll look into them. So, as I was filling out the application, I just looked at the different programs that they had...To be honest, I had no idea what I was supposed to expect or what the scholar's program really was supposed to be like. So, I guess I kind of figured that it would give me some opportunities to, I don't know, to just like learn about humanitarian applications to engineering. And I figured there would probably be opportunities to get involved in some projects that were humanitarian based.

While chance was reported from some students as motivation to pursue international programs, this contrasts with the experience of other students who were interested in international work. For instance,

Marie described their interest in global work, “My older sister went to [my university] and participated in [the program], so I just kind of knew about it. They do a pretty decent job advertising for it. And I’ve always loved to travel not necessarily for service but my own enjoyment, so I thought that it would be neat to actually use what I’m learning in the classroom to put it into practice.” Another student, Jayme, described “I think just being able to be a part of [the program] and to use those engineering skills and those technical skills in very tangible way to improve people's lives. That was my primary motivation for sure.”

Adam described his participation in his program as beneficial to his career path in a traditional engineering career. They explained how they would use some of those technical skills in their future career in an engineering field.

> That was a lot of really good wisdom to gain so young into engineering. It can really benefit me in what I'm doing, but also the people that I'm making stuff for. It's helping me to be a better engineer, and ultimately that means that I'm going to be able to produce work that's of higher quality.... I think the most impactful part of the program was the technical elective I took last spring, because while it's great talking about stuff, in theory, it means nothing if you actually never apply it. So, I liked that I was able to take all the stuff that we were talking about and make it happen and realize that it was really making a difference in someone's life. I think the principles that I've learned like user centric design, that's something we've really talked about, I think that's something that I can incorporate into my future work. It doesn't necessarily have to be something that sounds especially humanitarian, but it's kind of the way that you do your work. So, I think that's something I could take with me wherever I go afterwards.

Many students felt similarly that their experience gave them tangible skills that they would use in their engineering careers. Jesse stated, “I definitely use some of the skills that I learned in my program every day. Communication, design skills, but mostly the things I learned about communication. I use those skills almost every day in my job.”

Students within this group, overall, aimed to use their experience in the international engineering program to strengthen their own engineering skills while giving some value to their international partners. Some

sought out these experiences, while others found them by chance. For those who traveled, cultural and project experiences tended to outweigh the classroom course material. This demographic of student tends to value the strengthening of applied engineering skills as a primary outcome for participation, while aiding their international partners was a secondary interest.

Experiences of a multi-experience participant and those who pursue international careers

Students with multiple experiences sometimes participated for numerous years in one project or split their time between multiple programs. This can look like repeating a program course a number of times, participating in multiple programs, or participating in more than the minimum requirement for the program. These programs range from embedded (5%), independent research (15%), and independent project (80%). The projects were reported to be related to study (10%), tangential to study (20%), and unrelated to the student's area of study (70%). Most of these students participated in formal travel (90%). Travel opportunities ranged from large group (10%), small group (80%), and independent experience (10%). Students with multiple experiences tended to have their first experience in a related area of study and then quickly added or expanded their experiences to projects less related. Trip structures varied across experiences. Partner communication for most students was more frequent and, similar to those with one experience that included travel, travel tended to create stronger lines of communication with partners. Team dynamics varied by the project team size and the types of projects.

One student, Paige, participated in multiple international program experiences during their time in undergrad. Paige participated in one formative international experience and numerous additional programs within their university each with varying trip structures and program outcomes. Therefore, Paige reflected on different aspects of my questions using her experience across multiple programs. This led her to provide deep, specific experiences in multiple dimension responses as opposed to those students with one program experience who tended to choose only one aspect of a dimension. In part, this is due to the increased number of experiences, but many students with multiple participations reflected more deeply on their learning related to all of their projects broadly. Figure 10 shows Paige's coded responses.

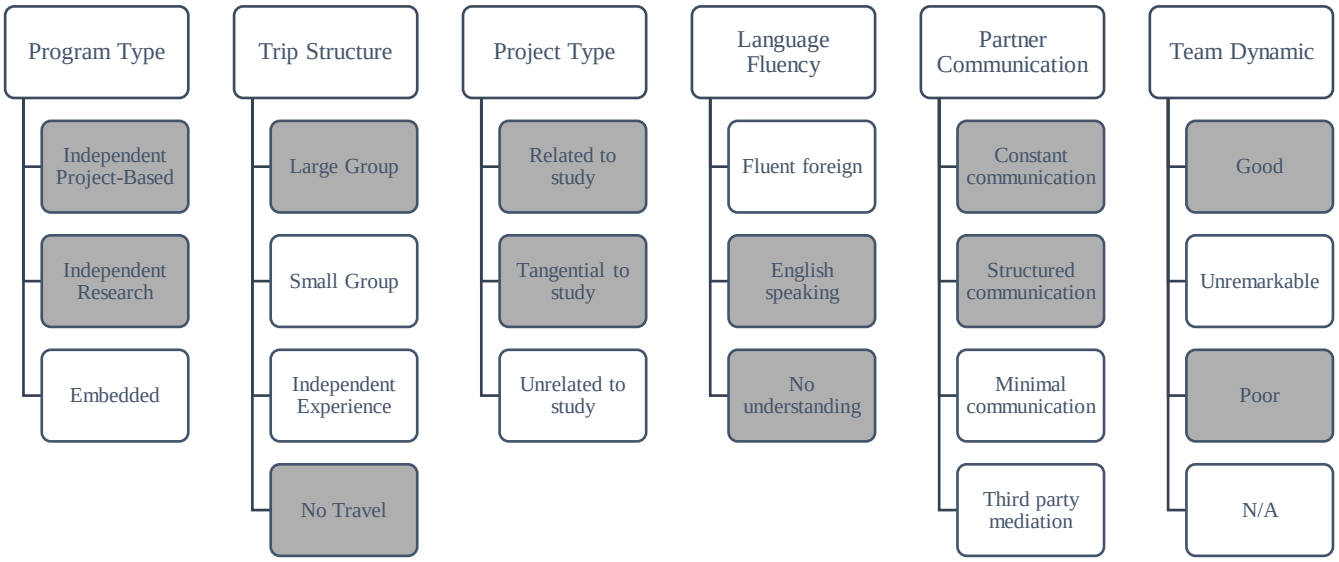

Figure 10: Paige's reflection on program structures

Partner communication depended on the type of project, the leadership position of the student, and travel. For students with travel experience, they often reflected on their communication in-country with partners as opposed to communication prior to travel. For example, Paige described, "our partner was on site with us almost all of the time. When he wasn't there, it was tough, because communicating with some of the local workers wasn't possible with the language barrier sometimes. It was also good to have him there to describe little things that we didn't understand or to just talk about the area." In contrast, when describing a research experience that didn't require travel, she described, "I worked over email and video chats with some of our partners a time or two a semester to review specific findings or data that I was working on. The calls or email updates were scheduled way in advance to make sure the partners were available." This was similar to other's experiences. For example, Joseph described his experience as an intern in another country as being in constant communication and in more informal settings with their partner. In contrast, while they worked to develop new project their partner communication was highly structured and focused explicitly on project development. These students were able to strengthen skills related to informal communication which primarily builds relationships and develop formal professional skills in other forms of communication [87], [209].

Reflecting on her experiences Paige described her experience with team dynamics as both having good and bad components. In one high-pressure team project experience, she described, "It was really hard [being a project manager] because everyone thought that I was being negative, when I was actually being

realistic about what we could do in the time we had. It definitely made me feel separated from the others at times." While this was a high-stress team dynamic, she goes on to describe that, "the stress brought us together, so while we fought at times and the dynamic was bad, we worked through it and were all on the same page by the end of the project." The change in team dynamics was a work in progress throughout the project, and the tension tended to be a result of a high-stress project environment. In contrast, another student, Emma, described her team dynamics as overall very positive. She stated, "our team had a solid project plan, and it was easy to work together to finish it. We were lucky—the team before us had to work through so many challenges to give us a good jumping off point." These students both reflected on their team experience as related to the difficulty of their respective projects. The more complex and stressful the project, the more tension and effort that teambuilding required.

Another student, Miranda reflected on a different set of challenges that their team had to overcome:

> There is a really big example of that. We were designing a very long bridge in Bolivia. The one that I built, it was ninety-seven meters, and it was built in solid rock. It was the same project that [student] worked on, actually, and they weren't able to finish. Yeah, they had a very different experience. God bless them. But basically, we went back to build their bridge, and by then we knew about the right conditions that we were trying to design an alternative rock anchor. And we're doing that with a professional engineer who was there, he was extremely non-communicative. During the first semester, he just told me he moved to Australia out of nowhere and I was like, that would have been nice to know for scheduling purposes that you were going to do that.

Working through this lack of mentorship was a significant challenge for Miranda and their team. Mentorship in general was an important aspect for these students. From the mentor's perspective, one graduate student mentor, Allie, reflected, "I would say we do get a lot of experience working with project partners and going through the design phase and a lot of leadership skills and organizational skills and kind of figuring it out as you go along, because there's a lot of different projects and not a lot of faculty to guide them. So, they give it to the graduate students who are the mentors." While they gained significant leadership and organizational experience, one major drawback from their perspective was the lack of discipline specific experts to support the technical side of projects. This led to feelings of inadequacy from a technical skills perspective.

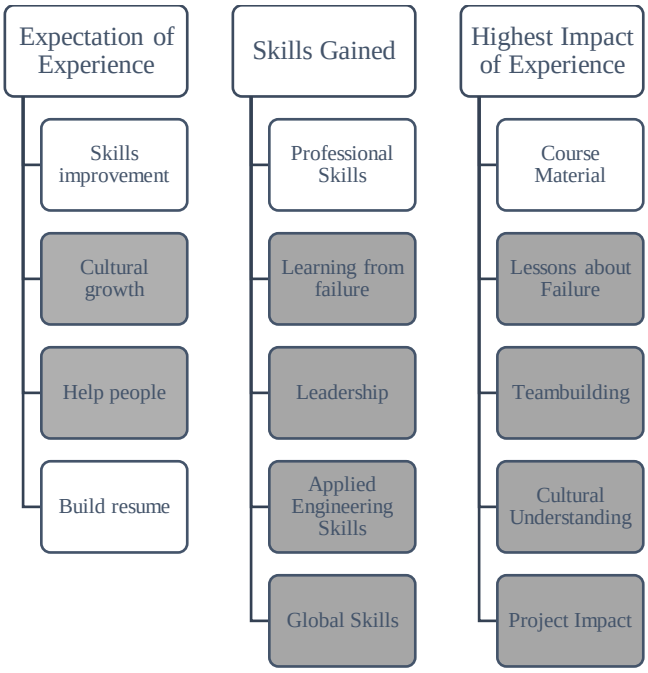

Figure 11: Paige's reflection on perceived learning

Most students (90%) with multiple experience traveled in one or multiple of their experiences, and as such, none considered course materials as their primary driver of impact. Those that did not participate in travel were scheduled to in upcoming semesters. In response, they anticipated that their highest experiences were yet to come during their travel experiences after hearing about experiences from their peers. Students reported their expectations as shifting between each iteration of participation. Before their first experience, most reported expecting to help others. For example, Paige described their expectation of their first experience as, "I wanted to use my skills to help others, and [the program] seemed like a way to do that." She later described her motivation for participating in a different international program as, "I was interested in learning more about the culture." The shift from helping people to other aspects of the experience was common for multiple experience participants.

As students participated in more international programs, or the same program multiple times, they described experiences that influenced them the most and the types of skills gained. Over half of the students who participated multiple times in international programs, consistently reflected on the idea of recovering from failures and addressing complications and barriers in projects. For example, Paige described one of their projects as mostly a failure. They had many challenges with their project during the implementation phase, and it caused massive changes to their overall project. They stated:

> And then we realized looking at the schedule because everyone my team was really optimistic and I was trying to be realistic and definitely was the Debbie Downer because I was like, well, you know, he said next week. But like he always says next week. As the project manager, a little bit more than halfway through, I took the schedule and wrote out even the best-case scenario and presented it to the team, and we decided, okay, we're not building this bridge this summer and it's not going to happen. You know, we're just moving on because we're excavating a massive amount of rock by hand. So, then we decided are we going to go as far as we can? And then we said, well, we couldn't even do that because [of significant technical considerations that would become complicated with partial completion]. We have to set whoever is going to finish this. We have to set them up for success. So, we basically decided to not even continue on building a bridge. We must have spent like six weeks digging a hole and then decided that, yeah, we're going to stop. We're not going to even take it as far as we can. We're going to stop after the tower so that the people in next year's team can figure out a better way to do this. And also, this entire time, we were at 13 and a half thousand feet in the middle of winter up in the highlands of Bolivia with no running water, no electricity, no source of heat, no toilets or latrines or anything.

