A SYSEMATIC INQUIRY ON GLOBAL ENGINEERING EDUCATION: STRATEGIES AND IMPACT

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Higher education has increasingly emphasized global education programming as a core piece of its strategic goals over the past few decades, yet little empirical data has been collected to inform the decisions of global programming within the U.S, especially in the engineering discipline. As higher education institutions attempt to formalize their strategies for achieving global competency and invest in internationalizing their engineering programs, research is needed regarding: (1) key global engineering education target areas and their relationship to sustained global programming efforts; (2) programming directions that can be used by universities in general and engineering schools in particular; and (3) how effective programming contributes to students' global competency development. Three separate studies framed in different analytical lenses are employed to address these research objectives.

The first study uses a participatory, integrative mixed-methods approach to develop an operational framework for global strategies, policies, and programs. A thematic, qualitative analysis of semi-structured interviews with a group concept mapping activity was conducted with directors of study abroad and vice provosts of global education from nine universities regarding their global programming strategies, intended outcomes, and organizational resources that support the internationalization process.

Global engineering education research has grown increasingly complex, and of particular importance is related to engineering students' global perspectives. The second study applies finite mixture models to characterize engineering students' global perspective development patterns. Further, the relationship among global perspective patterns, student backgrounds and prior international experiences is explored.

The third study employs data envelopment analysis to investigate how engineering students utilize international experiences in college and the relative efficiency of students' global perspective development. The results are used to identify which international experiences get the most "bang for your buck" and how engineering programs can tailor their international experiences to their student populations.

The results of this research provide both implicit and explicit engineering school-wide global programming strategies and their sustainable development. Triangulating the results from each study informs international engineering education policy makers and scholars, and provides actionable information for program directors to further educate engineering student populations for the 21st century.

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ACKNOWLEDGEMENTS

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This dissertation goes out to all of the people who thought I could do this and to those people who think they cannot (whatever that might be). My Dad used to read this poem to me as a child, and I have never forgotten it:

If you think you are beaten, you are;
If you think you dare not, you don't.
If you'd like to win, but think you can't
It's almost a cinch you won't.
If you think you'll lose, you've lost,
For out in the world we find
Success being with a fellow's will;
It's all in the state of mind.

If you think you're outclassed, you are:
You've got to think high to rise.
You've got to be sure of yourself before
Before you can ever win a prize.
Life's battles don't always go
To the stronger or faster man,
But soon or late the man who wins
Is the one who thinks he can.
-Walter D. Wintle

1.0 INTRODUCTION

Higher education has increasingly emphasized global education as a core piece of its strategic goals over the past decade. Engineers in academia and industry are beginning to recognize the importance of preparing current and future generations of engineers to be successful in the new global economy[1]–[7]. The National Academy of Engineers (NAE) letter *Educating Engineers to Meet the Grand Challenges* commits to providing students with "global and cross-cultural perspectives gained through experiences that promote involvement with globally complex issues in unfamiliar environments, such as semester abroad [8]." However, in 2012 a national survey found that 43% of engineering deans, department heads, and senior faculty believed that international programs were not valued and not promoted at their institutions [9]. Today, universities in general, and engineering programs in particular, are beginning to pay more attention to their students becoming more globally competent. In the 2014-2015 academic year, US students majoring in STEM fields made up 24% of all US study abroad students, a 48% increase in the last five years compared to a 16% increase for all US students [10]. The most recent *Open Doors* report of the Institute of International Education found 5% of U.S. students who studied abroad in 2014-2015 were engineers, compared to less than 3% ten years ago[11]. Thus, global engineering education has increasingly grown over the past decade, requiring investigation into the assessment of programming strategies in terms of student learning and development.

There is now a pervasive belief among educators that success in a global context requires students to acquire specialized knowledge to further augment their skills and attitudes. A particular issue of importance has been engineering students' global competency[3], [12]–[14]. Global competency can be achieved through a wide variety of programs (curricular, co-curricular, and extracurricular) and strategies [15], [16]. As a consequence, engineering programs are beginning to emphasize international education opportunities, investing substantial resources to increase participation, both curricular and co-curricular, with the expectation that students who participate in such experiences will become more globally competent. This, along with increased enrollment in US engineering programs, increased enrollment of women, and increased international partnerships and exchanges, has contributed to an increase in engineering participation in study abroad programs over the recent years [11], [17], [18]. While study abroad programs remain the most popular methods to prepare students for the global workforce [19], engineering schools are beginning to develop a wide variety of international experiences, ranging from credit-bearing, globally focused courses to international internships and research projects.

Although global perspectives and experiences are being developed through a wide variety of initiatives and opportunities, engineering programs have been slow to integrate into a cohesive strategy; and consequently are often operating with limited knowledge regarding the effectiveness of their international program strategies and the organizational capacity for supporting the internationalization process. As higher education institutions continue to invest in internationalizing their engineering programs, research is needed regarding programming target areas, their relationship to sustained programming efforts, and how engineering students' global competency is conceptualized and developed through programming. The following research questions are addressed in this dissertation:

1. *How can universities develop evidence-based, sustainable global programming strategies for undergraduate engineering student populations?*
2. *How are engineering students' global perspectives influenced by backgrounds, international experiences, and college environments?*

1.1 RESEARCH SCOPE

Research in international education has fallen into two major categories: student assessment research and program performance research. Sub-elements of each type include models for international education[1], [7], internationalization of the curriculum [15], [20], [21], programmatic elements of international experiences [22], [23], learning outcomes from international education (types and structures) [24], [25], and global competency development [26] and its assessment [4], [27]. However, there exists a lack of research regarding global engineering programming strategies, target areas, and the impact each has on student development. Additionally, the desire to internationalize engineering programs has focused more on the effectiveness of one-off, co-curricular programs and less on global engineering education as a *system* (composed of learning objectives, strategies, learning environments, student backgrounds, and international experiences). This limits the advancement of sustained global programming efforts and fails to maximize desired educational outcomes [28]. Empirical research is needed to assess the impact of various forms of international experiences and how engineering programs can build and sustain strategies that take advantage of this impact. Thus, this research focuses on the following three areas: (1) strategic planning around global engineering programming; (2) engineering global perspective typologies and their relationships to student backgrounds and experiences, and; (3) the relative impact of the various forms of international experiences on global perspectives.

This dissertation incorporates tools from applied social science research, operations research, applied statistics, and quantitative psychological methods to help inform engineering education policy makers on the essential constructs necessary for implementing and assessing effective global programming strategies. While there is contemporary research that investigates global education offerings, student learning, and higher education policy, there are no studies that triangulate the findings from integrated, yet theoretically diverse research lenses, which this research does. In doing this, it also addresses the need for more evidence-based, actionable research in the field of global engineering education.

1.2 THREE STUDIES ON GLOBAL ENGINEERING EDUCATION

In this section, the overarching framework for the dissertation is described (Figure 1), along with the methods for each individual study contained therein. Then, an overview of the research grant leveraged for two of the three studies is described, as well as the data collection techniques used to measure students' global competency, backgrounds, and past international experiences.

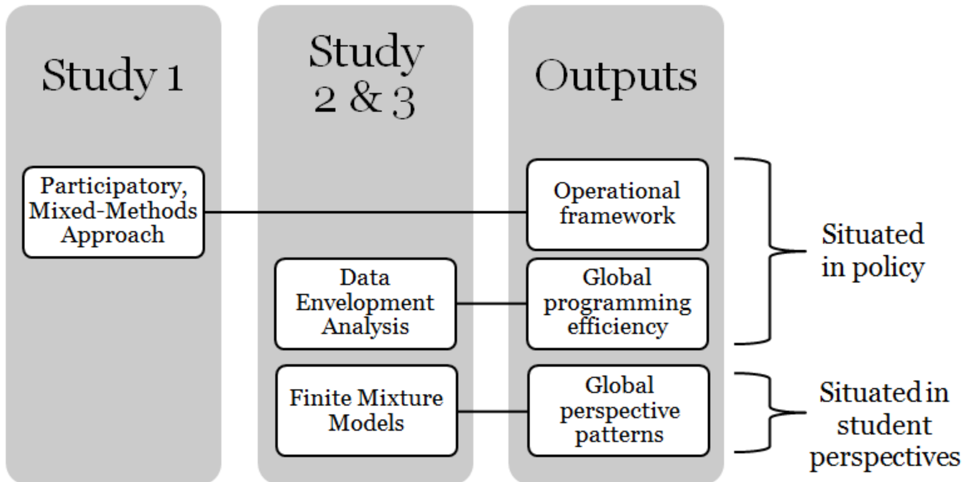


Figure 1. Dissertation Framework

To address the research objectives, three separate studies framed in different analytical lenses are performed to: (1) identify key global engineering education targets areas and their relationship to sustained global programming efforts; (2) explore how effective programming can contribute to students' global competency development; and (3) provide programming directions that can be used by universities in general and engineering schools in particular.

1.2.1 Overarching Framework and Methods

As engineering schools continue to invest in global programming and initiatives, research is needed regarding vital programming target areas and their relationship to sustained programming efforts. Thus, the first study employed a participatory, integrative mixed-methods approach to explore the global programming strategies, intended learning outcomes, and organizational resource used to support the internationalization process. Group Concept Mapping (GCM) was then used to develop an expert-authored, operational framework for global strategies, policies, and programs geared towards engineering schools.

Global engineering education research has grown increasingly complex, requiring investigation into the assessment of global programming strategies in terms of student perspectives and development. Particular importance is on engineering students' global perspectives. In the second study, finite mixture modelling techniques are applied to characterize engineering students' global perspective development patterns. The relationships between global perspectives patterns and student backgrounds are also investigated. A result of this study is collection of global perspective typologies that exist within engineering student populations, the characteristics that describe the typologies, and recommendations for what engineering schools can do to improve the global perspectives of their students.

To provide empirically-based programming directions to engineering schools, the relative impact of experience types on students' global perspectives is sought. As engineering administrators, faculty, and students continue to invest resources into international opportunities, research is needed to identify which experiences get the most "bang for your buck". The third study leverages Data Envelopment Analysis (DEA), an operations research technique that assesses the relative efficiency of decision making units (DMUs) having multiple inputs and outputs. In this case, students are the DMUs, their international experiences are the inputs, and their global perspectives are the outputs. The third study explores the types of international experiences senior students are participating in, the relative efficiency of this participation, and how efficiency is differentiated between experience types and student subgroups.

1.2.2 Description of NSF Grant – Assessing the Spectrum of International Undergraduate Engineering Educational Experiences

This dissertation was motivated by work on an ongoing National Science Foundation (NSF) REE project called *Assessing the Spectrum of International Engineering Educational Experiences* (EEC-1160404) [29], [30]. The purpose of the multi-university (University of Pittsburgh, University of Southern California, Clemson University, and Lehigh University) grant was to investigate how globally focused learning experiences within engineering (both co- and extracurricular) impact students' global preparedness. To enhance students' global preparedness, the project aimed to identify the various ways that global preparedness can be developed in and out of formal curricular, as well as how each approach enhances global preparedness. These objectives were delineated into three separate studies. The first study developed with experts an operational model of engineering global preparedness, establishing constructs of international education learning outcomes. The second study was a mixed-methods experiment among the four collaborating schools that mapped the outcomes to educational practices, institutional characteristics, and student backgrounds. A series of student interviews were conducted to tease out underlying reasons that international experiences contributed to their global preparedness. The third study involved a large cross-institutional quantitative study of 14 engineering schools to analyze the impact of various international experiences.

1.2.3 Data Collection

The data used in this dissertation has two primary sources. The first set of data, used in Study 1, consisted of one-on-one semi structured interviews with subject matter experts (SMEs) from nine institutions regarding their global programming strategies, intended outcomes, and organizational resources. Information from these interviews was coded and distilled into unique global programming strategy statements, which the SMEs sorted and rated to help create the Global Engineering Programming (GEP) Model. The Institutional Review Board at the University of Pittsburgh approved this study (IRB #PRO16020008).