In the previous passage, Paige reflected on their experience with total project failure during their implementation trip. While they described the failure initially as difficult, they found it to be a highly educational experience. They went on to say:

> Yeah, it was fun. It was very challenging. You know, trying to get something done—when you bring that mindset over like ‘man, I really want to get something done’ and that's what happened, [the project failed]. Yeah, from a leadership perspective, definitely really challenging to work through all of those different scenarios with a whole team of people [with different perspectives]. And then having to make that call. I've been working three years for this, so I'm not going to walk across this bridge when it's done or even do any of the fun parts like building things and we just dug a hole for six weeks. It was hard. It is definitely hard. But we set the next years’ team up for success. So yes, things came out of the project, but it was a [difficult] experience.

These students often integrated personal, cultural, or contextual experiences when discussing aspects of failure or challenge. Several discussed learning about cultural norms, understanding social constructs, or adapting to local ways of living as a major point of learning. One point of note is that while many of these students discussed numerous experiences with failures or project challenges, they did not find them to be deterrent to engaging in future participation. As noted above, although Paige found the project to be exceptionally challenging both technically and personally, they started their description with “it was fun”. They went on to participate in a handful of other experiences prior to graduation. They were considering returning to academia to work towards an international career instead of their current traditional career path. Student experiences with failure tend to help strengthen their understanding of problem solving and work to improve their engineering skills [113], [212]. Extended exposure to experiencing and addressing project failures helped these students be better prepared to face future challenges.

While most students focused on project-specific learning, some presented explanations on how their international experience provided different types of learning from traditional engineering courses. Joe described, “being able to really contextualize research especially in the international context is a super difficult thing to do and super necessary, and I don't think I would have gotten that from any of my classes because as an engineer, I'm not really taking classes in explicitly internationally focused topics. Also, outside of that, I've just gotten exposed to a lot of different ideas, both inside and outside of engineering that exist in research that don't necessarily exist in coursework.”

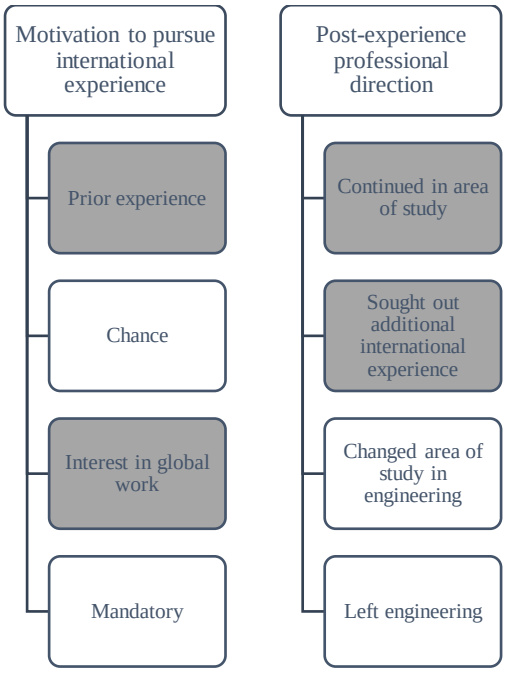

Figure 12: Paige's reflection on motivation and professional direction

Students who participated multiple times in a program were often motivated by personal interests that they had prior to involvement with the international program and a strong motivation to help people through global work. For example, Paige described their motivation to participate in their international program as, “I mentioned I come from a family that has emigrated and my parents tell me, you know, slightly vague stories about their lives growing up and why they came here and [why they] wanted to give my brother and me a better life. But that's a story, and that's a movie, and that's a picture. I want to help [others] understand from a personal perspective, these are people [that we are doing projects for].” Personal values are highly motivating to students pursuing engineering [213]. Another student, Joseph, described their motivation as more closely tied to things that they were personally interested in learning more about, “I have always enjoyed anything microbiology related—microbes, water, water sanitation and hygiene, so wash related concepts, infectious diseases, obviously, that's why I'm [working on] my epidemiology master's. [My program] was a great outlet for me to use my skills and passion to get a taste of it as an undergraduate while [helping people].” Combining both of these perspectives, another student reflected, “I had a little bit of expectations before actually stepping on the plane, which was, I'm going to go and try to make a difference. I'm going to meet up with [culturally different] people. I'm going to be working with a nonprofit to be able to work generally on solar power [their technical interest].” These personally tied or career-based motivations were common for multiple program participants. Some participants found

their first international experience by chance, but their motivation to continue to engage in programs closely aligns with their personal values.

Some of the students who participated in multiple international experiences were interested in pursuing this as a career and some were interested in applying the lessons learned to a non-international career. The impact that their experiences had on their career plans was noted regardless of a traditional versus international career choice. One student, Emma, stated, “I immediately started working for [my company], so I never really stopped [working on international projects]. For me, I just very much changed courses, and now I work for the parent organization!” While Allie felt less confident in being able to find a career in international development that matched their needs, “I think a lot of the jobs that I would potentially get would still be research assistants working in the US, probably in an office. Even though it's projects that I'd be more passionate about because it has an international development focus and I can see how it's impacting communities who don't have access to things like clean drinking water, I don't think it's what I want to do with my time. As far as what my day to day would look like, I'm tired of staring at computer screens.” They went on to describe their preferred career path in sustainable agriculture with a focus on integrating innovations from international cases. For students working to integrate engineering and more global concepts, some find that building on their undergraduate education with a non-engineering program could help them to continue growing. One student, Joe, described their reasoning behind leaving engineering as a way to pursue their career interests more directly. Another describes their reasons for leaving engineering as follows:

> What draws me to a masters more like global affairs, but also with a business education is that I already have a pretty good engineering background. I think what's important is that for any of these projects and these solutions, doing the engineering for it is just a small part of that and really getting it fully implemented takes a lot more skills than just doing differential equations. And that's where I think that my education could be grown most...Ideally, it would be something [entrepreneurial or design in nature] with an international focus where I could also learn business skills.

While the programs vary, the students’ continued participation tends to strengthen their interest in future projects and shifted their perceived learning away from classroom learning and focused more on their project or in-country experiences. These students often reflect more often on teamwork, the project itself,

and their global skills over specific technical ones. There is a strong emphasis on rising from failure, and many of these students with international experiences reflected that failure was common and necessary to address. Some of these students decided to pursue international work as a full-time career. While some of these students discuss fears that the industry is difficult to find careers in, others are actively pursuing careers. Each student in this group had numerous experiences with international programs, and the work aligned with their personal motivations and engineering identity.

4.2.3 Student Reflections Show the Value in International Engineering Programs

Students with strong motivations to help others or engage with other cultures participated in programs multiple times and were more likely to pursue international careers, while those who felt that the program allowed them to strengthen their engineering skills while secondarily helping others were more likely to pursue more traditional careers and participate in less iterations in international programs. As student participation in programs increased over time, their reflections shifted from a focus on single instances of learning such as building a specific technical skill to more generalizable concepts like overcoming failure or achieving project success. There were several considerations that shaped student's learning with the most prominent including travel and student leadership opportunities.

In understanding course structures, travel was found to vary by the program's primary emphasis on student learning or partnership aid. The student responses from this data supported that variance, although travel tended to have an overarching impact on students' perceived cultural consideration, ability to communicate, and consideration of systems as opposed to technical project considerations. Associated travel for a program which emphasized student learning used global citizenship, cultural consideration, or similar objectives as their primary learning outcome. These objectives were supported by travel. However, for programs focused on partnership aid as a primary focus, these skills were still reported by students who engaged with travel. This aspect of student learning insinuates that working with an international partner in a global environment, regardless of project type, helps students learn critical global engineering skills.

In a similar manner, student-led experiences tended to give students greater learning experiences. Students described leadership as including both program-level leadership (connecting with partners, owning projects from conception to finalization, managing teams) and small team leadership (teamwork, making design decisions, communicating in formal manners with partners). While there are inherent differences

to the learned skills based on the size of the leadership opportunity [214]–[217], each helped students to gain professional and teamwork skills that they carried into the next phases of their lives.

Student engagement with and education from international engineering programs is connected to the student's motivation for pursuing engineering. For those who participated to strengthen their technical engineering skills and better prepare them for traditional career paths, gaining real world experiences helped build the relevant skills that they felt they needed. However, for students who pursued engineering with a strong desire to help others, these international engineering programs allowed them to blossom. Whether students reported that they were pursing international careers or not, these students carried their desire to help forward into their next chapters. Across engineering, students want to help others [218]–[220]. As a mechanisms for diversifying the engineering community, international engineering programs allow students with a strong drive to help others to thrive in the application of engineering for societal advancement. These international programs are a clear mechanism to break some of the traditional engineering stereotypes that may not interest some of these types of students.

4.3 Faculty Motivation and Perspectives

This section answers Research Question 3 which explores faculty motivation and perspectives. In short, faculty are motivated to participate in international programs to help and learn from their partners and to educate students how to do the same. Often, this stems from their personal identity and values. While it was not always easy to participate in these programs, faculty felt that the outcomes of the programs were worth the effort. Faculty motivation tends to stem form three categories. Each are described in detail.

Faculty are perhaps the most important aspect of international programs and courses because they could not exist without faculty support—from directors to teaching staff. This has been noted in a number of prior studies that aim to understand the barriers to institutionalizing international programs [221]. Understanding faculty motivation to become involved and stay involved with these programs is a fundamental component of starting, maintaining, or growing a program.

The specific reasons and stories told by faculty for why they pursue careers and opportunities in international programs and courses are unique. However, they tend to fall into either personal motivations or career-related motivations. Introduction to international programs either drew faculty to programs for the first time or encouraged them to continue their international experiences through international programs.

4.3.1 Faculty are Motivated to Help Others and Educate Students while linking their personal and engineering identities

For faculty with personal motivation to participate in international programs, it primarily revolves around the idea of tangible impact and helping others. A majority of faculty (68%) mention their drive to create impact in their work, either tying it to their desire to help others or to educate students. This desire is consistent across faculty position, university type, and university location.

A Desire to Help Others

A major difference between international program faculty members and other faculty member's motivations to educate students tends to be a stronger motivation for creating global impacts. When asked what motivated them to continue working in the international space, a program director at a large, public, land grant research institution in the Midwest stated, "waking up every day and going—'how do we make the world a better place in some small but tangible way today?' Dream job! (14)" This statement tends to embody some of the "big picture" perspectives of faculty working in the interantional space.

This motivation for creating impact stemmed, for some faculty, right out of college. A program director from a large research university in the Midwest explained that this global impact drove her to pursue international work out of college: "In my senior year, I got struck with the idea that I didn't want to just go work in a cubicle for a corporation for the rest of my life. That sounded like torture to me...And [my professor] told me about cookstoves and how 40 percent of the world cooks on open fires and it's this big, big health issue and gender equity issue and climate change and deforestation issue--all this stuff. And I was like, oh my god, this is what I want to do with my life as an engineer. (24)" Another faculty, a program director at a large east-coast research institution, commented on their decision to pursue international opportunities as: "...when I was a college kid studying engineering, it didn't really excite me at the time. And so, I took a lot of time...I really tried to understand what was motivating me in life. But I decided there was three things that were really important to me: humanitarian work. I was really passionate about that. I wanted to do something that was engineering related, and I liked the idea of doing an intercultural immersion, you know sort of stepping out of my comfort zone a little bit in that space. (15)" The perspectives of these faculty members is similar to the considerations studied in graduating senior engineering students[18], [75], [222]. Many graduating engineering students are unsure about their likelihood to remain in engineering careers [222], [223]. However, many students are motivated to pursue

engineering because of their personal values [213]. This is similar to the motivations described by faculty members in this study to pursue engineering. These international opportunities helped to combine the field of engineering with their personal values.