The second set of data was collected under the aforementioned NSF grant, which includes two related data sets. The first set, used in Study 2 of this research, includes quantitative data collected from a grant-developed instrument which consisted of 35 items from the Global Perspective Inventory (GPI) and a set of questions soliciting demographics and prior internationally-related experiences. This instrument was administered to freshmen and senior engineering students across the 13 participating institutions from Spring 2016 to Fall 2016 (see Appendix A). One of the schools from the NSF project was not included due to timing of the data collection, thus Study 2 used 13 of the 14 schools. The second set of data, used in Study 3 of this research, consisted of a subset of the data gathered as mentioned above. As part of the survey, students were asked when they participated in any international experiences, given the options of before college or during college. While the data for Study 2 used all of the student respondent data, regardless of whether they had international experiences or not, Study 3 included those senior students with international experiences **in college only**. The Institutional Review Board at the University of Pittsburgh approved these studies (IRB #PRO16020008 and # PRO15080172; respectively).

1.3 ORGANIZATION OF THE DISSERTATION

The organization of the dissertation is as follows. Chapter 2 provides the overarching literature background for all three studies of this dissertation. It includes five sub-sections on related literature pertaining to the state of global engineering education, defining engineering global competency, the factors that affect global competency, theoretical frameworks on student learning, and the Global Perspective Inventory (GPI) which was used to assess the competency in turn. Chapters 3 through 5 provide the specific background literature, methodology, analyses, results, implications, and discussion for the three studies; i.e., mixed-methods investigation of global programming target areas, quantitative investigation of global perspective patterns, and the DEA analysis on the efficiency of students' experience patterns. Chapter 6 summarizes the research and proposes contributions of this body of work to the literature. Finally, Chapter 7 discusses the limitations of the study and outlines potential future work.

2.0 LITERATURE REVIEW

2.1 STATE OF GLOBAL ENGINEERING EDUCATION

The necessity for engineering global competency has been recognized and spotlighted by both professional and educational engineering communities in conferences, national reports, and publications [31]. The National Academy of Engineering (NAE), the National Science Foundation (NSF), and the National Research Council (NRC) have urged engineering schools to prepare engineers for global workforces [8], [32], [33]. Accreditation bodies and national engineering organizations have also recognized the importance of global education for the success of engineers in today's interconnected world. ABET Inc. first introduced a global element (criterion 3h) into its innovative "EC2000" criteria for undergraduate engineering programs[34] in 1997. The American Society for Engineering Education's (ASEE) Green Report has called for engineering schools to adapt curricula and programs to incorporate "an appreciation of different cultures and business practices, and the understanding that the practice of engineering is now global" [31]. As a result, many universities have begun to embrace global education at the institutional level, yet there exists a gap between rhetoric and practice regarding global engineering programming at the school and department level, partially due to financial and logistic constraints for sending students abroad [41].

As such, many engineering programs have yet to emphasize global education programming as a core piece of their strategic goals over the last decade. In the NSF project "Creating a Culture for Scholarly and Systematic Innovation in Engineering Education", Jamieson and Lohmann found that international programs are not widely promoted, and nearly half of the faculty committees rated international programs as not important (Figure 2) [9]. It appears that many engineering administrators and faculty value traditional learning environments and put less emphasis on global programming as a strategic effort.

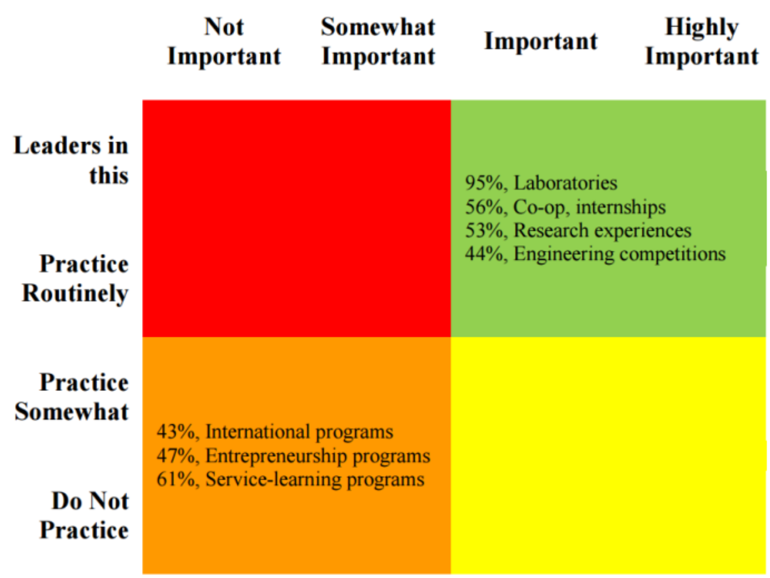


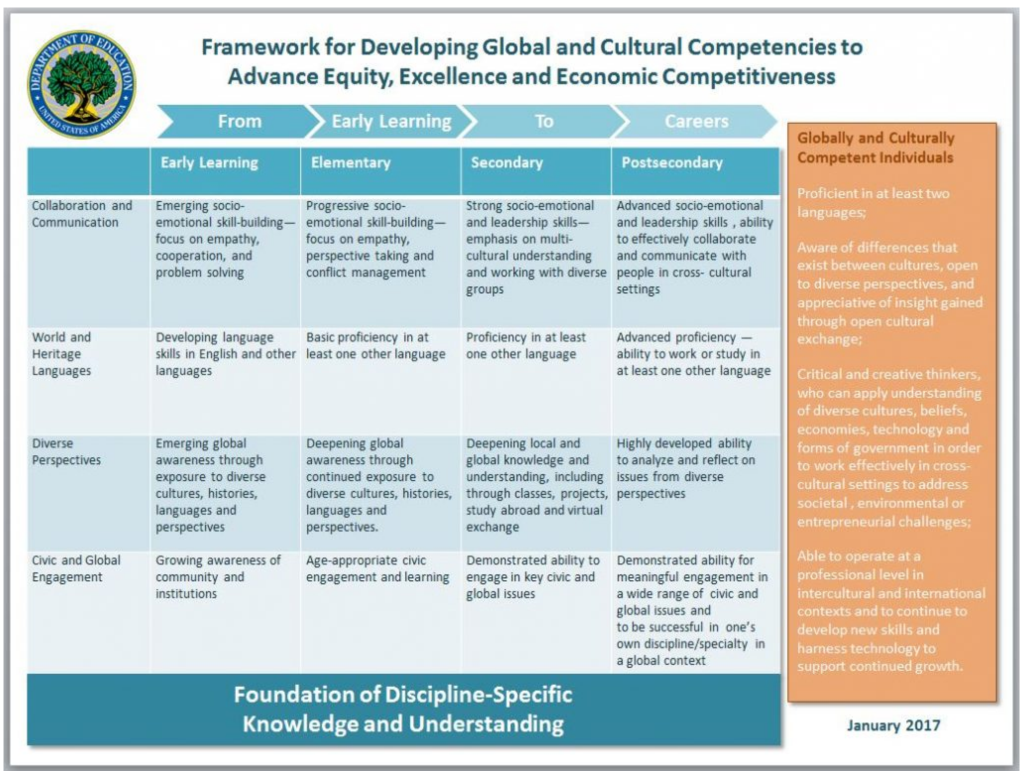
Figure 2. Undergraduate learning environments [9]

Mestenhauser argues that the global programming in general has focused too much on isolated projects and programs, which target far fewer students than a cohesive strategy would otherwise [36]. Study abroad programs remain the most prevalent method to incorporate global programming into an engineering curriculum [19]. Yet, there are constraints on these programs that make it difficult for all students to be involved. Challenges such as a highly sequenced curriculum, high implementation costs for institutions, risks in delaying graduation, transferring credits, and finding suitable partners indicate that a more comprehensive, and operational approach to global engineering programming is necessary to meet the changing needs of society [7].

2.2 ENGINEERING GLOBAL COMPETENCY

Post-secondary institutions have attempted to instill in students the “global competency” skills necessary to successfully engage, compete, and thrive in an increasingly diverse and globally interconnected world [37]. Yet, not enough has been done by U.S. universities to normalize global education. Before engineering schools can develop globally competent students, global competence must be operationally defined. The ultimate definition of such terms including global competence [1], [6], global preparedness [27], intercultural competence [37], intercultural maturity [38], and the various other terms prevalent in the literature [39], might be impossible. These terms are often bounded by disciplinary context and philosophical leanings, influenced by people and goals [40], [41]. Defining and measuring global competency has proven to be difficult, generating increasingly divergent approaches that have made reaching a consensus troublesome among scholars. However in most cases, conceptualizations of global competency differ more in terminology than in substance.

Many have attempted to instead develop conceptual frameworks for global competency or some version of it [39], [40], [42]. The U.S. Department of Education most recently produced a framework for ‘Developing Global and Cultural Competencies to Advance Equity, Excellence and Economic Competitiveness’ (Figure 3). This framework builds on existing research and details the development of global competencies beginning in early childhood. The framework, in part, includes attributes such as: proficiency in at least two languages; awareness of differences that exist between cultures and appreciation of insight gained through open cultural exchanges; understanding of diverse cultures, beliefs, economies, technology, and forms of government in order to work effectively in cross-cultural settings; and the ability to operate at a professional level in intercultural and international contexts [43].



Framework for Developing Global and Cultural Competencies to Advance Equity, Excellence and Economic Competitiveness

From > Early Learning > To > Careers

	Early Learning	Elementary	Secondary	Postsecondary
Collaboration and Communication	Emerging socio-emotional skill-building—focus on empathy, cooperation, and problem solving	Progressive socio-emotional skill-building—focus on empathy, perspective taking and conflict management	Strong socio-emotional and leadership skills—emphasis on multi-cultural understanding and working with diverse groups	Advanced socio-emotional and leadership skills , ability to effectively collaborate and communicate with people in cross- cultural settings
World and Heritage Languages	Developing language skills in English and other languages	Basic proficiency in at least one other language	Proficiency in at least one other language	Advanced proficiency — ability to work or study in at least one other language
Diverse Perspectives	Emerging global awareness through exposure to diverse cultures, histories, languages and perspectives	Deepening global awareness through continued exposure to diverse cultures, histories, languages and perspectives.	Deepening local and global knowledge and understanding, including through classes, projects, study abroad and virtual exchange	Highly developed ability to analyze and reflect on issues from diverse perspectives
Civic and Global Engagement	Growing awareness of community and institutions	Age-appropriate civic engagement and learning	Demonstrated ability to engage in key civic and global issues	Demonstrated ability for meaningful engagement in a wide range of civic and global issues and to be successful in one's own discipline/specialty in a global context

Foundation of Discipline-Specific Knowledge and Understanding

Globally and Culturally Competent Individuals

Proficient in at least two languages;

Aware of differences that exist between cultures, open to diverse perspectives, and appreciative of insight gained through open cultural exchange;

Critical and creative thinkers, who can apply understanding of diverse cultures, beliefs, economies, technology and forms of government in order to work effectively in cross-cultural settings to address societal , environmental or entrepreneurial challenges;

Able to operate at a professional level in intercultural and international contexts and to continue to develop new skills and harness technology to support continued growth.

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Figure 3. US Department of Education framework for 'Developing Global and Cultural Competencies to Advance the Equity, Excellence, and Economic Competitiveness [43]

Of particular importance is the work conducted by Bennett in the area of "intercultural sensitivity" and the underlying framework called the Developmental Model of Intercultural

Sensitivity (DMIS) [44]. The DMIS was created to explain how people construe cultural differences, with the underlying assumption that as one's experience of cultural difference becomes more complex and sophisticated, one's potential competence in intercultural relations increases [44]. Bennett identified six orientations that people move through in their acquisition of intercultural competence: *Denial, Defense Reversal, Minimization, Acceptance, Adaption, and Integration* (Figure 4). The first three DMIS orientations are conceptualized as more ethnocentric, meaning that one's own culture is experienced as central to reality. This can be seen as ways of avoiding cultural difference, either by denying its existence, raising defenses against it, or by minimizing its importance. The second three DMIS orientations are defined as more ethnorelative, meaning that one's own culture is experienced in the context of other cultures. These orientations reflect ways of seeking cultural difference, either by accepting its importance, adapting perspective to take it into account, or by integrating the whole concept into a definition of identity.