Some felt that their engineering skills could impact specific aspects of global work that were needed. One faculty member at an eastern private research university identified a lack of professionals willing to venture into the international workplace, stating, “I mean, I became an engineer because I want to help people, and we have tons of engineers in the United States who wanted to work in the States, but there's not as many people who are willing to work overseas. (3)” In a similar manner, a faculty member at a northern private research university explained that the work is impactful because it creates new solutions to pressing issues. They stated, “So I wanted to work on problems for which we did not have answers and I thought that was worth pursuing. (25)” Another faculty member at a public research institution described their motivation for working in international programs as applying their skills to an issue that they felt was morally positive (24).

Faculty working in international programs had strong values for helping others that related to their personal identities and values. These values arose from personal experiences and family values. The international programs offered these faculty members an opportunity to align their professional and personal values. This is a significant outcome for faculty, as most engineers are motivated by their personal values in choosing engineering [213], so aligning these values with professional work allowed faculty to meet both professional and personal expectations.

A Desire to Educate Students and Provide Unique Opportunities for Them

On a student level, several faculty members focused on the impact that they brought to students as a major driver. One teaching faculty from a large research institution in the Midwest stated that they were motivated by “the experience in which we provide to students” (13) While an adjunct professor at a large, southern research institution stated, “I like to see [the student’s] eyes open...using their skills for the betterment of humankind (22).” The personal motivation to educate students is perhaps best explained by an associate professor at a large private research university, “You can build an army of people ready to solve these problems, or you could just try to run and solve it yourself.” (16) The drive for student motivation extends even to the most senior faculty involved in international programs. A program director at a large research institution in the west responded, “The students are my greatest joy. I love my students.

That's why I do what I do--for the students," (4) when qualifying his answer to why he continues to work on the program despite challenges.

The drive to educate students is not surprising for individuals that have built a career in education. It extends from junior faculty through senior program directors and was not unique to any demographic or university size or type. The motivation to educate students and provide an experience that helps to prepare them for the workforce is consistent with other findings in literature [221], [224]. One study found that professors across university types (undergraduate and graduate) "are similarly motivated by their enjoyment and value of teaching." [72]. Another study specific to service learning programs in higher education found that faculty were often more motivated by their drive to improve student learning outcomes than other personal factors like personal enjoyment or interest in the projects [224]. When specifically considering service learning faculty motivations, 83% in a study "reported that teaching was their most important professional responsibility" [38]. Faculty with this perspective are often drawn to service learning structures due to the educational value for students [224]. One faculty member included in this study working in a service learning-based program described, "I think from a teaching perspective, it was the most valuable thing I've ever done as a professor. I mean, nothing came close to that. When you look at the actual engagement of the students, they're learning and their excitement level, nothing came close to this (8)."

However, a major difference between international faculty member and other faculty member's motivations to educate students tends to be a stronger motivation for showing students that they can create global impacts. One faculty member described their vision as "being able to bridge the gap between such a cutting-edge technology [industry, Silicon Valley] with the needs of emerging markets." They describe their goals of student learning by the following: "Don't let those challenges overwhelm you. Think about innovation and think about what local resources you have available. Leverage the local resources, not only materials, but people. So that kind of mindset is what we try to embed in our students." (11) Another faculty described their motivation as an "opportunity to broaden students' horizons beyond what's in front of them and show them different opportunities for how they can put their education to use. We undeniably play a very important role in that [here] and want to be able to continue to do so and expanding that opportunity (10)."

Overall, the drive to help and educate others is a significant motivator for faculty. This motivation is high within faculty both across demographics and across faculty positions. Faculty tend to focus on the specific value of international contexts when considering why they find motivation in international projects.

A Desire to match their engineering identity with their personal identity

Personal identity was a motivator for faculty participation in international experiences. Faculty motivation is often related to the linkage of content to student education [224], [225], however, little is known about faculty member's personal identity as a driver for motivation. Some similarities may be drawn between student and faculty identity. Students who participated in international experiences have described their own personal identity as the reason that they pursued the experiences [6], [60]. Students who participate in cocurricular international experiences have a higher sense of engineering identity and tend to include the idea of helping others or society as a motivation for participation [59], [151]. This is similar to findings of this study.

Some (40%) faculty described personal identity as a motivation for participating in international courses. One faculty member from a southern, large public institution stated, "I'm an engineer at heart. My energy is in helping people." (20) Another (a program director) stated "I grew up believing that you should be socially engaged," (14) when asked why they decided to stay in their current role. Several other faculty members described a misalignment between their goals and their view of what a traditional engineering career would look like. For example, one faculty member at a large, public, land grant research university in the West stated, "I didn't want to go work in a cubicle for the rest of my life." (24) Finding international work helped to change their perspectives of engineering work. Similarly, a program director stated, "When I was a kid studying engineering...it didn't really excite me." (15)

4.3.2 Faculty viewed international work in their careers as a tool to help and educate others

Faculty working in international programs and courses tend to fall into one of two categories: faculty who were hired specifically for international-related work, and faculty who shifted into international roles in addition to or instead of more traditional roles in the university. The experiences of these two groups varies, and university mechanisms tend to have a strong impact on the faculty experience. Faculty members who were hired into international specific roles had years of international development experience (92% had more than five years of prior experience) while faculty who shifted into these roles had various prior experience ranging from participation in international work as a student to more than 5

years of experience internationally. Across both types of faculty, the amount of structure and university support varied, which also impacted faculty member's career experiences.

Faculty with extensive international experiences prior to the program tended to look for ways to integrate the lessons learning in their experiences into the programs that they were hired into. Additionally, they described providing connections for students to the organizations or operations that they were involved with. One faculty member was hired to direct a large international engineering program. They had decades of experience in the space and felt that they would be able to shape future international experts through the role (5). Their role highlighted and leveraged their career skills and continued to allow them to connect with other experts internationally. Another faculty member returned from the Peace Corps to pursue a role in an internationally focused space with the goal of translating their knowledge into the program (1). This faculty member directs a large international engineering program and has significant university support due to the reputation and size of the program. Another program director only returned to higher education after working on international projects. They said that it was the "perfect fit" and that their international work directly led to their pursuit of a career in higher education (24). This program, compared to the others, was smaller in size and reach, but had a strong focus on impacts of international projects. These faculty roles looked similar to non-tenure or professor of practice roles [226], [227]. The goal of the professor of practice role is to integrate industry or professional knowledge into higher education to provide additional learning opportunities for students. These faculty were integrated in similar ways to benefit their international programs.

Meanwhile, faculty members who shifted into these roles tended to learn through involvement with the international work. For example, faculty noted the strong impact that their work had on them directly stating things like, "It changed my worldview" (21) and "I was so impressed with the community partner's work" (13)) and then translated that impact to the student experience. Faculty described a strong linkage between their experience with international partners and their desire to help others (13, 6, 8). Most of these faculty members with limited international project exposure found the work by accident (60%), some were recruited by other faculty (15%), and others had a single international experience that drove them to pursuing an opportunity (25%).

Faculty pursing tenure track roles tend to find the balance of traditional tenure expectations along with international work difficult to manage with 70% reporting that they felt that their international work did

not always fit into their expected role within the university. However, those faculty who felt this strain emphasized that they felt that their job was to provide opportunities to educate students on big, complex, international projects. One faculty member stated: “My job 100 percent is to form them [the students] and to make it so that there is not just one of me, but dozens of them every year doing the work.” (17). This was a question of the scale of impact that the faculty member wanted to have. Establishing this motivation in faculty without prior experience, though, was very difficult if they were pursuing tenure. One program director described the difficulty of recruiting faculty to teach in the program as partially due to a misalignment with their traditional engineering role and the lack of value it provides towards tenure (20). This can make it difficult for faculty without prior involvement to become involved with internationally focused work. Across tenure track positions, there is a strong perception that external experiences outside of the tenure track role are difficult to maintain [226], [228], [229]. Those adding to their already difficult workload perceived more challenges to balancing their international work.

For faculty already in tenured positions, this balance was less of a concern. When considering why they started including international projects in their capstone program, one faculty member stated, “what motivated me into these projects was an interest to inject international humanitarian work into the mechanical engineering curriculum. I learned that most projects were narrowly focused in traditional...areas...I was excited to give students an opportunity to work in new cultures, travel abroad, and apply their engineering know-how in difficult and challenging environments. (6)” They went on to describe that their continued involvement stemmed from the work being both personally rewarding and impactful for students. Another faculty who was tenured described their international research compared to the research of their more traditional peers as “the most important [type] of research on the planet.” (16) when considering the implications of their work for others.

Some faculty were so motivated to work in international programs that they worked to create their own positions within higher education (20%). While this was not the path that a majority of faculty members took, these faculty members were highly motivated to create an opportunity in a space that did not traditionally accommodate or include such a role. For example, one faculty member was not recognized in a formal position by the university for numerous years, but they dedicated their free time to building the program that they direct. They stated, “I mean, I volunteered 17,000 hours. And [a colleague], they were around 15,000 hours. So, when you think about that combined effort between the two of us, that's 15 years of free time. We gave the university 15, 16 years of free time.” (20). Similarly, another faculty

member was hired for a different position, but found that they were often bored and decided to integrate some of their international projects into the university structure (25). They stated, “So, the program, that was my baby. [I] was not hired to do it, I was a staff member doing a lot of cool stuff, but I got bored, and I started doing more work [internationally] (25).”

Overall, faculty pursued these positions and opportunities to support their goals of helping, educating, and aligning their personal and engineering identities. This was true regardless of their specific role within their university. The specific roles that faculty had within higher education, though, tended to either aid faculty in this pursuit or create barriers to their intended results. For faculty who felt that they were working on international projects in spite of their position descriptions, or without a position at all, their motivation to continue their work was highly unique and showed their dedication to achieving their goals through international work. Just as it is important to create diversity in the undergraduate engineering student population, these faculty provide unique and meaningful contributions to higher education. Without access to these international programs, we may miss the opportunities to retain faculty who may be motivated similarly to these included in this study.

4.3.3 Introduction to International Experiences

Faculty had varying experiences that lead them to international courses and programs. International experiences that drove faculty motivation happen both before and during experiences with international courses and programs. Similar to students, these international experiences tended to attract faculty to connect with partners and develop a stronger urge to help others.

Many faculty drove projects forward through personal relationships. For example, when asked how they develop projects one faculty responded, “It was me picking up the phone and calling [a colleague] who says, ‘we can use you in Senegal’. And then later says, ‘I want to go to Peru’ and I tag along. And then I made these connections with these other NGOs. So, I mean, a lot of it was me, quite honestly. I mean this didn't fall into my lap by any means, but it wasn't that difficult either. So you go to a clinic, it's not rocket science to say that there's going to be some mechanical engineering project that comes out of that visit. (6)” Another senior design instructor described finding their projects as “my relationships. I knew [someone] who was working in Panama, and they said they needed help with a project, so I took some students and went down” (1). Another faculty was working closely to several international projects and saw the parallels between those projects and the capstone course. They stated, “I ran their senior design

in civil engineering, and I sort of said these international projects look a lot like what we used to do for senior design. So, I sort of said, well, why the hell can't we just pick one of these projects and have it a senior design project? (8)"

For some, the international experiences associated with the program drove their motivation to stay involved. One faculty member stated, "I have been working with [our partner] since 2015, and how we've been working is that we have been working alongside both the non-profit. But then they've also supported us and helped us engage with the community to identify engineering or technical related issues, problems, and solutions that they're looking to solve." (13) Another faculty member described her motivation to pursue a career with international work as directly related to her experiences in the program during their time in undergrad. They stated, "...the reason that I am back [here] are these humanitarian projects. It had a big impact on my life. It changed by view of the world". (21) As described above, personal values are highly influential to individual's interest in pursuing values [213], and these faculty members found value in their partners and work in the international space.

4.4 International Partner Relationships

This section answers research question 4 which explores the formation and maintenance of international partner relationships. The goal of this question was to establish the ways that differently structured programs create partnerships and maintain them over time. This section addresses the length of time that programs engage in partnerships and how this affects the management of the relationships. Some programs deeply develop their relationship with a single partner in a single location, while others work to partner with a large number of different partners over numerous locations. Across all partnerships, the cornerstone of the relationship formation was trust building. Trust is built in these partnerships either through personal relationships or through the program reputation. The level of trust within programs led to different levels of student and faculty engagement for the maintenance of partnerships.

4.4.1 Type and Length of Partnerships

Across all programs, there were two approaches to building relationships: 1) on a programmatic basis and 2) on a project scale. Programmatic relationships extend multiple projects and occur with intent to build a relationship over multiple semester or years. Project scale relationships were usually more targeted and smaller in scope. Faculty who discussed building programmatic relationships discussed a lot about trust and tended to focus on more diverse projects to meet their partner's needs. On the other hand, faculty

focused on working to find appropriate projects for students discussed the concept of trust minimally, but aspects of "swift trust" emerged as their primary focus. Swift trust lacks emphasis on interpersonal aspects of trust building and in general is a fragile type of trust between actors engaged in a one time, short term endeavor [230]–[232]. The differences between these perspectives are highlighted below.

Partners First

Programs that build relationships on a partnership basis focused on creating long term partners by developing strong connections with their international partners that extended multi-semester or years. These relationships often led to numerous projects that could build on or from each other, and years of students with a strong understanding of a single partner or a small number of partners. For example, one faculty member in an independent project-based program responded to a question of changing or adding more international partners:

> We've never had a discussion of working with a different in-country partner or different nonprofit. I mean, I guess there's always that possibility, but we've never even discussed that...it's been helpful that the other co-instructor has been working with me almost since the beginning, and we've had that consistency when it comes to developing those relationships. Even knowing the consistency in their own staff that there's lots of the same folks that continue to work in the nonprofit has been helpful, you know, when it's the same people helping continue to build our relationship (13)

This faculty member highlighted the importance of trust within the international partner relationship. They highlighted the familiarity between the university staff and the employees within the international partner organization. Trust created the foundation upon which projects were created and operated. Trust plays the same role in global and virtual teams in industry and other areas of higher education [217], [233]–[237]. Trust was described as "the prerequisite in all endeavors concerning uncertainty and interdependencies" [236]. A key component in trust building shared among trust research is the inclusion of consistent communication between parties. In these international engineering programs, trust building through continued communication was described in a similar fashion for long-term project creation and domestic partnerships [94], [132]. Additionally, the long-term consistency helped them to continue the partnership over the years. Another described their strategy of building long-term relationships by leveraging faculty. They stated:

> So, the partner that we work with in Guatemala, we've been partners with them for almost 10 years now, and specifically, I've been the one that has been leading the communication between that partner. So, we try to keep that partner in a relationship with somebody who can continue to go there for a long period of time. That's why sometimes it's easier for faculty members to be team leaders because faculty members are going to be involved a long time and they can continue that relationship. (21)

Through this approach, faculty members built trust through deep, long term personal relationships that included consistent communication. This trust helped to encourage partners to provide insights for future projects, explain project failures, and helped to educate students working in the program. Long term relationships were a major consideration for programs using a partner first approach. When describing while undergraduate students were not as reliable for maintaining these relationships, one program director described, “Relying on students is like trying to run a business by firing your best employees every year (17).” Due to graduation and other commitments, they felt that students, although incredible assets, were unable to be the backbone of the structure due to the turnover rates.

Another consideration that faculty had for these long-term partnerships was consideration of virtual support, whether related to COVID modifications or unrelated factors. Virtual work especially aimed to mimic in-person teamwork and project building in ways similar to how virtual teams in industry work to establish trust and strong teams [234]. One faculty member described one of their long-term partnerships:

> Haiti goes all the way back to the founder, and he ran across an opportunity with the Episcopal Diocese. And they reached out and said, ‘there's this opportunity in Haiti would you like to look at? He actually went down and... decided to tackle it. So that partnership has grown over time. Due to the civil unrest, we're no longer there physically, but we're still supporting remotely. So that's one of the things that we're trying to do at the moment is to bolster our international engagement virtually and try to figure out how close can we get. And I think we discounted too many opportunities for remote communications over time because you always you had to be there to do this work. (20)

Within this model, faculty often explained that meeting project objectives allowed for students to learn project specific skills. Many that approached relationships from a partnership approach focused on

providing their partners with solutions to their specifically requested problems over worrying about the technical feasibility for students. For example, one faculty member described balancing their student educational needs with their partners' needs as:

> We really work hard to build a relationship in clear communication with your in-country partner as to what we can and cannot do and make sure that there's some clear guidelines with that, but then also build in enough flexibility between the two that we are holding ourselves accountable, that we're really hearing what the community partner needs in the community, what they want and having the structure set enough that we're going to have the educational experience. The students can have the educational experience that we promised, but within the flexibility of meeting the community's needs. Because if we're doing what we just want to do because we want to learn something new, it's not helpful. It's counterproductive. And we're it's an unhealthy way for us teachers to train our students in how we work with other people (13).

One drawback of the partnership first approach was that sometimes the projects were not relevant to the participating student's area of expertise. Faculty described that some long-term partner projects do not receive enough student interest due to a misalignment of the project topic (1). This can limit the student learning related to engineering—for those focused on educating students in relevant engineering areas. However, for programs aiming to build skills like professionalism, long term partnerships work well to establish those opportunities (20).

Project First

Programs that approached relationship building from a project perspective looked for specific projects to fit their student learning objectives. This approach allowed faculty to match the students' current skills and skill development to the needs of specific projects. One way that these projects were formed is through the use of third-party organizations. These organizations work to present multiple opportunities for students' participation. These organizations can be US-based or internationally based. One faculty member described the process that their third-party organization uses to match students to projects as, "the tinder for humanitarian engineering (4)." They went on to describe this process as "an artificial intelligence platform that matches community development needs—so they actually go into the communities, and they look for specific needs and projects—with the student skills on this side (4)."

A benefit of using a third-party organization for a project approach to partnerships was that these organizations work to establish long-term relationships with the international partners in place of the university program itself. As trust is often built through consistent communication [236], these third party organizations are especially useful for programs who's faculty are unable to dedicate time to maintain these relationships. Although, there were sometimes limitations to student ownership of projects using a third-party organization (7). One faculty member of an independent project program described the benefit of the third-party organization for their program as:

> What we find extremely beneficial with working with them is their ability to assist with the community partnerships and the planning. So, for example, when we take on a project, it's really important for us not to just go abroad and do something one off in a community and leave and never come back or never know how that project worked out or if it really benefited the community or if it became a detriment. If this community needs continual support in their smaller projects, then [the organization can arrange for us] to go back to and revisit (7).

Some programs developed this project-first approach without the use of a third-party organization. Faculty with strong connections to international organizations tended to develop these projects naturally. Their independent relationships allowed them to leverage a number of shorter-term partners. One faculty member described their program as partners choosing students to fulfill project needs. In instances of one-project partnerships, faculty mentioned aspects of swift trust formation such as alignment around a common task and finite time horizons for projects [232]. These projects were often tailored to the student's skillset that the partner had been described in advance. With respect to the pairing process, the faculty member described:

> We look around and find some resources, but in no case does the students say, 'I'm working on this at my lab, so I'm going to come and do this for you.' We really make a point that the agencies tell us [what projects that they want done]. Now we give them some idea of the scripts and the background without names of all the students, technical backgrounds. So, [they] can come up with a scope of work for a global engineering student. [The question is:] can you come up with the scope of work for a student in construction management who's studying post disaster reconstruction or earthquake

> resistant housing, [for example]? So, I'm really emphasizing that point. We're very much demand driven. (5)

In this graduate program, the projects developed for the program allowed international partners to review resumes of participating students and select those that they want to work on their project. The concept was an inverted model to more traditional projects where the project is presented to students to select. Regardless, the project-first approach allowed for flexibility from year to year in terms of the projects available to students.

A faculty in an embedded project program described their approach to finding fitting projects differently. They described their process through an example: "I talked to [contact] who says, 'hey, I got a great idea for a senior design project it's a manufactured oxygen concentrator.' Then [I developed] water projects, like [contact], was a water guy. He had these ideas for water [projects]. I think it's always been you talk to the people who are on the ground, and they have their needs, and then me as an engineer says I think this is feasible for a senior design project." (6) After establishing projects that meet the course criteria, they placed students in the project through a matching process. Again, this faculty member described aspects of swift trust in their partner projects by understanding common goals and finite projects [232].

Whether the program used a third-party organization or faculty connections to establish projects, this approach aimed to curate specific types of projects for their program. For embedded programs like capstone, these projects were required to meet the learning objectives. For others, curating projects that leveraged student expertise is critical.

Balancing Partners and Projects

Both approaches were effective ways to build international partnerships. For programs focused on exposing students to long-term partners and partner-tailored projects, the partnership first approach is appropriate. For programs aiming to provide relevant projects to their student's interest or to meet specific project criteria, the project first approach may be more appropriate. These two approaches are not always exclusive. In many cases, projects arise from long-term partners that meet student learning needs. The cases presented here aim to provide perspectives from each end of the range. In the middle, some larger programs aim to balance long term partnerships while creating "attractive" projects for students. One faculty member at a large independent project program describes balancing these two things:

> My job is to keep the program running, and sometimes that means keeping students returning and sometimes that means keeping partners returning. It's a delicate balance sometimes to manage. [For example,] I know this partner is really frustrated with the outcomes that have been generated or maybe it's a new partner, and I know this partner has extremely high expectations and will be disappointed if we aren't making progress. So, I'm going to select a team to work with that partner that I have confidence will generate that outcome that I know they need and sort of not care so much about whether that team is getting the same kind of learning outcome as another team. On the other hand, there are students who I see a lot of potential in or who are new students or who only are going to come back if they get a specific kind of learning experience. And so, we kind of customize and we play a little balancing act [between students and partners] (1).

This consideration is prevalent to some degree in all programs. The foundational goals are to educate students and assist international partners, so regardless of the partnership approach, all faculty are aiming to balance these two groups.

4.4.2 Formation of International Partnerships

International partnerships were formed in one of three ways: faculty connections, university program recognition, or through the work of third-party organizations. In some cases, the formation was a combination of these.

University Recognition

Programs that have been in operation for a number of years (typically greater than five) began to create connections with international partners through name recognition. While these connections may fit into the program, they were often less tailored than those developed through faculty. These programs created legacy through publications, completed projects, and through building a reputation in the community. For one large program, they stated, “20 percent [of our projects] are cold applications. So, people who come to us and say, ‘you know, I read about you in the news or something, and here's an idea...’”. (1) However, the faculty member noted that these proposals are not always in line with the program objectives.

For smaller or newer programs, recognition was not a feasible way to develop partnerships. These programs relied on the connections of their faculty or by a third-party organization that specialized in

international work. One faculty member described the transition of recruiting projects as their reputation became more well-known as, “Early, we found our projects through faculty connections. We started small...now through [our work] we work on [bigger, more well-known] projects that are accessible to us [because of] the work we have done (10).”

Faculty Connections

Some programs relied on one faculty member to develop relationships while others lean on multiple faculty to develop these relationships. Faculty responsible for managing and building these partnerships often build connections through personal channels establishing long term trust through intrapersonal connections and consistent communication [235], [236]. One faculty member described their project-building process:

> I was reading the [university] news blast one day and there's a story about [a faculty member working] in Senegal. And I'm like, well, that would be a cool senior design project, so I called her up. So, the whole Senegal thing started because I just blindly called [them] because we needed projects, and I thought what a great addition to our portfolio. And then [they] wanted to go to Peru so she set up a trip and we all went to Peru on a scoping trip. And on that trip, I met the people at [partner 1] and some other and then [partner 2]. I made these connections with these other NGOs. So, a lot of it was me, quite honestly. This didn't fall into my lap by any means, but it wasn't that difficult either. So, you go to a free health clinic in Peru. It's not rocket science to say that there's going to be some mechanical engineering project that comes out of that visit, right? (6)

Another faculty member described a mix of personal relationship building and relying on other faculty and university employees saying, “probably 80 percent of our projects come through either my personal network or the program's extended family of partners, and some of them are returning partners, some of them are people who were brought by friends of partners that came to the events or, you know, our dean or program chairs or whatever. One faculty described their ability to pull from other faculty connections:

> It's definitely not me because the diversity is so significant, right? I'm an engineer. I don't have contacts in human rights law. So, because I don’t someone else has to because the work is integration—integrate all possible disciplines that work on global issues. It was

> about us building a system that was robust enough to source that out quickly. So, it is using referrals in some cases. Partnerships are often brokered through the universities network (17)

These relationships were very personal and required a one-on-one connection to begin. For programs just beginning, these were some of the easiest ways to create partnerships. However, a significant risk in establishing relationships in this way for new programs came to project vetting. It was critical to establish strict guidelines for partner projects and outcomes for both students and partners. One faculty member described, "we had to work hard to understand the limitations of our work and what the partner wanted from us (1)."