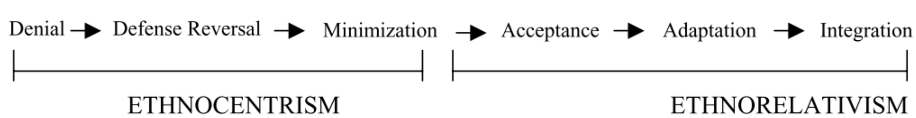


Figure 4. Developmental Model of Intercultural Sensitivity (DMIS) [44]

Engineering global competency research on the other hand has mostly involved developing a list of attributes or skills deemed important or essential for global engineering work. Downey et al. discuss global competency in terms of being able to work effectively with people who define problems differently [3]. Parkinson further identified 13 dimensions of global competence among engineering graduates based on the literature and personal experience [1].

The most important attributes of a globally competent engineer were found to be appreciating other cultures, proficiency working in a team of ethnic and cultural diversity, ability to communicate across cultures, and dealing with ethical issues arising from cultural differences. Warnick has also created a list of eight global competency attributes for engineers, with many of the aforementioned competencies being valued by industry, including appreciation and understanding of different cultures, ability to work on international teams, and cross-cultural communication skills [5], [14]. As part of the work by Jesiek et al. on situations and behaviors of globally competent engineers, a task force defined a globally competent graduate as one who has the ability to "work effectively with colleagues across national, cultural, and ethnic boundaries" [45]. His team conceptualized this definition through the Global Competency Pyramid (Figure 5) which highlights intercultural knowledge, communication, development, and effectiveness [45]. As an alternative to defining global competence, Besterfield-Sacre et al. developed an operational framework for engineering global preparedness using a Delphi method with experts in academia and industry (Figure 6) [26].

Figure 5. Global Competency Pyramid [45]

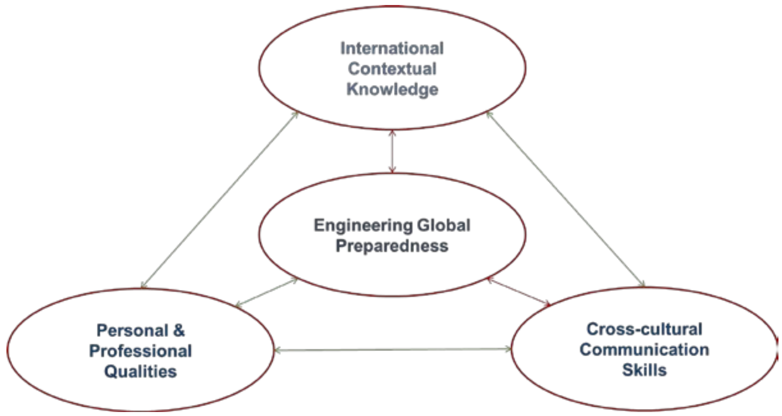


Figure 6. Semantic Map of Engineering Global Preparedness [26]

Though many scholars have attempted to identify the necessary knowledge, skills, and attributes of global competency (or some version of it), this study leverages the work of Braskamp, Braskamp, and Enberg on global perspectives [46], [47]. The dimensions that define a global perspective are derived from holistic student development theory [38], [48]. The Global Perspective Inventory (GPI), a nationally normed and extensively tested instrument, was used in this study to measure engineering students' global perspective, a proxy measure for global competency used throughout this paper.

2.3 THE GLOBAL PERSPECTIVE INVENTORY

The GPI measures how students think, how they view themselves as people with a cultural heritage, and how they relate to those from other cultures, backgrounds, and values. A global perspective is defined to include the acquisition of knowledge, attitudes, and skills important to intercultural communication and the development of more complex epistemological processes, identities, and interpersonal relations. The GPI includes 35 items and uses a 5-point Likert-type agreement scale. The GPI identifies three major dimensions of human development: Cognitive, Intrapersonal, and Interpersonal. Table 1 illustrates GPI sample items by selected dimension. The full list of items can be found on www.gpi.hs.iastate.edu.

Table 1. GPI Sample Items by Selected Dimensions [47]

Dimension	**Sample Index Item**
Cognitive	I take into account different perspectives before drawing conclusions about the world around me I can discuss cultural differences from an informed perspective
Intrapersonal	I put my beliefs into action by standing up for my principles. I am sensitive to those who are discriminated against.
Interpersonal	I frequently interact with people from a race/ethnic group different from my own. I think of my life in terms of giving back to society

The items in the GPI address the following critical questions related to human development: How do I know? Who am I? How do I relate? [46], [47]. The **Cognitive** dimension of global perspective examines “epistemological processes used to evaluate and make meaning of different knowledge sources” [50] as well as the “acquisition of knowledge to enlarge one’s understanding of cultural differences” [51], [52]. The **Intrapersonal** dimension emphasizes “how identity development parallels the process of acquiring greater intercultural sensitivity” [53] and how one integrates one’s personal values into one’s personhood and how one becomes aware of this process. The **Interpersonal** dimension reflects “the interdependent nature of a global society, emphasizing the need to interact across difference and make socially responsible commitments to local, national, and global communities” [38], [54]. Each GPI dimension contains subscales based on two different holistic human development perspectives: the theory of cultural development and intercultural communication theory (Table 2).

Table 2. GPI Dimensions and Subscales [47]

Dimension	Subscale	α*	Description
Cognitive	**Knowing**	0.66	Degree of complexity of one's view of the importance of cultural context in judging what is important to know and value
	Knowledge	0.77	Degree of understanding and awareness of various cultures and their impact on our global society and level of proficiency in more than one language
Intrapersonal	**Identity**	0.74	Level of awareness of one's unique identity and degree of acceptance of one's ethnic, racial, and gender dimensions of one's identity
	Affect	0.73	Level of respect for and acceptance of cultural perspectives different from one's own and degree of emotional confidence when living in complex situations, which reflects an "emotional intelligence" that is important in one's processing encounters with other cultures
Interpersonal	**Social Responsibility**	0.73	Level of interdependence and social concern for others
	Social Interaction	0.70	Degree of engagement with others who are different from oneself and degree of cultural sensitivity in living in pluralistic settings

*Cronbach's alpha is an estimate of the reliability of a test's scores and score interpretation

Braskamp and colleagues have collected a large sample of college student GPI scores, which can be taken as national norms (Table 3) [47]. Based on a very large sample of college students, there is an upward trend in only three of the six subscales – knowing, affect, and social responsibility. These norms are based on a sample of about 20,000 undergraduate students from mostly liberal arts universities and include less than 15% engineering students. Further, it is biased by a large majority of female students who have been shown to score higher on the GPI [55]. These subscale norms and their trends will be used as a frame of reference as the GPI scores for engineering students are explored.

Table 3. Average Scores of GPI Subscales by Class Standing [47]

Scale	Freshmen	Sophomore	Junior	Senior	Average
Cognitive Dimension	**3.56**	**3.61**	**3.63**	**3.67**	**3.62**
Knowing	3.51	3.65	3.68	3.70	3.63
Knowledge	3.62	3.56	3.57	3.63	3.60
Intrapersonal Dimension	**4.07**	**4.07**	**4.09**	**4.12**	**4.09**
Identity	4.05	4.01	4.03	4.07	4.04
Affect	4.10	4.15	4.16	4.17	4.14
Interpersonal Dimension	**3.57**	**3.55**	**3.54**	**3.57**	**3.56**
Social Responsibility	3.69	3.71	3.73	3.74	3.72
Social Interaction	3.42	3.35	3.30	3.36	3.36

2.4 FACTORS AFFECTING GLOBAL PERSPECTIVES

It is posited that global perspectives are influenced primarily by student backgrounds, prior experiences, and the learning environments promoted by universities and engineering schools (programming policies, programs, and strategies). An increasing number of engineering faculty have anecdotally recognized (and have agreed upon) the impact international programs have on students' ability to develop skills such as problem solving, cross-cultural communication, and working effectively with culturally diverse teams. However, the extent to which various experiences benefit students remains unanswered. McKeown echoes similar beliefs in his book *The First Time Effect: The Impact of Study Abroad on College Student Intellectual Development*, indicating that previous international experiences and family backgrounds can lead to greater perceived levels of global competency [56]. Salisbury, An, and Pascarella explored the impact of study abroad on intercultural competence and found that although international experiences such as study abroad can contribute to gains on measures of intercultural competence, the nature of these gains is dependent on precollege characteristics, institutional differences, and college experiences [57]. Kilgo, Sheets, and Pascarella found that "high impact" educational practices such as study abroad only modestly enhanced intercultural effectiveness and openness to diversity [58]. Much research around the effects of study abroad on global perspectives is limited in a couple of ways. First, seeking the influence of abroad experiences immediately upon completion undermines the longitudinal and developmental nature of global perspective development as outlined in the DMIS and the theoretical framework of the GPI. Second, this body of research does not account for student background and how that affects this development [57]. Salisbury found that students with high precollege intercultural competence scores were more likely to study abroad, suggesting that the students who might benefit the most from studying abroad are less likely to participate. So while abroad experiences have traditionally been perceived as the primary way for students to become more globally competent (especially in the engineering discipline), research has shown that comprehensive and holistic global programming strategies are a more effective approach to promoting global competencies[21], [59]. To this end, this dissertation in part explores the nature of global perspective development among engineering students by taking into account the various experiential and background variables of the students.

2.5 THEORETICAL FRAMEWORKS

While previous studies have focused on the effect that study abroad experiences have on student perspectives, the engineering education community's understanding remains limited about holistic global perspective development, the factors that affect this development, and the specific actions educators can take to foster this development. The guiding framework for this study combines empirically grounded conceptual models of global perspective development and experiential impact research; namely, Pascarella's general model for assessing the effects of differential environments on student learning and cognitive outcomes [60] and Astin's Theory of Student Involvement [61].

Research on student learning generally has ignored the joint effects of student precollege traits and institutional/program characteristics [60]. Pascarella's model examines the direct and indirect effects of different college environments on student learning and cognitive development (Figure 7). This model emphasizes a systems perspective that accounts for the range of different individual and institutional influences that shape student development [62]. Pascarella suggests that student growth and development are affected by students' backgrounds, university and college characteristics, campus culture, socializing agents (faculty and peers) on the campus, and the quality of effort put forth by students. The effects of student backgrounds are posited to have more influence on learning and cognitive development than any other variable in the model.

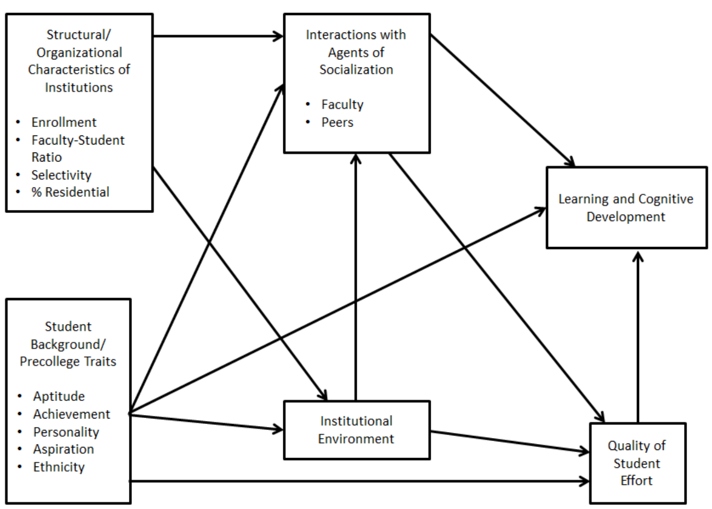


Figure 7. Pascarella's Model for Assessing the Effects of College Environments on Student Learning and Cognitive Development [60]

Student involvement theory has been explored for many decades [61], and the premise is simple: students learn from what they *do* in college. The other important aspect to student involvement theory is institutional policies and practices influence levels of involvement on campus. Research has shown that the relationship between student backgrounds and involvement during college was low [63]. Astin argued that the "effectiveness of any educational policy or practice is directly related to the capacity of that policy or practice to increase student involvement." The core concepts of Astin's theory, published in 1984, includes student "inputs" such as their demographics and prior experiences, student "environments" which accounts for experiences during college, and student "outcomes" which cover a student's knowledge, values, and perspectives [61]. Researchers have continued to study student involvement, finding that co-curricular activities such as student organizations, leadership positions, and campus activity have a positive correlation with retention and academic achievement. Thus, universities have since encouraged students to become involved. This model, as well as Pascarella's model, has been applied in various intercultural competence contexts.