Third Party Organizations

Utilizing third party organizations reduced faculty's workload and helped provide long-term international partner engagement without university maintenance, however in some cases it could be limiting in the amount of involvement students had with a project. Third party organizations were often very well versed in the university schedule and work to coordinate projects across multiple courses, programs, or even universities. An example of this would be building a school with an international partner. A group of students from Program A may handle the planning of the site and fundraise for items 1-3 while a group from Program B works in the next semester to construct and fundraise items 4-6, and so on. One faculty member who utilizes a third-party organization for their independent program described, "[they] are a non-profit organization that works with community partners in foreign countries as well as academic organizations and businesses to link these kinds of opportunities...they do a lot of groundwork for us and can plug in other universities to fill in gaps." (7)

Third party organizations that worked within specific locations often had direct ties to those spaces through locally hired employees. This created a stronger connection than some programs were able to develop in-house. One faculty member described their arrangement, "We're going to be collaborating with [company], which is an organization in Columbia, to create an artificial intelligence platform that matches community development needs. They actually go into the communities, and they look for specific needs and projects and with the students' skills and interest on this side." (4) Another described:

> I think the third-party relationship has almost universally been a good thing [to help mediate relationships to create better outcomes for students and the local communities], but also further for more practical reasons. [For example], language is a big issue for some of our partners and having a third party that is able to translate as well as sort of technically translate needs has been really important. (1)

Each of these methods helped to build relationships in a way that supported the program's partner-first or project-first approach. Faculty-generated connections were often personal and required that faculty member's continued involvement through long-term relationship building. Those relationships created through university recognition leverage the university's name to create a foundation of trust which could yield relevant projects or long-term partnerships. Third party organizations were able to "lend" their relationships to programs that are strong to allow for students and faculty to jump in on relevant projects.

4.4.3 Maintenance of International Partnerships

The maintenance of strong, older relationships between international partners and university programs were described as students having more control over managing partner communication on a project level over faculty. Whereas newer relationships often relied heavily on faculty members to maintain relationships. One faculty member described their level of initial effort in building relationships as, "we try to keep that partner in a relationship with somebody who can continue going there for a long period of time. That's why...it's easier for faculty members to...continue that relationship" (21) Another described the difference between longtime partners and newer ones as a change in their involvement in the relationship building process. They describe first how they leverage student teams to engage in consistent communication with their partners, then explain when they engaged in more constant communication with other partners.

> The last thing you want to happen is saying 'okay, here's your community and project. I've helped establish a relationship. Now you own it.' and then check back in at the end of the semester and they've never even reached out to them. So, we do regular checkups on all the teams, but there are definitely teams that I tell to make sure [they] CC me on all communications for the first couple of weeks. Mostly I don't even need to read it. It's mostly, the idea that [they're] sending it to me and [they] know that I'm knowing whether [they] sent it or not. So that gives me a sense [of their communication]. Then, there are

> other [partners] who are really, really critical community partners that I talked to [directly] on a regular basis. Maybe they have multiple projects. I can say, 'hey, how are things going or are there issues?' so that I can get [their perspective] from them. The other thing is we really focus on cultivating a relationship with our partners at the program level.

As relationships become stronger and older, students tended to take a more active role in communication. One long-term program leveraged students as a critical means to maintain relationships with partners. They did this by integrating interns that spend longer periods of time in their partner country working directly with their partners. The faculty member described:

> So, I am going back to the model of the interns of Haiti. We could not have done the work if it had not been for the boots on the ground. Knowing the community, working with the community, making things happen, overseeing things, being our eyes and ears on the ground and in making sure things happen to a certain standard. But more than anything, you can't build trust unless you're there. In other words, yes, you can show up with your briefcase and you can go attend the meeting and you can be the subject matter expert, but they don't trust you. One of the things that happened—this was with our second intern; he was there for [about a year]. So on month eleven I was there, and we were meeting with the community members and [the partners] kept referring to [the intern] as the son of Haitian. And I was like, 'when did you become from here?' Well, over time with more interns coming into the community they kept referring to them as becoming Haitian. And I was trying to figure out what that meant because Haitian wasn't about a nationality—it's not about a race, it's about a state of mind. Do you understand me? And so, you really can't be trusted until you understand them, and you've walked a mile or two or three or 10 in their shoes. (20)

In this program, students were able to fill a similar role to many program's use of third-party organizations. This was both innovate and created a way to provide a deeper level of experience for students who were interested and create a very strong formal tie to the program. Other programs relied on students to build relationship from a distance or work to strengthen relationships during their time in-country. These programs used similar sentiments of trust building to explain their student engagement strategy.

Formal evaluation of international projects was one of the biggest weaknesses of the field, because programs were typically not funded or structured to do post-project evaluations in a formal way. This was in part due to academic schedules, and in part due to lack of time and availability of potential evaluators. Nearly all (90%) of programs reported underperformance when considering their ability for long-term project evaluation. Some leaned on their third-party organizations for this type of work (7, 21, 23). Others established ownership of the project to their international partner to evaluate and maintain long term (20, 15, 25, 5). Most, regardless of how they evaluate projects, note that this was an aspect that lacked funding and support from a programmatic standpoint to assess and monitor. One faculty described, "we don't [have an evaluation mechanism] –that's definitely a downside. That's part of the reason we rely on our community partners is because we know that we don't have the bandwidth to stick with this [and evaluate and maintain it long term]." (3)

One program was an exception to the lack of monitoring and evaluation structure. This program pursued USAID funding to help support evaluation from the student perspectives about projects. They were able to hire a full-time person to pursue this work, however they note that they are not able to evaluate all projects specifically, but approach evaluation at the programmatic level. The faculty member described:

> It's more of a program level scale. We ask questions about student's projects. We ask questions like: how important do you think your contribution to this project was? How successful do you think this project is going to be in the future based on your engagement with it? So, we ask questions like that about general project engagement, and we don't have the capacity to do this across the board, but we do monitor some of our partnerships that have a lot more engagement. [For example], we have this long-time collaboration with a women's cooperative in Uganda that has a lot of different entrepreneurial activities, and our students have worked with many of those activities over the years. Because it's been a project with such a high and consistent engagement, we are giving a little bit of extra attention to that project to monitor its outcomes. And there are a few examples where we're paying attention to specific projects or collaborations, but most of our monitoring and evaluation is more a baseline of 'how was your engagement on a team with a project in this class this semester' rather than digging into the specific projects. (10)

Aside from this program, none incorporated concrete long-term evaluation plans for individual projects in their courses. This is one major benefit of using a third-party partner or establishing concrete ownership of project within the international partner's purview upon project completion. A limitation of this, though, is that programs are not able to adjust structures and approaches of the program to better achieve goals in the future based on previous project long-term outcomes. Monitoring and evaluation is a necessary component in humanitarian work and is structured through toolkits and other evaluation tools [238], [239]. Monitoring and evaluation frameworks help to provide insights and real-time feedback on project successes and shortfalls [240]–[243]. Without these structures in place, there is limited feedback beyond direct partner communication to evaluate the work that programs develop and implement. This is a future area of improvement for international engineering programs that would find long-term project feedback to be helpful to conducting current and future projects.

4.5 Barriers to International Programs for Engineers

Faculty described four primary barriers when discussing their experiences and perspectives of their international engineering programs. These four barriers were university structures, funding, course structures, and faculty tenure track processes. Each of these barriers included limitations of either institutional capabilities or the perceived value of the work. Additionally, the limiting effect of terminology barriers became apparent when considering programs for this study. These barriers all limit international engineering program's abilities to form and grow. Addressing and rectifying these barriers could help improve international programs in the future. It is important to note that many of these barriers may not be unique to the development of international programs, but in many cases can be more broadly applied to innovative or unique programs to the existing university structure. This data examined specific mechanisms that are in some ways unique to the goals of these programs, but in others embody the traits of any program that looks to build something new.

4.5.1 University Structures Barriers

International programs have identified a major tension within higher education—the system is not always designed to integrate innovative or new structures effectively. One faculty member described setting up procedures for their program as "fitting a square peg into a round hole (14)." The availability of university programs to support international projects and the overall university buy-in also played a significant role in program success or failure.

University structures sometimes created a difficult environment for international programs to form and grow. One example of these structural barriers was shown through traditional administrative requirements. In the early years of one of the largest international service-learning programs in the United States, for students to leave campus the administration office needed a completed field trip form for each student and each day that they would be off campus. For a program traveling to and from communities, this was severely limiting administratively for faculty. To change the policy, the faculty member submitted hundreds of field trip forms for their class and convinced the administration office to allow for one form that covers the semester, instead of day (14). Small barriers, even as simple as paperwork, could be a deterrent to developing international programs. While this faculty member found a creative solution, others described, "some of our work is easier to run as a co-curricular program. There are less requirements, and it is easier than making a new course (2)." These difficulties are not limited to international programs. Many types of innovative programs find conforming to existing university structures to be difficult [244]–[247]. For example, sustainability efforts have been implemented by horizontally (embedded) and vertically (independent) within engineering programs globally, however a major takeaway is the need to develop top-level (structural) strategies to better integrate these programs in universities [247]. This is a similar consideration needed for international programs.

Other barriers included the administration's support of the programs and availability of international travel support (global offices). For example, one faculty member who worked to create an international program was ultimately unsuccessful due to the administration's lack of confidence in the value of the program. These programs required the university to take on risk of supporting faculty to teach courses while recruiting students to participate and successfully find job placement upon completion of the program (3). The burden was on the faculty member to prove the value of the program to students. The university was unable to accept the potential risks related to funding, student interest, and future career potential for program graduates. Without buy in from the administration, the program could not receive the necessary funding to create the program courses (3). International travel support office helped to alleviate the responsibility for safety considerations and coordination of travel entirely from the faculty in charge. These offices also helped students find funding to help alleviate travel costs. For international programs without access to such offices, the planning and execution of international travel was more work. This again, was a structural component that could alleviate the faculty workload and help to facilitate program participation with students.

Some factors that contributed to the barriers in institutional structures have been shifting in universities across the country. One example of this is the increasing number of international experiences for students. Over the last 20 years, universities on average increased student's international exposure by approximately 20% per year [248] . This helps to resolve administrative barriers for travel by creating a norm for international travel requirements. While progress may seem slow to some, one program director was quick to remind me: "while progress is slow, we must look at the forward momentum as positive (14)."

4.5.2 Course Structures Barriers

Engineering students have limited availability in free or flexible credit hours in their schedules. For programs that integrate into engineering capstone courses, this limitation is the foundational point of their program structure decision. For programs that integrate students across disciplines, it can be difficult and limiting to create formal credits for students that aid in their varying degree paths. This is less of a concern for specializations like minor programs or programs that offer benefits outside of formal credit like internship or leadership opportunities. To mitigate this barrier, programs have used creative structures to help alleviate this issue with students like integrating research opportunities, utilizing 1 or low credits to fit into schedules, and creating iterative courses that allow for students to return when their course loads allow them time and space.

There is a lack of centralized and distributed information about how to build programs within higher education. For many of the younger programs included in this work, along with older programs recounting their founding and early years, there is little data to help structure courses, exercises, or evaluation metrics for student performance. One faculty member described this as, "we just learned as we went, and I learned a lot along the way (7)." Another research faculty described, "what I am doing is drastically different from my peers (17)." Pairing this with the heavy workload that faculty can carry by participating in these courses [249], this lack of information can be a major barrier to meeting program goals, achieving project requirements, and truly understanding the value that the program gives to students. Young programs that are able to learn from older ones may be able to circumvent some of these initial challenges.

4.5.3 Funding Barriers

University and course structures were critical for program success, but financial support may be one of the most critical to grow programs. Of the programs and courses captured for this study, the largest and most robust programs tended to be the most well-funded. Funding included all financial support ranging

from student travel funds to physical space allocation on campus to development and delivery of a final product. Some programs require students to fundraise for their own travel, project costs, or both. Others required help fund matching from their partners. Some require their partners to fund the entirety of the work beyond the development and testing.

Some programs, such as tailored programs (like honors programs) or specialized programs (such as minor tracks) have a high rate of both internal and external investments or funding streams. For example, one honors faculty member described, "We have a large number of alumni that we are able to tap into to help fund projects and students. Our graduates like to give back to the program (11)." Another described, "Our program receives a certain amount of funding directly from the university and we can use it how we like (10)." More tailored programs often work to fully fund programs and travel for students (1, 9, 10, 11). However, some require a certain level of financial investment from students who wish to participate. In this case, the amount that students usually must contribute is small.

IP courses that are standalone or outside of tailored programs often approach funding differently. Some look for department or college level donors or funding mechanisms to help fund student travel (7), while others tend to place the ownness of the project funding and travel on students (7, 6, 8). For example, one program utilizes student fundraising for projects and therefore limits the size and cost of projects based on what can realistically be fundraised by students (7). This second model is common with study abroad trips, which require students to pay a fee that covers theirs and their instructor's travel while project funding is considered independent.

Another mechanisms used is the concept of split costs. This was seen across program types. It entails the international partner or smaller subset community to fund the project costs partially or fully. This model aims to establish a direct line of ownership with the IP to eliminate risk from the university side (8) and create a sense of ownership for those who will keep the project after completion (20). While this model is used in just a few cases in this study (8%), the concept is one that can help create ownership of projects while alleviating some of the funding costs from the IP home institution or students.

While the mechanisms described above account for the large majority of funding mechanisms, there was an outlier worth noting and exploring. One program worked to obtain USAID funding for their work within their program. The funding from USAID allowed the program to expand staffing, and student learning outcome evaluation (10). The program helped bring many engineering products to market. For

new programs starting out, this level of funding may not be appropriate, but opportunities may exist to fund work such as this.

Funding mechanisms enhanced or limited the scope of work that programs could engage with. Student travel and international projects both require significant funds to operate. While some programs had established sources of funding, others had limited scope funding or required students to participate in fundraising efforts. These characteristics changed the types of projects and support for student travel that a program could provide. When considering establishing programs, the source of funding is critical to supporting program goals effectively.

4.5.4 The Tenure Track Process

There was a perception among faculty working on international projects that it can be considered "not a real type of engineering". One major limitation of this "othering" is the effect that it has on the tenure track process for faculty. Not all faculty interviewed for this research were tenure track faculty, in fact only 44% held tenured positions or were actively pursuing them. Of those faculty, nearly 50% described difficulties between international work and their career progression. Additional faculty outside of the tenure track also described the difficulty of recruiting other faculty to programs due to the hinderance towards tenure (20). This is similar to other reported faculty perceptions of their tenure track work when they actively pursue external work such as service [249].

International work is highly motivating for career choices. However, faculty often find that it can limit their career progression due to existing evaluation metrics. For example, one faculty recounted early on in their career that they "...[would] put [the international service-learning course that I taught] in my service portfolio and I'll get to teach real design classes (14)." However, after recognizing the value, they developed the rest of their career around international service work by pursuing specific international service-learning roles (14).

A common theme emerged around the idea of traditional vs non-traditional engineering, and the different levels of emphasis given to each. Faculty often participate in international experiences in addition to or outside of their more traditional engineering faculty role. Some use their international work as a basis for their research (2, 17, 18). Often, they are confronted with the difficulty of defending why their work "counts" as engineering work to colleagues and the university. For example, one faculty member noted

that when speaking to their colleagues, they say, "[my] colleagues are like '[international work] is not real research.' There could be no more important research on the planet (17)!"

For faculty who pursued international project work despite other concerns, the value of their project outputs often felt undervalued in the university evaluation process. For example, one faculty discussed the lack of importance that their publications in non-science focused outlets (policy, general public) garnered with both their peers and their career evaluation portfolios (17). Another described the lack of faculty involvement across the university as directly tied to this issue of value. They stated, "So the number one thing that you're going to fight in getting faculty involved in this is the concept of scholarship for most universities. For the tenure track and promotion components, they only look at the scholarship of discovery. So, they put their blinders on [to this work (20)]." Another faculty member who felt limited in their ability to continue working on international projects used this as motivation to find a new job (3).

Faculty members are highly motivated to do international work, despite these barriers. Faculty members' personal motivations tend to help faculty overcome this barrier. To sum up the challenges with this barrier, one tenured faculty member stated, "so that's pretty much why I think we continue to do this against our best interests professionally, because it does not align with the incentives. I think that's one thing that your work has to acknowledge. There are zero incentives to do this work. It's riskier, it's harder. It takes more energy and effort, and it gets zero reward (19)."

In general, university positions that are specifically focused on international programs or courses tended to create better work environments and perspectives for faculty members. Those working in more "traditional" spaces who do international work in addition to or despite those traditional roles reported a significantly higher negative perspective of their career experiences. This is not a phenomenon exclusively experienced in international programs. Any activity given little time allotment in a traditional faculty role can fall into this category of experience. For example, participation on commissions that count as service, such as inclusion and diversity panels, is not always given adequate weight in a faculty evaluation given the time and effort required as other considerations [250]. To truly do well in a roll, faculty must be effectively compensated for the level of effort involved whether it is to support research, a course, or university-related service [250]. This lesson is one that should be considered in all types of innovative or new program areas.

4.5.5 Terminology Barriers

The final barrier to consider is the idea of terminology and definitions. In this work, several programs of different descriptive terminology were included. For example, one university described their program as primarily entrepreneurial in nature, citing their connections with global markets (25). Another touted their inverted methods (from what many describe as the standard in traditional international project programs) for identifying partner projects and connecting students to the projects as the major divide (5). While these features tend to set programs apart from others, overall, the programs aim to achieve similar goals or use similar structural components to achieve international program objectives for students and international partners.

A consistent perspective throughout faculty interviews is the perceived difference of programs that use differing terminology. Some viewed service-learning programs as damaging to international partners and therefore used a term like humanitarian engineering, some felt that the student experience should take precedent over project outcomes and that service learning was an appropriate term. However, each of the included programs in this study worked to create and maintain international programs that provide value to all participants. This phenomenon can be seen in the various terms used across journal publications about international engineering programs [36], [86], [110], [251].

Conversations with the faculty involved in these programs has shown that there is a need for conversations around terminology in this space. Stigmas and misconceptions seem to limit the spread of information between groups who identify under different terms and limits the potential for collaboration unnecessarily. Through this research, it has become apparent that every faculty member involved with this work is driven to create positive impact. The divergence seems to come through methodology, which creates opportunities for cross-collaboration to explore these methodologies in different contexts. Exposing faculty who are new to this work to those with decades of experience could change the way that new programs are built and grow. Creating space for diverging methodologies allows programs to avoid pitfalls while building strong institutions and lends credibility to the field. This research highlights some of these methodologies and structures, but nothing short of cross-collaboration can help to expand programs and experiences for all parties involved moving forward.

CHAPTER 5: CONCLUSIONS, IMPLICATIONS, AND CONTRIBUTIONS

Universities should be intentionally building and strengthening international engineering programs. International engineering programs provide learning and professional opportunities for participating faculty and students while aiding international partners in their own efforts. These programs are unique from traditional engineering courses and projects and generate outcomes desired for engineers entering the workforce including professional skills, critical thinking skills, and a strong understanding of their target audiences. The examination of the dimensions of international engineering programs provides a foundation of knowledge for future programs to build on and for existing programs to compare their approaches to. This is a critical step to implementing these types of programs in a more widespread and intentional way. As the world becomes more global, new engineers must enter the workforce equipped with the necessary skills to adapt to these changes. Additionally, these programs provide avenues of support for communities around the globe. When managed effectively, there is value for all participating stakeholders. To create strong programs, program faculty should consider each of the dimensions presented in this work.

5.1 Key Insights and Contributions to Theory

Prior to this research, international engineering program literature focused on the structure, processes, and student learning outcomes from single programs [7]–[9], [61], [110]. For example, student learning outcomes have been thoroughly investigated at the single program level and results have shown that international engineering programs help students develop technical, professional, and global skills [5], [36], [187] This work, instead focused on collecting perspectives from 25 US programs to develop common experiences that programs share while understanding what differentiates programs. Working off of the fundamental work of these individual programs, I aimed to understand what unique and shared program structured encouraged and shaped these program outcomes. Each question explored in this research aimed to understand where programs shared perspectives and where those perspectives varied. The primary contribution to theory in this work is combining the perspectives across programs.

All of the questions investigated in this work are affected by the answer to research one question: does the program focus first on student learning or international partner goals? Each primary focus leverages different aspects of program design, learning, and participation outcomes to achieve those goals. All programs consider both of these questions, and many program faculty want to be equally and fully focused

on both students and partner goals. However, the reality is that emphasis is always placed on one over the other due to the nature of the program design. This emphasis, though, does not mean that students cannot learn in partner-focused programs or that partners cannot achieve goals in student-focused programs. It does mean, though, that all stakeholders have to have realistic expectations and goals given that program focus. In fact, two program components were consistently effective for student learning across both program focuses: student leadership and travel opportunities. When appropriate, integration of these two components can help heighten student learning opportunities and strengthen their professional and global skills in addition to their technical skills, when appropriate.

A critical aspect of program success are faculty members. Faculty are highly motivated by their work in these international engineering programs and see tremendous value for their students in the work that they are creating and that which aligns with their personal and professional values. As new programs are created, universities must work to create value for faculty in these positions and help alleviate tensions that can exist within the university structures.

Finally, the relationships that programs develop with international partners reflect the goals of the program and often result from personal connections made by faculty members. As programs grow, their international relationships are shaped by their program goals and often shift to allow students more responsibilities in connecting with their partners. While relationship formation and maintenance are something that faculty can actively describe and engage with, monitoring and evaluation of projects is highly limited. The efforts of monitoring and evaluation require significant improvements to effectively evaluate the outputs of program-partner efforts.

5.2 Conclusion

On the whole, international project programs provide educational experiences for students while providing value to their international partners. These programs give students experience with real world, cross-cultural projects and allow for opportunities in professional development outside of traditional coursework. International partners are able to gain assistance with relevant projects for their organizations which ultimately benefit communities or society as a whole. The projects are meaningful, and the goals align with the engineer's responsibility to society. Faculty who participated in these programs are motivated by the projects themselves, the partnerships they form, and most of all by the education that they can give to student participants. Students are able to gain experiences that boost their resumes while

learning about aspects of engineering that are often overlooked in traditional curricula. They are also able to strengthen their consideration of cultural and global perspectives as they pertain to the field of engineering and beyond.

The structures, learning outcomes, and international partner relationships vary among programs and can be combined differently to achieve different program-level goals. The structure implemented in international programs aim to leverage structures to increase student learning and assistance to international partners. Five key components of program structures are especially important to creating value and robustness for programs. The associated learning outcomes of these programs aim to support program goals and can be related to the program type. International partner relationships are fundamentally the result of trust building efforts. Programs of different size and status develop these partnerships differently.

Collectively, the program structure, learning outcomes, and partnerships work to create meaningful experiences for all participants. For example, the following components may be integrated into a single program with a primary goal of achieving partner goals while focusing on student education on global skills and more general engineering skills related to problem solving.