Figure 8 outlines the hypothesized model for the global perspective development system that is being used to guide this research study.

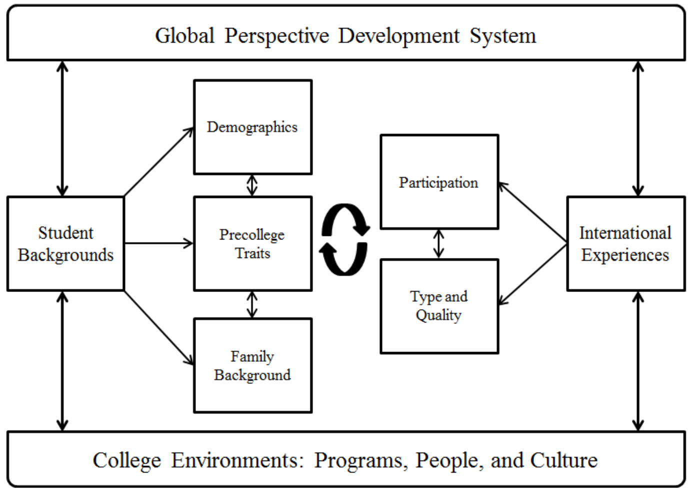


Figure 8. Global Perspective Development System

This dissertation posits that global perspective development among undergraduate engineering students is influenced by student backgrounds, pre-college experiences, and participation and involvement in curricular, co-curricular, and extracurricular international experiences during college. It is also hypothesized that student backgrounds and pre-college experiences generate statistically significant effects on global perspectives, and are correlated with student involvement in international experiences while in college.

3.0 STUDY 1 – DEVELOPMENT OF OPERATIONAL MODEL

This study draws on a participatory, integrative mixed-methods approach that combines qualitative and quantitative data from engineering programs across the U.S. A thematic, qualitative analysis of semi-structured interviews was conducted with subject matter experts (SMEs) from nine institutions regarding their global programming strategies, intended outcomes, and organizational resources that support these efforts. To further investigate global programming strategies, Group Concept Mapping (GCM) [64] was used to develop an expert-authored operational framework for global strategies, policies, and programs geared towards engineering schools. GCM is a mixed-methods approach for organizing the ideas of a group of stakeholders and aiding in the development of a conceptual framework that can be used for planning and evaluation[65]. This approach helped the SMEs describe global engineering programming target areas and represent these areas visually through a series of related two-dimensional maps. In doing so, this study provides an empirically-based Global Engineering Programming (GEP) model that can be used by universities in general and engineering programs in particular. The following questions are addressed in this research:

1. *What are key global engineering education target areas and their relationship to sustained programming efforts?*
2. *What target areas are most useful in developing sustained school-wide global programming strategies?*

This work was motivated by the interest of universities and engineering programs to build comprehensive and sustainable global programming strategies. Producing successful engineering graduates requires a systematic and intentional approach to internationalization efforts[20]. Results from this relational study map out explicit and implicit programming strategies and provides actionable information to engineering schools on how to prepare current and future engineering student populations for the global economy.

3.1 BACKGROUND LITERATURE

3.1.1 Group Concept Mapping and Its Applications

Group Concept Mapping (GCM) is a structured conceptualization method designed to organize and represent ideas from an identified group [66]. This methodology has demonstrated value in addressing a variety of practical and theoretical questions [67]. GCM is defined as "a methodology that creates a stakeholder-authored visual geography of ideas from many communities of interests, combined with specific analysis and data interpretation methods, to produce maps that can be used to guide planning and evaluation efforts on issues that matter to the group" [65].

GCM involves five steps (Figure 9): idea generation, idea reduction, sorting and ranking ideas, compute maps, interpret and utilize maps. GCM integrates both group process such as brainstorming and unstructured sorting with multivariate statistical methods of multidimensional scaling and hierarchical cluster analysis[68]. GCM helps a group of stakeholders articulate their ideas and represent them in a variety of visual results. The output of GCM is a series of stakeholder-driven visual diagrams that show the relationship between ideas that are taken from qualitative studies (e.g., semi-structured interviews, Delphi studies)[69].

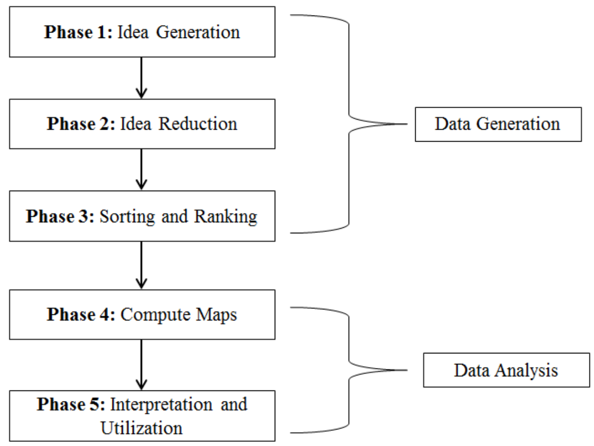


Figure 9. Group Concept Mapping Framework [70]

GCM has been applied in a number of fields over the last two decades, such as business [71], public health [72], energy policy [68], and many others [73]–[75] . Within the higher education space, GCM has been used in the development accreditation standards for graduate programs[76], the development of learning goals for university departments [77], the examination of issues and barriers for adopting technology into faculty instruction [70], and the investigation into engineering students' global workforce perceptions [69]. GCM is used in this study to create an operational framework for global strategies, policies, and programs, and to describe the relationship of the target areas of the framework therein.

3.1.2 The Spectrum of Global Engineering Programming Strategies

While previous studies have focused on “internationalizing the curriculum”[28], [78], [15], the engineering education community’s understanding of global engineering programming remains limited about the strategic actions administrators and faculty can take to prepare students to be successful in the global work environment. According to the Center for Internationalization and Global Engagement (CIGE), internationalization refers to “the efforts of institutions to meet global challenges by incorporating global perspectives into teaching, learning, and research; building international and intercultural competence among students, faculty, and staff; and establishing relationships and collaborations with people and institutions abroad”. An adapted version of CIGE’s Model for Comprehensive Internationalization was used to better understand the scope of GEP strategies and to guide the SMEs responses during the semi-structured interviews. Because the focus of the study is on engineering programs, the CIGE model was adapted to reflect the target areas controllable at the department and school level in engineering (Figure 10).

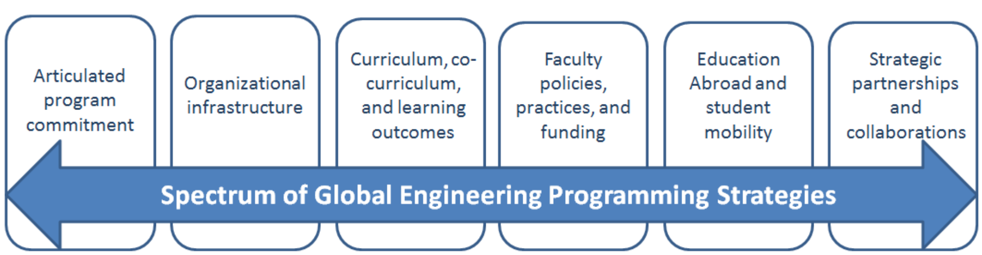


Figure 10. Adapted Model for Comprehensive Internationalization [79]

The initial spectrum of GEP consists of the following six elements.

1. **Articulated program commitment –** mission statements, strategic plans, and formal assessment mechanisms
2. **Organizational infrastructure –** reporting structures, staffing levels and configurations
3. **Curriculum, co-curriculum, and learning outcomes –** general education and language requirements, co-curricular activities and programs, and specified learning outcomes
4. **Faculty policies, practices, and funding –** hiring guidelines, tenure and promotion policies, faculty development opportunities and provisions
5. **Education abroad and student mobility –** study abroad programs and international student recruitment and support; and
6. **Strategic partnerships and collaborations –** joint-degree or dual/double degree programs, branch campuses, and other offshore programs.

3.2 RESEARCH APPROACH

To examine global engineering programming target areas, a participatory, integrative, mixed-methods approach was employed across multiple universities. The study began with semi-structured interviews that covered GEP resources, strategies, outcomes, and assessment (Appendix B). The interviews were thematically coded based on a deductive coding schema, informed by global programming logic model areas and prior research on institutional change. Particular focus was put on the strategies discussed throughout the interview. Next, the research team unitized the GEP strategy statements into a list of unique GEP strategies, which was used as the focus for the content and structure of the GEP concept mapping activity. Finally, the resulting concept map, related analyses, and interview data were used to create an operational model for GEP that represents the strategic practices that support sustained GEP efforts.

The GCM process structured the methodological approach for this study. As previously noted, GCM involves five major steps [65], [67], which is represented in Figure 9. Each step is described in the following subsections.

3.2.1 Case Selection

Multiple universities and job roles were selected due to the contextual variation in global education practices and to capture the perspectives of different types of people in the global education space. Universities and their engineering programs were purposively sampled by non-randomly selecting a broad range of engineering programs that were likely to reflect the full GEP spectrum. A mix of public and private institutions was selected based on their variety of global programming efforts, geographical location, variety in student populations, the existence of established international programs and people who run them. Out of the 15 universities that were selected, 9 participated in the study. Two SMEs were interviewed from the University of Pittsburgh, where the study was conducted. Table 4 includes the summary of background information of the 10 SMEs and their universities. Organizational structure refers to the administrative structure of the global activities and programs at the institution. Information about each SME can be seen in Appendix C.

Table 4. Background Information of Subject Matter Experts (N=10)

Job Role	**n**
Directors of Study Abroad	6
Vice Provosts of International Education	4
Organizational Structure	
Centralized	6
Decentralized	4
Presence of Internationalization Strategic Plan	
Yes	6
In-Development	3
No	1
School Size*	
Large	5
Medium	5
Control*	
Public	7
Private	3

*Defined according to Carnegie Classification of Institutions of Higher Education

3.2.2 Data Collection

One-on-one semi-structured interviews were conducted by the author, either in person or via the phone. Each interview lasted approximately 60-90 minutes, was audio recorded, and transcribed verbatim. The interviews focused on GEP strategies at their institution and within the engineering programs, along with essential resources, outcomes, and assessment of those outcomes. The SMEs were informed and guided by the adapted CIGE Model for Comprehensive Internationalization. The interview protocol contained only open-ended questions [80], and was supported with prompts when necessary. The interview protocol can be viewed in Appendix B. The salient interview questions were:

1. Tell me about the global programming strategies that have been adopted at your school. These can be either explicit or implicit. What makes these strategies different from other colleges and/or institutional strategies?

2. How do schools move away from one-off programs to creating a committed and sustained school-wide global programming strategy?"
3. What conditions and/or factors need to be considered when adopting global engineering programming strategies? How can schools develop a more articulated GEP strategy?