Table 4: Example 1, Program Considerations

Program Aspect	**Selected characteristics**
Program Type	Independent Project Program
Faculty	Motivated to work on international projects to support their personal values
Students	Varying backgrounds and academic years
Partnership	Single partner engaged with multiple projects across years
Expected Learning Outcomes	Establish strong global skills and general engineering skills related to problem solving in a multicultural environment
Recognition	Course Credit, multiple course offerings

Travel Opportunity	Guaranteed for participating students
Leadership Opportunity	Team-based learning, students to lead project development alongside community
Funding	Project funded through program student travel funded independently

In contrast, a program with goals to educate students in a specific, technical aspect of engineering may look differently and include the following components:

Table 5: Example 2, Program Considerations

Program Aspect	**Selected characteristics**
Program Type	Embedded Program—Capstone Course
Faculty	Motivated to use international project to educate students
Students	Senior, single discipline engineering students
Partnership	Partner acquired with specific, relevant project which meets capstone objectives
Expected Learning Outcomes	Students to learn discipline specific technical outcomes which align with program outcomes
Recognition	Course Credit
Travel Opportunity	Not included formally in course, must be pursued externally
Leadership Opportunity	Team-based learning in classroom/campus setting; students required to produce several formal documents and presentation for on-campus evaluators
Funding	Project and student travel funded independently at faculty and student discretion

These variations in structure, learning outcomes, and partnerships are widely under investigated across programs. While some programs have published on the work of their programs and projects, comparison

across programs is limited. Through this study, I provide a framework for programs to understand and evaluate program components for their own benefit and for the use in building future programs. Faculty and universities can use the key insights from this research to effectively modify and build programs to meet program objectives. Additionally, we must understand the barriers that exist in creating program structures to effectively create programs that allow students to participate while progressing in their degree-granting pathways. More work is needed to effectively integrate independent programs into these pathways.

Students with leadership and travel opportunities tended to reflect more deeply and explained greater learning from their experiences. These two components were highly beneficial for student learning in all program types. Student participants who participate in multiple international programs tended to gain a deeper level of appreciation and experience with project failure, cultural considerations, and overcoming challenges in real-world projects compared to one-time participants who often focus on the relevant learning outcomes related to their area of study or professional goals.

The student experience through these real-world projects is not completely controlled, and much of the learning that occurs cannot be controlled in the same way as a course case study or on campus experience. As such, program learning outcomes should reflect this variability to effectively capture the effects that these real-world projects have on students. One example of this is including the understanding and overcoming of failure in course objectives.

Faculty participation is critical for international program success. Their motivations to participate in these programs are useful to consider in creating meaningful career opportunities for faculty through international programs. However, we must address existing barriers for faculty participation to make it more accessible and meaningful beyond faculty's personal and career motivations and interests. The barriers most frequently mentioned across faculty relate to the tenure track processes' valuation of participation in international programs.

5.3 Implications for Institutions, Faculty, and Program Directors

One of my primary goals with this work was to provide some foundation for the development or modification of future international engineering programs. Having taught a program which existed prior to my own involvement for two years, I wished that I had resources to help understand and operationalize the program design decisions that were put in place. At a minimum, understanding where I was really

creating value for students and our partner would have helped me to develop the program more quickly in key areas. To create an international engineering program, program creators should consider the following four questions primarily:

1. What type of partner relationship do you want to maintain?
2. Who are your target students and how do you plan to compensate students for their participation?
3. What are your program goals for faculty and how do you plan to compensate them?
4. Are project outcomes important, and if so, how will you measure them?

5.3.1 Partner Relationships

To begin planning, first a program creator must understand who and what kind of partnership relationship that they want to maintain. If the goal is to develop a deep, long-term partnership spanning multiple years, then the creator may develop an independent program to allow them more flexibility to accommodate a range of partner projects. If the goal is to use partner relationships to meet specific program needs, a creator may revert to an integrated course or decide to utilize the services of a third-party organization to achieve their relationship goals. Partner relationships are the cornerstone of forming programs. Without understanding the type and value of the partnership, a new program will not be able to effectively create their structure, let alone vocalize their program goals to administration, participating faculty, potential partners, or to student recruits.

5.3.2. Student demographics and compensation

What student population supports program partnerships and goals? How do we attract and compensate students for their participation? This study found that student academic years, discipline, prior international experience, and the total number of these participating students differed based on the program goals. If a program's intent is to highlight cross-cultural learning and implements less technical projects, a wider range of student disciplines and academic years can effectively be included. However, the academic years could be modified to encourage more maturity of the team for travel.

As creators establish programs, student compensation can be used to help achieve program-level goals. Iterative single courses provide a different type of compensation than a minor program provides for students, and it allows for different levels of involvement either with the years or depth of participation.

Internships provide students with prolonged international experience and formal resume-building experiences. Mentorship allows programs to re-engage students or professionals with relevant experience into the programs. Each type of compensation should be considered to establish which will best bolster the program goals and reinforce interest in relevant student demographics.

5.3.3 Faculty participation and compensation

Will the program provide additional merit for faculty or help to reduce their existing workload while participating in the international engineering program? For faculty pursuing tenure, how does their work in the program further their progress? Perhaps more important than consideration of student participation is the consideration of faculty participation and compensation. This may be an interesting consideration as many program creators are faculty members who would then remain involved in the program as it progresses. However, there must be a clear understanding of what compensation that participating faculty will receive for their involvement in an international engineering program. For independent programs, faculty have more tailored, single-focus work whereas for faculty "adding on" international engineering program involvement, it increases the faculty's workload. For tenure track faculty, considerations for how this involvement can aid their tenure portfolio should be considered prior to participation.

5.3.4 Project/research outcome value and evaluation

What goals does the program have for project or research outcomes? Once a program understands their partner relationships goals, this may be an obvious answer. For some programs creating tangible projects is a key goal. For others the goal is to produce accessible research publications that can help anyone who experiences the research area topic. For others, the goal is continuous partnership, and the individual projects or work may be considered temporary or iterative in nature.

Regardless of the intended outcomes, programs must begin to develop metrics to evaluate these outcomes. Of course, we measure student learning, but these other outcomes are often overlooked. To best inform program practices and relationships programs need information about the effect of their program outputs. A notable tool that could serve as a framework for project evaluation is the USAID monitoring and evaluation toolkit which can be found through a quick internet search. For research evaluation, metrics like the place of publication (open source or paid), the number of publications, and the number of times that the works have been cited are a few measurable items to consider.

5.4 Contributions to Research

This dissertation provides a comparative platform for international programs for engineers across the United States and categorizes the key features of programs from the faculty perspective. While institutions have published literature describing their program's function and outcomes, there was no comparative measure between programs. This foundation will allow future researchers to investigate more thoroughly the differences between program types and future faculty to develop programs with a deeper understanding of the possibilities that programs have.

Additionally, I captured faculty perspectives about why they were motivated to participate in international programs either instead of or in addition to other faculty positions. This work shows that faculty's motivation is a major aspect of their participation, but that they can be limited by the structures of and value from their host institutions in participating in international programs.

While each of these programs have relationships with international partners and several faculty have published about their decision-making process for establishing projects, little information was available for finding partners. Understanding how these partnerships are originally, typically developed will aid future program creators in their efforts to establish meaningful relationships.

Finally, categorizing student reflections on their participation in international programs of all types provides future researchers the opportunity to expand on this work and more deeply evaluate student perspectives as they relate to program structure, learning outcome intentions, and project types.

5.5 Limitations and Future Research Recommendations

Future research could benefit from an expanded qualitative research study on student reflections on their experiences in international programs. Increasing the sample size of students will provide more in-depth findings about student's post-participation views in international programs. This study included 40 students, which did not reach a consensus on perspectives. Additionally, I recruited students through the help of faculty which may have resulted in a biased sample. I chose to use student reflections to capture student learning after participation which allowed me to include a wider range of students and account for programs not running due to COVID restrictions. However, future research may look to integrate pre and post evaluations to capture student perspectives more concretely before and after participation in experiences.

Another limitation of this study is the perspectives captured to explain international relationships. I interviewed faculty to learn how relationships were formed and maintained, but future research would strongly benefit from investigating the international partner perspective in these relationship formations. Additionally, inclusion of non-US institutions or other forms of partnership programs such as domestic service learning may be of interest in future studies to explore the impact of international experiences in different institutions and explore the necessity of the international component on program goals.

Several new questions arose from this work with respect to community partners, program types, and student participation as a result of the limitations of this work. These are listed below:

1. How do programs and partners establish projects?
2. How do these international programs compare to those focused on domestic projects?
3. How do institutions outside of the United States structure and run their international programs?
4. How do students reflect on their experiences before, during, and after program participation?

5.6 Reflections

International programs are varied and operate under numerous terms. Starting this work, I at first limited my search to only international service-learning programs, as this was the focus from my master's thesis and my background. However, one of the most important things that I learned through this work is that international programs, whether they are service learning, humanitarian engineering, or something else entirely, all have valuable insights and lessons that the others can learn from. In expanding this study to be representative of these different categories, I was able to connect with faculty and students engaged in different, yet meaningful acts of international engineering for societies. This work has shown me the necessity of building bridges between our siloed areas, and work to creating stronger programs and experiences for all involved.

Another aspect of this work that stands out to me is the changes that I made with respect to international partnerships. My original goal was to categorize programs that had "successes" and "failures" with their partners, but I found that our area as a whole lacks foundational understanding of these partnerships from a literature perspective. Several institutions have worked to disseminate information about meaningful partnerships. Villanova's publications on the topic is especially interesting. However, across programs,

we have limited understanding of how we are forming partnerships and maintaining them. Even less considered, however, is the evaluation of the impact of program outcomes. As international engineering programs get more popular, we must strengthen these aspects across all programs to ensure that the work aimed at achieving huge, positive impacts is indeed achieving them.

5.7 A Guide for Practitioners

For those interested in establishing or strengthening an international engineering program, there are two main categories of considerations: starting out and continued development. In this guide, I will provide key considerations for both categories to help ensure program success.

5.7.1 When Starting Out

When starting out with an international engineering program, there are several key considerations to keep in mind. These are the primary considerations that are necessary

Hiring Faculty Members

One of the most critical aspects of program success is the investment from and support to the involved faculty members. The chosen faculty participants are often internally motivated by their own identities or perception of value that they can create through these programs. However, often these highly motivated individuals can be limited by their formal positions and workload. Creating opportunities for faculty to be fully supported within the international engineering program can help to support faculty and limit their additional workload burden. For example, tenure-track faculty members who also participate in international engineering programs were more likely to report dissatisfaction with their career progression, perceived value of their work by their peers and institution, and express negative feelings towards their workload and ability to effect change.

Program Legacy

Another important consideration is the kind of legacy that your program will leave. It is essential to determine the long-term goals and objectives of the program, including what kind of impact it will have on the participating students and partner institutions. Identifying a clear vision for the program will help to guide decision-making and resource allocation. Using a model like Simon Sinek's in "Start with Why" may be a good reference for those finding it difficult to determine their intended legacy. An example of

program legacy is, “I want my students to go out into the ‘real world’ and know how to make a difference for the communities that they are working in.” This legacy has a primary focus on student learning. Others may primarily focus on partnership goals.

Who are your students?

It is also crucial to consider the students who will be participating in the program. What kind of students are you looking for? What are the eligibility requirements, and how will you ensure that the students have the necessary skills and knowledge to succeed in the program? The included student demographic in your program will change the program’s learning objectives, formal compensation, and the overall program structure. For example, if you are only able to develop a single instance, one semester course, you may want to select a small demographic of students who are able to meet specific, time constrained learning or partnership objectives. In contrast, programs that stretch multiple years, multiple projects, or multiple engagement opportunities may want to include students of wider backgrounds and academic years to accomplish program goals.

Who are your partners?

Most often, programs initially develop partnerships through personal networks of faculty members or university employees. As programs grow in size and reputation, new relationships form through the perceived program reputation and the more robust networking that programs are able to do. Understanding where you will identify and establish a partnership from is critical. If what I have described does not seem feasible for you and your program, you may want to investigate a third-party organization that is able to arrange an appropriately matched relationship between your program and an international partner looking for assistance with projects.

The partners that you develop with affect the types of projects, travel, and collaboration that your program will have. Some primary considerations for establishing partners at a very basic level include, 1) the types of work that they would like to collaborate on and its alignment with your program goals and student demographics, 2) their location in the world and your ability to (or desire to) establish travel opportunities there, 3) the language barriers needed to overcome, and 4) the organization of your partnership. In some programs, partners are treated as clients who approach the program with specific problems, and the program provides an appropriate solution for the client to implement how they see fit. Others work

collaboratively with their partners to determine what the project needs are and travel to the location to help facilitate implenentation. This range is wide. Establishing these expectations and boundaries early is critical. A great reference for this consideration, once you answer some of the more basic questions posed above, is the Villanova publication titled "Vertically Integrated Humanitarian Engineering Program Design" by Ermillo et al provides a fantastic framework to consider when building partnerships.

What funding structure will support these goals?

One of the most critical aspects of establishing an international engineering program is determining the funding structure that will support the program's goals. This can include internal university funding for the program, scholarships for students, and grants and other funding sources. As the program ages, often the reputation strengthens and opens doors to alternative funding mechanisms such as grants and industry partnerships. If this is a long-term goal of your program, strong documentation of your work will be critical for these later submittals. Consideration of funding for faculty, students, and partners is a primary structure needed for a program to be established. Often, younger programs run on "shoestring" funding, which can limit their effectiveness. On the other hand, older programs often utilize multiple funding streams.

First and foremost, basic funding for the program must come from internal funds. Often, faculty funding is split between "traditional" roles and their international role. From my research, this split often overloads faculty and leads to negative feelings about the value of their work. The ideal faculty funding would allow faculty to focus specifically on their work within the program. These funds often originate from a particular department or college that will host the program. The primary consideration of internal funding is for the faculty to be supported through the establishment of the program.

Student funding limits or encourages diverse sets of students to participate. Access to internal program funding support, university scholarships, or external funding opportunities gives students who may not otherwise have access to participate.

Partnerships and project funding is yet another consideration when establishing a program. For programs who aim to integrate a third-party organization, there are similar consideration about where their funding comes from as faculty funding. These third-party organizations have a wide range in cost which often depends on the level of involvement in the program, but often well-established organizations charge thousands of dollars for their work. Some programs, on the other hand, require their international partners

to fund the in-country portions of the programs. This depends entirely on the type of partners that you establish. For those who cannot afford your projects, this choice could kill projects.

You can also consider alternative funding mechanisms, such as crowdfunding, alumni donations, or corporate partnerships. Crowdfunding can be a useful tool for specific program goals that the program cannot fund directly, often this includes student travel or project completion costs. Alumni donations can also be an effective way to support the program, particularly if the program has a strong alumni network. Corporate partnerships can provide funding support, research opportunities, and networking connections for the program, but it is essential to consider the potential impact on the program's independence and academic integrity when forming these partnerships.

Finally, as I mentioned above, as programs age, they tend to diversify and solidify funding sources both within and outside of the university. This strategy provides flexibility and independence for the program. While this is difficult to develop during program creation, considering the most useful mechanisms for your work long-term is a critical consideration to begin work-in towards at the inception of the program.

5.7.2 Things to Consider Once Established

Once the international engineering program is established, there are several things to consider to ensure continued success. These considerations include long-term partnership goals and continued student engagement primarily in a combined effort to grow the program.

Maintaining Partnerships

One of the most important considerations is how to maintain and identify future partnerships. Several questions to consider are listed below.

- How long will you work with one (or each) partner?
- What do you consider an appropriate reason for a partnership to end?
- How many partnerships can your program realistically maintain?
- Is the diversity in partners and projects beneficial or hurtful to your program structure and student participants?

Partnerships are a critical aspect of the program success. Depending on your long-term goals for the program, your answers may vary to these above questions. Answering these questions also brings in considerations of funding, available faculty, and program robustness.

Continued Student Engagement

Continued student engagement is also crucial for program success. Providing opportunities for students to participate in research, internships, and other experiential learning opportunities can help to keep students engaged in the program and motivated to succeed. Providing opportunities for students to participate in research, internships, and other experiential learning opportunities can help to keep students engaged in the program and motivated to succeed. This type of hands-on experience is especially important for students pursuing careers in engineering, as it allows them to apply the theoretical knowledge they learn in the classroom to real-world problems. This dissertation identified that as students increased their participation time in programs, they tended to better synthesize and consider their experiences and education more holistically. This is a tremendous asset to the program reputation when these young professionals enter the workforce. At the same time, this continued engagement allows programs to retain knowledge within the program and more sustainably transfer and maintain knowledge.

Growing your Program

Considering your partnership and student engagement goals are the cornerstones of growing your program. Long term, you should revisit your established goals of program legacy to direct your growth efforts. For example, if a program goal is to complete many projects for partners, you may want to grow your capability to include more students to work on a diverse range of projects. On the other hand, if your primary goal is to deeply establish relationships with your partners, you may want to limit your program's expansion to provide resources and focus to the partnerships that you are working to deeply develop more effectively.

Similarly, taking time to check in on the types of work that your program is doing will help direct future projects and help to down select future partners. For example, if your program requires projects to be completed within a specific time horizon, you may not be able to pursue projects that would fall short or overrun that time horizon. Alternatively, if your program is flexible to these considerations, you can select different types of partnerships.

Establishing metrics to reflect on the program efficacy will be critical to effectively growing your program. These metrics can look like student surveys, program reflections, external evaluations, project monitoring and evaluation, or something more tailored to the work that you are doing. From existing programs, one of the most difficult and least measured metric is project monitoring and evaluation. Those with the most effective metrics are those who leave this work to third parties. Developing and implementing these reflective metrics may take a significant amount of time, money, and effort from the leading faculty members. When establishing these, it may be worth considering available funding sources that can provide support for this work such as adding staff, funding a summer for faculty members, or paying graduate or undergraduate students to work on this effort.

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APPENDICES

APPENDIX A: Student IRB Consent Form

Virginia Polytechnic Institute and State University
Informed Consent for Participants In Research Involving Human Subjects

Title of Project: Understanding the Impact of International Service Learning Courses on Student Learning Outcomes

Investigators: Dr. Tripp Shealy Department of Civil Engineering, Brooke Baugher Department of Civil Engineering

I. Purpose of this research
This research is meant to explore international service learning courses at institutions across the United States to determine the impacts of these courses on student learning. Interview data will be integrated with survey responses to understand student survey responses. The results may be published in journals and presented at conferences and workshops and will be used to inform future international service learning classes.

II. Procedures
Your participation and consent for this study is for participating in an interview. The interview will involve sharing with the interviewer your experiences and thoughts about in your international service learning course. The interview will require no more than an hour and will take place at a mutually agreed upon time and location or via Skype or similar app. You understand that the interview will be audio-recorded to accurately record your experiences, beliefs, and ideas.

III. Risks
This project poses minimal physical or financial risks to you; all identifying information about yourself or others will remain confidential, and inaccessible to your instructors and community partners.

IV. Benefits
Although this research provides no direct benefits to you per se, it will help the researchers better understand senior design, to improve international service learning courses for future students.

V. Extent of Anonymity and Confidentiality
Specific information regarding you and your work will remain confidential; published articles will use pseudonyms as appropriate to protect your privacy.

In the course of keeping accurate research records, we will identify you by a pseudonym and maintain a confidential list of which participants correspond to which information. No one but Ms. Baugher, who is not involved in your course grading, will have access to that list.

VI. Freedom to Withdraw

Your participation in this project is entirely voluntary. You are free to withdraw from this study at any time without penalty. You are also free to refuse to answer any question at your discretion without penalty.

VII. Approval of Research
This research project has been reviewed, as required, by the Institutional Review Board for Research Involving Human Subjects at Virginia Polytechnic Institute and State University.

VIII. Subject's Responsibilities
I voluntarily agree to participate in this research. I have the responsibility to participate in one interview of approximately one hour.

IX. Subject's Permission
I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:

_____ _____
Researcher Conducting Consent Process Date

_____
Subject Name (Print)

I consent to participating in a recorded interview: _____
Subject Signature

Should you have any questions about this research, you may contact:

Brooke Baugher, Co-Investigator, bbaugher@vt.edu
Tripp Shealy, Co-Investigator, tshealy@vt.edu

This research has been reviewed by the Virginia Tech Institutional Review Board (IRB). You may communicate with them at 540-231-3732 or irb@vt.edu if:

- You have questions about your rights as a research subject
- Your questions, concerns, or complaints are not being answered by the research team
- You cannot reach the research team
- You want to talk to someone besides the research team to provide feedback about this research

Appendix B: Faculty Email Recruitment Script

Instructor Recruitment Emails

Instructor Invitation

Subject: Understanding International Service-Learning Course Experiences - Research Study

Hi,

My name is Brooke Baugher, and I am a PhD student in Civil Engineering at Virginia Tech. For my PhD study, I am investigating the impacts that international service-learning courses have on students. I would like to invite you and your students to participate in my study! Participation would include a 60-minute interview about your course structure, goals, and impacts, distributing two 20-minute surveys, one at the beginning of the semester and one at the end, and reading a script for the students to help them understand their consent options. Upon completion of my research, I will provide your course's anonymized data to you along with access to my findings. If you have any questions, please feel free to reach out!

Thanks so much,

Brooke Baugher

Appendix C: A Priori Code List for Faculty Interviews

Categories	First Code	Second Code	Third code	Source
Emotional Engagement	Macro ethics			Herkert
		Social Responsibility		Canney & Bielefeldt
			Value formation	Harris et al
			impact of engineering	Bielefeldt et al
			humanitarian	Baer
			engagement	Ravel et al
		Global Citizenship		Brown
			Collaborative design	Herkert
			Societal impact	Felder & Brent
			Cross-cultural	Selby
			Social Sustainability	Bielefeldt et al
			Globalization	Newberry 2005
	Microethics	Responsibility		Herkert
			Engineer's creed	Code of Ethics
		Empathy		Strobel et al
			Knowledge	Lucena
			Cultural consideration	Kaminsky
Intellectual Engagement	Ethical Application			Newberry
		Safety		Basart and Serra
			Risk	Bielefeldt et al
			Liability	Bielefeldt et al
			Uncertainty	Bielefeldt et al
		Impact		Ravel et al, Alexander
	Ethical Evaluation			Olds et al
		Ethical Action		Selby
		Case Study		Haws & Lynch via Newberry
		Project		Felder & Brent
			Group	Johnson & Johnson
		Growth		Bringle
	Moral Reasoning			Self & Ellison
		Moral Judgement		Selby
		Theoretical Reasoning		Haws & Lynch

Particular Knowledge	Ethical Codes or Universal Objectives			Newberry
		Development Goals	Sustainable Development Goals	Mihelcic et al
		Codes	Engineering Code of Ethics	
			International Codes	
		Societies	Society responsibility	
			NSPE	Bielefeldt et al
		Laws	Building codes	
Engineering Skills	Technical Skills			Barry et al
		Design		Olson & Goldberg
			Iteration/Failure	Rendon-Herrero Oswald
			Global problems	Sasley
			Sustainable Design	Manion
		Limitation		Lucena
			Constraints	Passino
			Low-resource	Amadei et al
			Assumptions	Lucena
	Professional Skills			Barry et al
		Team		Toh et al
			multi-disciplinary teams	Felder & Brent
			multi-year team	
			effective practices	Felder & Brent
			accountability	Johnson & Johnson
		Communication		Shuman et al
			community engagement	Ravel et al
		Career Preparation		
Course Frameworks	Learning Frameworks			Felder 1988
		Problem Based Learning		Johnson, Johnson & Smith via Felder
			Real-world experience	Bielefeldt et al
		Cooperative Learning		Johnson & Johnson
			interdisciplinary teams	Johnson & Johnson
			student-led teams	

		Passive Learning		Felder
			Humanist Readings	Bielefeldt et al
			Guest Lectures	
			Lectures	Bielefeldt et al
		Active Learning		Felder
			Debates & Role Playing	Bielefeldt et al
			Discussions	Bielefeldt et al
		Reflective Learning		Felder
			Reflection	Johnson & Johnson
			Think-Pair-Share	Bielefeldt et al
Program Characteristic	Student population size			Budny & Gradoville; Ermillo, Oakes, Bargar
	Project number			Budny & Gradoville, Ermillo, Oakes, Bargar