3.2.3 Distilling GEP Strategies

The responses to the interview questions above were used to create the units of analysis for the GCM process. A unit of analysis consists of a sentence or phrase containing only one concept. The responses were unitized by breaking sentences (and paragraphs) into single concept phrases that are distinct from one another. For example, one response was, "Our unwritten strategy focuses on creating a series of attractive, short-term programs to increase participation…and to augment that with the number of students who go on semester long programs. We have also focused on providing students with international research opportunities over the summer." This response was broken into three separate units: (a) Create a series of attractive, short-term programs to increase participation, (b) Increase the number of students who go on semester long programs, and (c) Provide students with international research opportunities over the summer. This was done for all the relevant responses across the 10 interviews and resulted in 90 unique statements, which is a manageable number according to a meta-analysis that studied GCM research over the past 20 years[66]. Additionally, the authors ensured that each statement was understandable and syntactically similar for ease of sorting and rating in subsequent steps. The full list of statements can be seen in Appendix D.

3.2.4 Sorting and Rating Statements

Concept Systems, Inc. [64] was used to create an online platform to organize, collect, and analyze data from multiple universities simultaneously. The SMEs were asked to sort the 90 statements into piles based on perceived similarity in theme or meaning, and asked to create a label for each of their piles. Specific constraints were included in the instructions including: (1) Do not create piles according to priority or value, (2) Do not create piles such as “Other” that group together dissimilar statements, and (3) Do not sort a statement into multiple piles. Sorting concepts in this manner allowed for a web of concept relationships to be represented by the people immersed in the environment, instead of introducing the arbitrary biases of the researchers[81]. Additionally, instructing sorters to create their own categories helps ensure that categories are exhaustive (a common threat to external validity).

The SMEs were then asked to rate each statement on a five-point Likert-type scale based on three measurable variables: usefulness, likelihood of success, and priority. In this context, “likelihood” does not refer to statistical probabilities, but instead a subjective measure of whether strategies can work at an institution. Specifically, the rating prompts were as follows:

1. Rate each strategy based on *usefulness in terms of developing comprehensive international programs and strategies*, where 1= Not useful, 5=Very useful
2. Rate each strategy based on the *likelihood of success at your institution*, where 1=Extremely unlikely, 5=Extremely likely
3. *If all strategies were feasible at your institution*, rate each strategy based on priority for strategic planning purposes, where 1=Not a priority, 5=Essential

The SMEs were directed to think of the relative value of each of the variables associated with each statement (i.e., all statements cannot be “Very useful” or “Extremely unlikely”). The rating step happened after the sorting step to disallow the grouping of statements based on the variables.

3.3 DATA ANALYSIS

3.3.1 Multidimensional Scaling and Clustering

Quantitative approaches were applied to convert the sorted and rated statement data into a visual point map representing individual statements. The main strength that GCM offers to validity is that it uses multidimensional scaling and cluster analysis to represent the similarity judgements of multiple coders [70]. This allows meaning and relationships to emerge by aggregating the ‘biases’ or ‘constructions’ of many. Multidimensional scaling (MDS) was performed based on aggregated individual understanding of the responses. A 90 x 90 binary, square matrix was created for each SME where rows and columns represent the statements. The cell values represents whether (1) or not (0) a pair of statements was sorted by that SME into the same pile. Then, the similarity judgements were combined by adding all 10 of the individual matrices together. From the resulting matrix, MDS was used to create a two-dimensional point map of Euclidian distances between the statements based on the aggregate sorts by the SMEs (Figure 11).

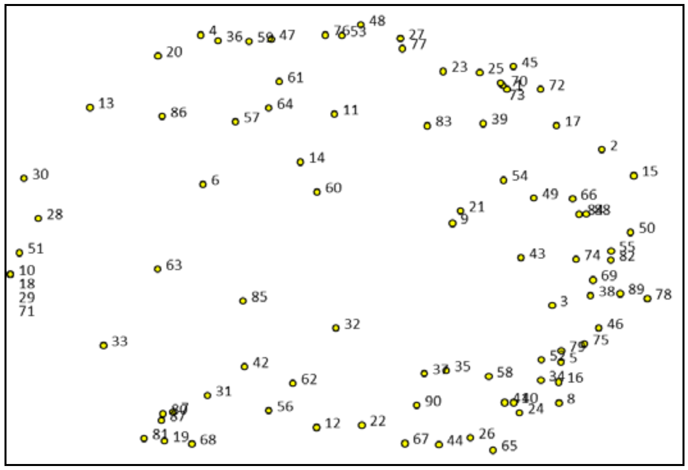


Figure 11. MDS Point Map of Statements

The distance between the points represents the estimates from MDS of how similar the statements are judged to be by the SMEs. Only the distance between points is important, not the position of the points themselves. A key internal validity measure in MDS is the "stress index"[65]. Stress measures the degree to which the distances on the map are discrepant from the values in the aggregate similarity matrix, with lower values suggesting overall better fits. The stress value for Figure 11 is 0.3005, well within acceptable range for GCM[65], [82].

3.3.2 GEP Framework

In creating the GEP framework, an agglomerative hierarchical clustering analysis of the MDS coordinates from the point map using Ward's algorithm [65] was employed. This approach yielded non-overlapping partitions on the point map. The resulting 'cluster map' divided the point map into conceptual clusters based on the similarity of concepts. The final number of clusters was determined using a sequential process of generating versions of the concept map with a change of one cluster per version. The lower and upper bound of the number of clusters considered was determined by the minimum and maximum number of clusters created by the SMEs. Consequently, concepts maps ranging from 5 clusters to 11 clusters were considered.

3.3.3 Concept Map Description

A 7-cluster solution was selected because it produced the richest, most differentiated and robust understanding of the target areas of GEP. Each cluster was labeled based on the predominant GEP idea and the SME suggested labels (see Figure 12).

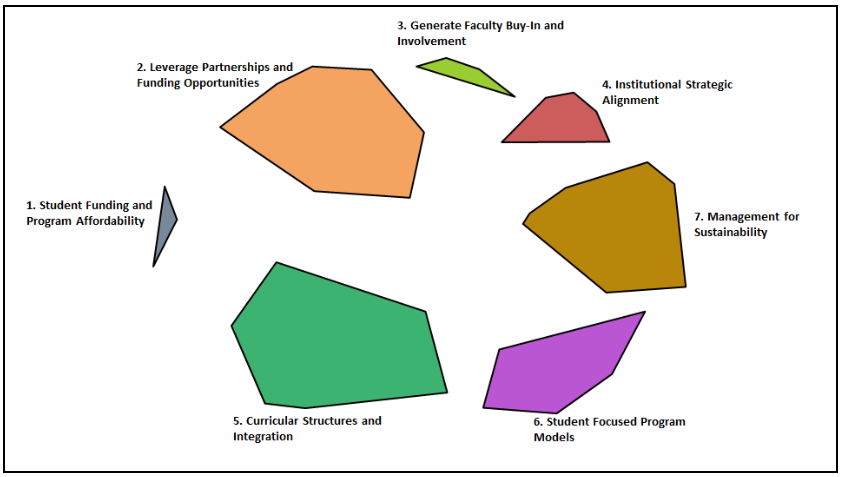


Figure 12. Cluster Map of GEP Strategies

Overlaid on this was an analysis of the ratings provided by the SMEs. An average rating for each strategy was calculated for each metric, along with average cluster ratings for each metric. In Table 5, average cluster ratings are shown along with the total number of statements per cluster. The entire list of statements, broken down by cluster membership and rating, can be seen in Appendix D.

Table 5. Description of GEP Target Areas

Cluster	GEP Target Area	# of statements	Usefulness	Likelihood of Success	Priority
1	Student Funding and Program Affordability	7	4.16	3.73	3.73
2	Leverage Partnerships and Funding Opportunities	6	3.54	3.39	3.36
3	Generate Faculty Buy-In and Involvement	19	4.03	3.47	3.72
4	Institutional Strategic Alignment	9	3.77	3.52	3.66
5	Curricular Structure and Integration	16	3.75	3.39	3.29
6	Student-Focused Program Models	14	3.72	3.63	3.61
7	Management for Sustainability	19	3.42	3.34	3.27

The three rating measures were all correlated above r = 0.8. Thus, a combination, rank-order measure was established for each cluster (and strategy statement) using mean normalization techniques for each rating variable. Normalized ratings were obtained by dividing every statement rating value by the overall mean of that rating within the cluster. Then those normalized ratings were summed together across the ratings to get an overall importance index. This index represents GEP areas and strategies within that are considered (relatively) the most useful, have the highest likelihood of success, and should be given priority during strategic planning. Tables 6 and 7 display the importance indices for each GEP area, and include the top three strategies for each GEP area, respectively.

Table 6. Rank-Order of Importance Indices

Normalized Ratings	Usefulness	Likelihood of Success	Priority	Importance Index
Student Funding and Program Affordability	1.10	1.07	1.06	3.23
Generate Faculty Buy-In and Involvement	1.07	0.99	1.06	3.12
Student Focused Program Models	0.99	1.04	1.03	3.05
Institutional Strategic Alignment	1.00	1.01	1.04	3.05
Curricular Structure and Integration	1.00	0.97	0.93	2.90
Leverage Partnerships and Funding Opportunities	0.94	0.97	0.95	2.86
Management for Sustainability	0.91	0.96	0.93	2.79

The clusters were rank-ordered based on their overall importance index. This breakdown provides a better understanding of where individuals in GEP at their institution can and should focus, and also helps sequence GEP planning in general. The most important GEP target areas consist of **Student Funding and Program Affordability** and **Generating Faculty Buy-In and Involvement**. These areas are the most useful in developing sustainable GEP strategies, have the highest likelihood of success, and should be given priority during the strategic planning process. Specifically, providing scholarships (based on financial need and diversity) and subsidies for students to go abroad; and creating sustainable programs by increasing the number of faculty and staff involved in global programming and encouraging active engagement in those programs.

Student-Focused Program Models and **Institutional Strategic Alignment** include offering global internship programs and short-term, faculty-led programs that are related to topics of interesting to engineering students and that fulfill engineering requirements. These target areas also emphasize designing programs that are consistent with college/institutional missions/goals and establishing strategic partnerships with international universities that can help support GEP efforts.

Curricular Structures and Integration and **Leveraging Partnerships and Funding Opportunities** include framing global programming as a core educational piece, rather than as an alternative to education. To do this, global programming should be made part of the curriculum by integrating into the majors and offering different price points to give students more options for the type of international experience for which they are most ready. Additionally, these target areas stress changing the culture of GEP by providing support to faculty to help them grow international curricula and strategic partnerships. The SMEs also point out the benefits of leveraging external and local partnerships to help build internships and research opportunities abroad.

The last and relatively least important target area is **Management for Sustainability**. The contents and relationships of this area does not imply they are unimportant. Rather, the GEP target areas described above are relatively more important than managing for sustainability. The importance of all of the GEP target areas is directly related to what areas are being supported and which ones need more attention. **Management for Sustainability** includes creating a GEP portfolio that meets a variety of student needs which may include establishing flagship programs to attract faculty and student interesting and moving past traditional study abroad models which have scalability and involvement issues.

Table 7. Most important strategies within each GEP target area

ID	Statement	Importance Index*
Cluster 1: Student Funding and Program Affordability		
10	Provide scholarships to go abroad based on financial need	3.54
18	Provide subsidies for students to help offset the cost of studying abroad	3.49
71	Provide scholarships to go abroad based on diversity (e.g., minorities, females, new locations, new majors)	3.15
Cluster 3: Generate Faculty Buy-In and Involvement		
27	Create sustainability by having many faculty and staff involved in global programming efforts	3.23
48	Encourage faculty engagement in global programming	3.24
53	Generate faculty buy-in	3.15
Cluster 6: Student Focused Program Models		
35	Increase the number of short-term, faculty-led offerings that fulfill engineering requirements	3.37
37	Offer global programs and activities that students care about	3.48
67	Offer global internship programs	3.51
79	Develop thematically-based programs that are related to topics of interest to engineering students	3.34
Cluster 4: Institutional Strategic Alignment		
17	Design global programs that are consistent with institution/college, and/or program missions	3.48
25	Establish strategic partnerships with international universities	3.38
73	Build international programs around globally strategic goals at the college and University level	3.23
Cluster 5: Curricular Structures and Integration		
32	Offer different price points in global programming portfolio	3.54
56	Integrate international experiences into the engineering majors	3.54
62	Frame international experiences as a core educational piece, and not as an alternative to education	3.62
85	Make global programming connected to the curriculum	3.65
Cluster 2: Leverage Partnerships and Funding Opportunities		
6	Leverage external industry partners to grow new technology and provide internships/research opportunities abroad	3.36
11	Change college culture regarding global engineering education	3.56
13	Provide resources to faculty to help support their efforts to grow international curricula	3.44
36	Offer seed grants for faculty to help them internationalize and build strategic partnerships	3.35
Cluster 7: Management for Sustainability		
3	Establish flagship programs to garner wide faculty and student interest	3.56
38	Move beyond traditional study abroad models which don't scale and don't have much faculty involvement	3.59
69	Develop a global programming portfolio that has variety and meets different student needs	3.74
78	Create a series of attractive, short-term programs to increase global programming participation	3.59

*The value of Importance Indices are relative to their cluster and shouldn't be compared directly

In GCM, every statement must be placed somewhere on the map. In some cases, MDS places a statement in an area because it was frequently sorted with statements immediately adjacent to it. In other cases, MDS places a statement in an "intermediate" area because it was sorted with statements somewhat distant on one side of it and somewhat distant on the other side of it. These are considered “bridging” statements because they bridge between two more distant areas on the map [65]. Bridging values assist in interpreting what concepts are associated with specific areas of the map. A bridging value is calculated for every statement, with a minimum value of 0 and maximum of 1. A cluster bridging value is calculating the average bridging value across all statements in a cluster. Clusters that are associated with multiple areas of the map will have higher bridging values (Figure 13). Bridging values and rating results are used in the development of an operational framework of GEP target areas by establishing relationships between different areas of the map.

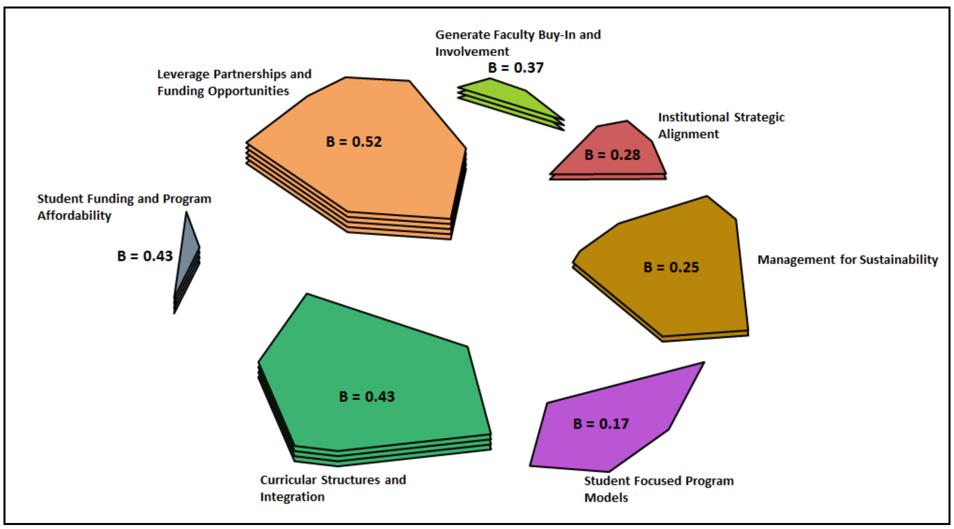


Figure 13. Bridging Map of GEP Target Areas

3.4 GLOBAL ENGINEERING PROGRAMMING (GEP) MODEL

Through the GCM methodology, results from this study outline the key GEP target areas that may be considered during strategic program development and how it should be implemented.

These results are combined with the qualitative data from all parts of the semi-structured interviews to generate a global programming framework that articulate and support GEP strategies. Finally, directions are provided regarding sustainable, school-wide GEP development.

The GEP model is a variant of the Center for the Internationalization and Global Engagement's (CIGE) Model for Comprehensive Internationalization. The GEP model was adapted for specific context of practice used in undergraduate engineering programs to provide practitioners, directors, and deans with foundational elements of sustainable global program development. There are four primary target areas of sustainable global engineering program development, outlined in Figure 14: ***Supportive Structures***, ***Engaging Change Agents***, ***Student Needs***, and ***Management for Sustainability***. These areas emerged based on the proximity of the clusters on the concept map, the ratings of each cluster, and the bridging values (Figure 13). The clusters closer to each other were seen as areas that affect each other. Clusters with higher bridging values indicate a stronger relationship with the other clusters in the map (and thus were seen as more supportive in nature). Each area is described in more detail below, along with exemplary quotes from the interviews that describe the factors needed for success in these areas.

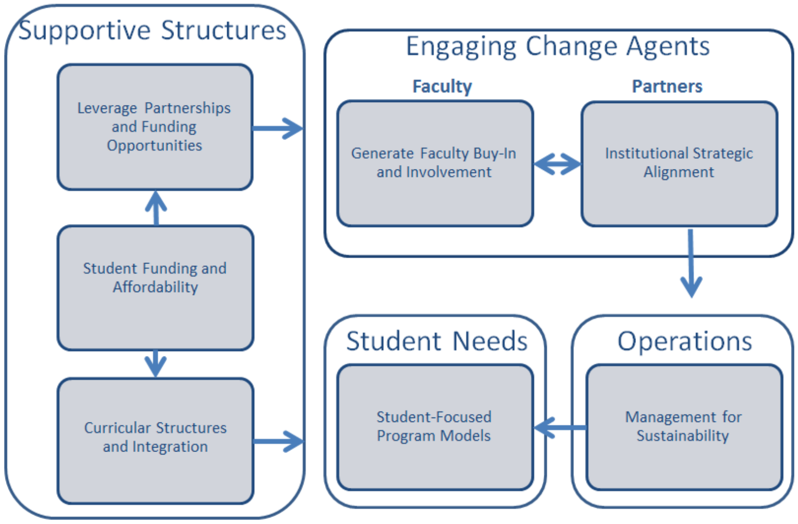


Figure 14. Final GEP Model

3.4.1 Supportive Structures

The three clusters that comprise the supportive structures target area are **Leveraging Partnerships and Funding Opportunities**, **Student Funding and Affordability**, and **Curricular Structures and Integration**. These are foundational in nature, and are required for any type of sustainable GEP success. Data from the interviews provided evidence that global programming initiatives such as scholarships based on financial need and diversity (e.g. underrepresented groups, new locations, and new majors) and subsidies for students to help offset the cost of studying abroad are critical. One SME emphasized this point in regards to faculty:

> *I think funding is a critical piece... Faculty are so busy and if they have a lot of pressure to go after grants, even seed grants, even small amounts of money can matter. And that funding goes out to scholarships, program support, and faculty*

or staff site visits …and specifically for student mobility, it ends up having a huge impact for the ability to build relationships or do course mapping for study abroad.

Engineering programs and institutions should ensure affordability to both increase institutional funds for scholarships, and to tap more into industry partners who can support programs. While many SMEs remarked on the importance of student funding strategies, there were also discussions on reducing barriers for students to get involved in global programming. Here, an SME described her experience:

You need to actually have pipelines to send students out with as few barriers as possible. Because as students hit barriers, they get disenfranchised, or frustrated, and then drop out, or drop off. Some of that can be financial, in terms of scholarship. Some of that can be ease of credit transfer, in terms of bilateral agreements, or credits that fall right onto the transcripts, so on and so forth. Not necessarily institutional-level policy…It's a process that gets students through with as few roadblocks as possible so that they don't get frustrated and leave.

Financial constraints faced by students and their families are a primary reason for the increased popularity of short-term programs, which cost less than long-term programs[83]. In addition to student funding, affordability, and access, another important area of global programming focus should be on curricular structures and integration. This includes making global programming connected to the curriculum, and framing international experiences as a core educational piece, and not as an alternative to education. Originally, the curriculum integration model was developed by the University of Minnesota. This model aimed at increasing the integration of study abroad into all majors and minors, providing scholarships, enhancing faculty awareness of the contributions of study abroad, developing innovative practices, materials, partnerships, and professional alliances, having 50% of the graduating class study abroad, and creating long-term institutional change [84]. Curricular integration involves identifying learning objectives specific to an engineering major for study abroad, identifying what the faculty are looking for as curricular enhancements from students doing study abroad, and developing programs that advance those pieces. Many SMEs echoed these goals:

> *I think the key is to make [global programming] curricular-connected. Because if it's seen as extra, the faculty members are going to burn out, it's not going to be put into a bucket where it counts. It's not going to help them with advancement or any of those types of things. So I think curricular connection is the key.*

> *I think it has to really be grounded in the curriculum...there are a lot of schools that do programs that are really kind of add-ons for engineering students. So it's, "oh, because you need to learn about the culture, you should go do this. Or you should learn the language. Or learn how business is done, or engineering is done in this country"…those things are fine, but that's not driven by the curriculum. That's in addition to the curriculum.*

Ultimately, the strategies discussed in this cluster by the SMEs reflect the need to treat global programming and international education in general as part of the educational process, and not as an alternative to education. Research has shown that integrated programming offers students' opportunities to gain knowledge about other cultures in more engaging and meaningful ways. Sustainable global programming development requires engineering program directors to integrate experiences and opportunities into the normative learning process. One SME reflected:

We all operate in environments with limited resources…So it's making the case that international programs are just as valuable as some of the other kinds of work that we do: design experiences, diversity initiatives, student project teams, etc. So where possible, align the international strategy with the other [experiences] – so not set international as an alternative, but as a way to enhance diversity initiatives, design experience, project teams, student organization competitions, etc…frame international [experiences] as just taking the core education to the next level.

A vital supportive structure for sustainable global programming within the engineering discipline is leveraging partnerships and funding opportunities. This includes leveraging external industry partners to grow new technology and provide internships/research opportunities abroad, changing the culture around global engineering education, and providing resources to help faculty internationalize and build strategic partnerships. The SMEs noted that having a multitude of external partnerships isn't always necessary. Instead, sustaining a few key partnerships is what engineering programs should focus on when building global experiences and programs:

Work with strategic partners. Don't be all things to all people. If you're just getting started, pick and choose key partnerships and sustain those partnerships. Work on student mobility with those key partners. Work on getting the top graduates through your programs so that you can build and grow it.

Faculty and staff are the ultimate drivers of the GEP vision, but external stakeholders must be invested in that vision as well. Along with creating strategic partnerships, there is value in the importance of knowing when an engineering program should leverage a partner. Engineering programs should be clear about which partnerships are appropriate and how it fits into the current programming strategies and initiatives. One of the most difficult challenges to overcome regarding global programming involves changing the culture around international education within the school. It's important to understand how programs see themselves of the types of institutions engineering programs sit in. A SME stated that institutional culture is the single biggest determinant of what an engineering program can do and how they can do it:

> *Universities have to be honest as to how important [global programming] is to them and how many resources, both human and financial, they're willing to put into it…they have to be realistic not just about that, but about their student population…I think it has to be really a well thought-out plan, because you're changing a culture…If education abroad doesn't exist at your school, you are changing the culture…you have to be really clear: how are you going to incentivize people to do something different…you have to know your institution.*

Having the correct support system to develop GEP strategies is a natural starting point. It starts with the students, and ensuring that funding exists to help those who want to engage in international opportunities. This is especially true for those who may not have had a chance to have international experiences prior to college, and for those underrepresented groups of minorities. It also means that the programs developed must be accessible to students from a financial and logistical standpoint. Curricular restrictions have been cited by engineering students as a significant factor in deciding not to study abroad [85], [86]. Many challenges have been associated with the implementation of international experiences including a highly sequenced curriculum, high implementation costs, and finding suitable partners [7]. A way to overcome these access issues is through curricular structures and integration. Finally, being able to leverage partnerships and external funding opportunities such as the Institute of International

Education's Generation Study Abroad Initiative and the Global Engineering Education Exchange can help sustain global programming efforts.

3.4.2 Engaging Change Agents

The two clusters that comprise the engaging change agents target area are **Generating Faculty Buy-In and Involvement**, and **Institutional Strategic Alignment**. Sustainable global programming requires champions and change agents to drive initiatives and visions. Data from the interviews suggested that creating sustainability involves having many faculty and staff involved in GEP efforts and encouraging and supporting faculty engagement in internationalization efforts. An SME put it the following way:

> *Faculty buy-in is critical, because ultimately the faculty are the best advocates for these types of programs, particularly if they're running them themselves. Because they can stand in front of a class and say, "This is my program; I've helped to design it. I believe in it. It's my thing. Come with me and you'll get more out of your educational experience and career, educational experience than you would otherwise." That makes a world of difference.*

In practically every institution, the faculty are the primary drivers in academic departments. If we want our engineering students to be more globally competent when they graduate, we need faculty to value this proposition. In establishing GEP strategies, it is important to understand how it affects faculty and how they can have power over the process:

> *It takes faculty passion to make that work….the number of engaged faculty I think is absolutely critical to [global programming]. And not only the number of engaged*

faculty, I'd call it duplicity or multiplicity of faculty engaged. And that is making sure that we're not relying upon one faculty member.

The belief that higher education is global and solving challenges are global problems is paramount for faculty buy-in and engagement. The level of buy-in is thought to be related to the intercultural competency of the engineering faculty:

Intercultural open-mindedness of the faculty at any institution plays a big role, and certainly at any engineering role, since that's specifically where you're looking, plays a big role in how quickly things internationalize, and what form that internationalization takes.

How a student receives information on global learning opportunities is equally as important as the information itself, and faculty are often the mouth pieces for many GEP initiatives [87]. What messages are faculty sending students about education abroad? How many faculty members encourage students to take advantages of GEP opportunities as part of their professional development? Understanding how faculty conceptualize global programming and their perspectives on global learning should not be overlooked during the planning process.

Another strategic aspect that supports faculty buy-in to GEP efforts is financial support. Providing the resources necessary for faculty to build programs and create strategic partnerships can jumpstart a plurality of faculty involvement:

Another part is recognition of the need for funding, for the institution to show some support, and one of the ways to do that is to have seed grants for faculty to help them internationalize. And it's not huge amounts of money – they're just seed grants but there are a couple of different sources and sometimes they're very specifically geared towards a strategic partnership that we're trying to build up.

What tends to be best is to have enough faculty willing to run international programs (and provide appropriate support) and encourage students to participate in them. But having buy-in at the department and institution level is essential. This leads to the target area around institutional strategic alignment. The data provides evidence that designing programs that are consistent with the institution/college missions, building programs around strategic goals of the University, and aligning institutional, faculty, and student needs is critical to sustainable GEP development. The GEP strategies that are most successful are the ones that are consistent with the college and/or institution's mission. One SME remarked on her own institution:

> *I have high hopes about what's happening with the development of these research programs because undergraduate research is something that [our university] is very committed to – we do it really well. We have just a great commitment and investment across the campus in our undergraduate research program. So to take that model and expand it into an international context makes so much sense and should be easy to do…I think things that kind of fit in that way is really important.*

Colleges and institutions should take advantage of their strengths and what is valued. What often drives university policy and faculty interests is curriculum development and research. Thus, developing GEP strategies should touch upon those areas. Otherwise, programs and initiatives will only have an impact around the edges. While the champions of your programs and initiatives are generally the faculty, institutional buy-in and support from the top is needed for sustained success:

> *Institutional buy-in is critical. If the institution doesn't support global programming, or sees it as a burden, it is very difficult to have success, in terms of output of numbers, in terms of student satisfaction – because oftentimes, that leads to cutting corners, or not*

designing things, or just simply outsourcing your students and having no real jurisdiction over them.

As mentioned both top-down (institutional) and bottom-up (faculty, student) support is critical for GEP success. With only faculty buy-in, programs will go away when faculty stop running them. With only institutional buy-in, GEP efforts and priorities changes when leadership at the school changes. There is a synergy that must exist between leadership at the school that impart the vision, the faculty that are the primary agents of that vision, and the students. All three entities are stakeholders in GEP and must collectively develop a shared vision of what it means to be international.

A critical piece to sustainable GEP development is engaging the change agents and intentionally designing programming around a shared interest and vision. Faculty play a vital role in GEP; buy-in and active involvement are required for sustainable programming, both in terms of championing the various programs that might exist and running the program. Data from the interviews pointed to the importance of plurality of faculty support. Research exists regarding institutional and/or organizational change. According to Henderson, Beach, and Finkelstein, effective change strategies must be aligned with or seek to change the beliefs of the individuals involved [88]. Hence, institutional, faculty, and student needs to be integrated. Developing successful change strategies also means understanding the university system and then designing a strategy that is compatible with this system [89].

3.4.3 Student Needs

This target area, which was ranked third in terms of importance, includes strategies such as increasing the number of short-term experiences that fulfill engineering requirements and offering global programs that are related to topics of interest to engineering students (such as global internships). This relates to what students want to get out of the experience, what students are prepared to do, and how it relates to their engineering discipline and career. Data from the interviews stressed the importance of knowing your student population:

> *It is knowing your student population. Are you an elite institution? Are you a broad access institution? What do your students come into the table with? What is the SES of your students? What can they afford? How many first generation students do you have? I think too often I see program professionals or faculty with these really complex, lofty ideas for what would be cool, when actually what their student population needs are a few gateway experiences to just initiate the cultural change.*

Some research has been conducted that explores the effects that prior backgrounds and international experiences have on students while in college. Having a better understanding of the background of your incoming students can help programs tailor their GEP portfolio to their student populations. Of particular importance is being more intentional about helping students who have never had the privilege of traveling abroad gain experience during college:

> *We all certainly have a portion of our population that comes from fairly privileged backgrounds, and they've had the pleasure of traveling with their families or doing that ex-pat assignment with their parents or going to boarding school overseas. But I think it's equally important that we think about these students who might be more regional, or from our home state, or from smaller towns, being more focused on getting them out the door so that we can level the playing field.*

From a curricular standpoint, the barriers for students to study abroad or engage in other types of international experiences are more present than other disciplines[85], [7]. It is perceived as difficult to have an international experience without delaying graduation or participating in exchange programs with credit transfers. Addressing student needs when developing global programming strategies also means meeting their curricular needs. Designing program models where students can get transfer back is critical; otherwise students will not participate or will look elsewhere. This stresses the importance of pre-approved courses and course mapping.

3.4.4 Management for Sustainability

The last target area consists of **Management for Sustainability**. The SMEs rated this cluster as the least important of the seven, due to the nature of the cluster itself and how it aligns with the rest of the target areas. Data from this target area provide evidence that establishing flagship programs that garner wide faculty and student interest, moving beyond traditional study abroad models to programs that scale and have more faculty involvement, and developing a GEP portfolio that has variety and meets different student needs are important aspects of sustainable GEP development. Once supportive structures are in place, change agents have been engaged, and programs are designed around student needs, there are a number of operational strategies that were encouraged by the SMEs to help manage the global programs and initiatives. Managing for sustainability involves thinking more broadly about the types of international experiences to offer, how those experiences are supported by faculty, and being intentional around program types that scale. Research by the author has started to suggest that students benefit more in terms of their global competency when engaged in variety of international experiences (in contrast to simply having a multitude of them). The qualitative data agrees with these initial assessments by two SMEs:

You can't just have exchanges. You can't just have faculty-led [programs]. You need to have internships; you need to have shorter programs, and longer programs. And you need variety in the types of programs that you offer. Part of that is because you involve different players across your campus, and even to run those programs. And so you're getting into the fabric of the institution and having a broad impact. But also because to be able to reach faculty and do things that resonate with them, and students, and provide programs that resonate with them and that they'll sign up for, everybody doesn't want the same things. So a variety in the types of programs I think is really important.

We need to start leveraging design teams, leveraging service-learning teams, leveraging student organizations…we thought that credit was a huge driver, and we find that nearly half of our engineering who go abroad will do so not for credit. They want the professional development. They want the experience for their resume. They want the challenge...So leveraging that co-curricular space….to balance the portfolio with some faculty-led programs, and some programs that don't rely on faculty travel from year to year.

In addition to have a diverse GEP portfolio that does not depend on only a handful of faculty, managing for sustainability also means being mindful of scale and moving beyond the traditional models:

Move beyond traditional study abroad models. So for example, bilateral exchanges don't scale. And a bilateral exchange typically has no faculty involvement. So think about having a couple programs that can accommodate a critical mass of students – thinking about programs that might blend a single course with experiential learning.

When designing international experiences and programs, there needs to be a willingness to focus on programs that scale and eliminating programs that do not. Having a large GEP portfolio is not necessary for sustainable and effect student development. Rather, it should have variety in terms of content and size and should address student needs in innovative ways.

3.5 IMPLICATIONS AND CONCLUSIONS

This research has important implications for practice and policy concerning GEP strategic development. A contextually relevant model was developed that researchers, program directors, and practitioners can use in the design and management of global engineering programs, policies, and initiatives.

As engineering programs begin to formalize their internationalization strategic plans and global programming initiatives, the results from this study (namely the GEP Model) can be used to better reflect the realities of and challenges associated with preparing an engineering student to be successful in the global workforce. Currently, there is no operational model to guide engineering programs for making informed decisions about how to internationalize their curricular or prepare students in a systematic and sustainable way. The models that do exist take an institutional approach, which do not take into account the needs, support, and challenges associated with the engineering discipline. The GEP Model is appropriate because it focuses on engineering schools' efforts to strategically incorporate global programming into their suite of learning opportunities. Study abroad has been the primary strategy to prepare engineering students, and these types of programs are typically additive instead of integrative, and target too few students [41]. Many scholars have emphasized the need for comprehensive internationalization efforts [20], [90], [16], [21], [91], but those in charge of engineering programs could use more guidance on programming planning and an overall strategic plan that should be followed. The GEP Model provides a structured approach in beginning to develop school-wide sustainable global program development.

It is also suggested that practitioners and program directors consider each GEP target area (supportive structures, engaging change agents, developing student-focused program models, and managing for sustainability), the clusters that constitute each area, and the effect each has on the others, when engaging in comprehensive global programming efforts. The GEP Model provides those schools who are just beginning to think about how to internationalize their programs, or who want to begin to develop programs, with a nuanced and contextually-relevant framework to guide their planning. Practitioners can evaluate the effectiveness of their current global programming efforts by mapping them to the GEP Model to identify what target areas they are not currently supporting or not sufficiently supporting? As such, the GEP Model can also be used as an evaluative tool that can help engineering programs make systematic and informed decisions, as well as begin to benchmark engineering programs against best practice. By considering the seven clusters and four target areas in the GEP Model, future global engineering education research can better understand the various ways that we can improve students' global competency and which strategies work best given institutional and study-body constraints. Overall, results from this study help facilitate a comprehensive and operational approach for a sustainable global programming strategy.

This research also describes what GEP target areas are most useful in strategic program development, which have the highest likelihood of success, and which should be prioritized in strategic planning. The metrics were combined to create an overall importance index, where

‘Student Funding, Affordability, and Access’, ‘Generating Faculty Buy-In and Involvement’, and ‘Student-Focused Program Models’ were seen as the most important target areas. This provides future research directions for engineering educators, namely how to increase the number or proportion of engineering students who participate in international experiences, what impact do faculty and the learning environment have on this and other global programming efforts, and which types of program models are most effective in developing globally competent engineering students.

4.0 STUDY 2 – GLOBAL PERSPECTIVE PATTERNS

Global engineering education has grown increasingly complex, requiring investigation into the assessment of programming strategies in terms of student learning and development. Of particular importance has been on engineering students' global competency[12], [3], [13], [14]. Global competency can be achieved through a wide variety of programs (curricular, co-curricular, and extracurricular) and strategies [15], [16]. But for these programs and strategies to have the most impact on student learning and development, research is needed to better understand how engineering students' global competency is conceptualized and developed.

There have been several attempts to define global competency, which often differ more in terminology than in substance [39]. There are also many engineering global competency frameworks that operationalize and explicate what globally competent engineering students can do [4], [5], [26]. In this study, Gaussian Finite Mixture Models (GFMM) were used to explore the multiple dimensions of global perspectives as defined by the Global Perspective Inventory (GPI) [47] as a surrogate measure for global competency. Model-based clustering approaches, such as GFMM, have been used increasingly to model a wide variety of phenomena [92]–[95]. GFMM and other variable-centered statistical approaches were used to conceptualize engineering students' global perspective development patterns and explore the relationship between these patterns and student backgrounds and experiences. The following research questions are addressed:

1. *What global perspective development patterns exist among undergraduate engineering students?*
2. *How do global perspective development patterns relate to students' backgrounds and prior experiences?*

If engineering students' global competency is to be effectively developed, then the factors that affect this development must be explored. Results from this study provide empirical evidence of the relationship between global engineering programming (GEP) strategies and global perspectives, aiding facilitators in making more informed GEP decisions.

4.1 RESEARCH METHODS

4.1.1 Instrument and Sample

Data for this study were drawn from an ongoing NSF REE project called *Assessing the Spectrum of International Engineering Education Experiences* (EEC-1160404). As part of this project, we administered an instrument that included the 35 items from the GPI and a set of questions soliciting demographics and prior internationally-related experiences. The student background items included academic level (e.g., freshmen or senior), gender (e.g., male or female), ethnicity (e.g., white, Asian, or underrepresented minority group), parents' educational background, type of location where the student was raised (e.g., urban, suburban, rural or small town), college GPA and second language fluency. These background variables were chosen based on prior research efforts and literature that suggests a relationship to global perspective development [96], [97]. Students who were multiracial and which included being a URM student were categorized as URM. Likewise, students that were both of white and Asian descent were categorized as Asian. The experiential items included the number and type of international coursework and service-learning related experiences and when these experiences occurred (e.g. before college only, during college only, both). Table 8 provides the complete list of background and experience variables. The resulting instrument took approximately 7-9 minutes to complete, primarily dependent upon the number of the students' international experiences.

Table 8. Independent Variables for Study 2

Student Background Variables	**International Experience Variables**
Academic standing	Time of Experience
Gender	Number of Experiences
Ethnicity	Variety of Experiences
Parents' educational background	
Type of location raised	
Fluency in foreign language	

The survey was administered to freshmen and senior engineering students across 13 participating institutions from spring 2016 to fall 2016. These institutions were selected based on their interest and activity in international engineering education, geographic location, and affiliation in an effort to be representative of those US institutions that are supportive of such activities. A sample of 200 participants from each institution was sought, with approximately 30 freshmen as a baseline, 110 seniors with international experience, and 60 seniors without any international experiences. International students were sampled but removed from the analysis. This resulted in 2,853 survey respondents, where approximately 71% of the sample were seniors, 63% were male, and 75% of the respondents were White, with students of color representing Asian/Pacific Islander (16%), underrepresented minority groups (9%), and unknown racial classifications (<1%). Additionally, over three-fourths of the respondents (83%) indicated that the highest educational attainment of their parents was a baccalaureate degree or higher, nearly two-thirds of the respondents (64%) indicated they were raised in a suburban environment, and almost half of the respondents (40%) indicated they were fluent in a second language. A full list of descriptive statistics can be seen in Appendix F.

The dependent/response variables in the study represent the six subscales derived from the GPI: Knowing, Knowledge, Identity, Affect, Social Responsibility, and Social Interaction. These six subscales were used to conceptualize global perspective patterns and consequently were used as indicators for the Gaussian Finite Mixture Modeling (GFMM).

4.2 DATA ANALYSIS

4.2.1 Analytic Model

Several analytical methods were used to answer the study's research questions. Both variable-centered and person-centered approaches were employed. Variable-centered approaches (e.g. descriptive statistics, correlation analysis, multivariate analysis of variance, and multinomial logistic regression) treat each variable in a dataset as related to another variable and aim to predict outcomes and assess intervention effects [98]. These approaches assume the sample under study is homogenous and the observed relationships generalize to all students, without considering that these relationships may differ in subgroups of participants. Person-center approaches like cluster analyses and mixture modelling focus on relations among individuals with the goal to sort those individuals into groups whose members are similar to each other and different from those in other groups[98], [99]. The use of person-centered approaches helped characterize the nature of global perspectives of the students, both quantitatively and qualitatively.

Gaussian Finite Mixture Modelling (GFMM) was the primary analytic technique employed in this study. GFMM is a model-based approach to clustering that assumes a multivariate Gaussian (or normal) distribution for each component. Finite mixture modelling approaches like GFMM allow for specification of alternative models that can be compared with various fit statistics, and includes more objective criteria for assessing model-data fit compared to more typical clustering approaches. GFMM also has the advantage of taking measurement error into account, which is not the case in the analysis of variance framework [100].

Finite mixture models are statistical approaches in which individuals are classified into unobserved subpopulations or latent classes. For any given variable, the observed distribution of values may be a “mixture” of two or more subpopulations whose membership is unknown. The goal of finite mixture modelling is to probabilistically assign individuals into subpopulations by inferring each individual’s membership to latent classes from the data [101]. The global perspectives of engineering students may be expected to be homogenous, symmetric, and unimodal. But when accounting for student backgrounds, international experience patterns, and individual characteristics, the distribution can become skewed in a multitude of directions. If the population consists of G sub-populations of global perspective patterns, a G-component finite mixture model would result.

Let $x = \{x_1, \ldots, x_n\}$ be a sample of n independent and identically distributed observations. The distribution of every observation is specified by a probability density function (pdf) through a finite mixture model of G components. The pdf of a mixture model is defined by a convex combination of the G components pdf [102],

$$p(x|\Theta) = \sum_{g=1}^{G} \alpha_g \, p_g(x|\theta_g),$$

where $p_g(x|\theta_g)$ is the pdf of the g^{th} component, α_g are the mixing proportions (or component priors) and $\theta = (\alpha_1, \ldots, \alpha_g, \theta_1, \ldots, \theta_g)$ is the set of parameters. We assume,

$$\alpha_g \geq 0, \text{ for each } g \in \{1, \ldots, G\}, \text{ and}$$

$$\textstyle\sum_{g=1}^{G} \alpha_g = 1.$$

Therefore, the interpretation is that global perspectives of engineering students can be expressed as a random variable X, which is generated from G distinct distributions. Each of these distributions is modeled by the density $p_g(x|\theta_g)$, and α_g represents the proportion of observations from population g. Most applications assume that all pdfs arise from the same parametric distribution family. The GFMM assumes a normal distribution for each component. Broadly speaking, each component or distribution is associated with a cluster or pattern.

Statistical analyses were carried out in a multistep process. First, GFMM was conducted to identify global perspective patterns in the sample. A series of models were created to identify distinct subpopulations of global perspective development. As described above, this procedure will assign students to their most likely subgroups on the basis of the observed GPI subscale data. The Bayesian Information Criterion (BIC) was used to identify the best fitting model. The BIC is typically a preferred indicator compared to other information criterion statistics (Akaike's Information Criterion, Consistent Akaike's Information Criterion, and Log Likelihood) [103], where lower BIC values reflect a better model fit. The conceptual meaningfulness and interpretability of various class solutions were also considered in the identification of the final model. Having identified the various global perspective patterns, students were assigned to patterns based on the probability of membership as indicated by the model. The GFMM solution was then validated by using multinomial logistic regression to predict class membership based on student background and international experience variables. Odds ratios and confidence intervals were estimated. Odds ratios refer to the likelihood of membership in one particular global perspective pattern versus a specified reference pattern (in this study, compared to the "average" pattern).

4.3 RESULTS

4.3.1 Descriptive Analyses

The data were screened to assess for skewness, kurtosis, multivariate outliers, and multicollinearity. Multivariate normality was assessed by evaluating the skewness and kurtosis of all major GPI subscales. Variables with an absolute skew index greater than three are considered extreme and tend to impact means. Variables with an absolute kurtosis index greater than ten affect tests of variance and covariance. Table 9 shows no indication of significant skewness or kurtosis for the subscales that would violate the normality assumption of GFMM. Analysis of missing data was performed on the experiential variables and 1.2% of the data points were missing information about their previous experience. Listwise deletion was performed, resulting in a final sample size of N = 2820 students across 13 institutions. Table 10 shows the bivariate correlations between all GPI subscales. These correlations align with norms established by Braskamp and Engberg [47].

Table 9. GPI Subscale Summaries

Subscales	M	SD	Skewness	Kurtosis
Knowing	3.59	0.52	-0.258	-0.120
Knowledge	3.57	0.60	-0.332	0.229
Identity	3.90	0.54	-0.372	0.426
Affect	4.05	0.51	-0.573	1.014
Social Responsibility	3.50	0.61	-0.255	0.229
Social Interaction	3.27	0.71	-0.027	-0.109

Note: M=Mean; SD = Standard Deviation

Table 10. GPI Subscale Correlations

	Knowledge	Identity	Affect	Social Responsibility	Social Interaction
Knowing	0.160	0.169	0.470	0.209	0.173
Knowledge		0.424	0.366	0.323	0.360
Identity			0.413	0.426	0.158
Affect				0.444	0.347
Social Responsibility					0.284

Note: All correlations significant; p<0.01

The means for all major study variables (background and experiential) are presented in Tables 11-19. Additionally, one factor analysis-of-variance (ANOVA) was conducted on each study variable and subscale combination. Females scored significantly higher on the Knowing, Affect, Social Responsibility, and Social Interaction subscales, with the largest effects occurring in the Affect and Social Responsibility subscales. Senior students scored significantly higher in the Identity subscale only, suggesting that academic status alone may not be a reliable indicator of global perspectives. White students scored significantly higher in the Knowing subscale compared to Asian and URM students; White students scored significantly higher in the Identity subscale than Asian students; and both Asian and URM students scored significantly higher in the Social Interaction subscale than White students. Students who have parents with MS or PhD degrees scored significantly higher on the Knowing and Affect subscales than students who have parents with HS or Associate degrees. Students raised in an urban environment scored significantly higher on the Social Interaction subscale that students raised in suburban and rural environments. Multilingual students scored significantly higher on all GPI subscales compared to students who don't speak another language.

Table 11. Descriptive Statistics-Gender

	Knowing*	**Knowledge**	**Identity**	**Affect***	**Social Responsibility***	**Social Interaction***
Male	3.56	3.57	3.91	4.00	3.43	3.22
Female	3.65	3.57	3.89	4.14	3.63	3.35

**Significant differences; p<0.01*

Table 12. Descriptive Statistics – Academic Status

	Knowing	**Knowledge**	**Identity***	**Affect**	**Social Responsibility**	**Social Interaction**
Freshman	3.60	3.56	3.85	4.02	3.53	3.22
Senior	3.59	3.57	3.92	4.06	3.49	3.29

**Significant differences; p<0.01*

Table 13. Descriptive Statistics – Ethnicity

	Knowing*	**Knowledge**	**Identity***	**Affect**	**Social Responsibility**	**Social Interaction***
White	3.63	3.55	3.92	4.05	3.50	3.13
Asian	3.50	3.63	3.81	4.05	3.49	3.69
URM	3.46	3.66	3.87	4.06	3.55	3.66

**Significant differences; p<0.01*

Table 14. Descriptive Statistics – Parent's Educational Background

	Knowing*	Knowledge	Identity	Affect*	Social Responsibility	Social Interaction
HS or Associate	3.54	3.53	3.90	4.00	3.47	3.28
BS	3.58	3.56	3.90	4.04	3.49	3.23
MS or PhD	3.62	3.59	3.90	4.08	3.53	3.29

**Significant differences; p<0.01*

Table 15. Descriptive Statistics – Location Raised

	Knowing	Knowledge	Identity	Affect	Social Responsibility	Social Interaction*
Urban	3.51	3.61	3.87	4.02	3.51	3.47
Suburban	3.60	3.57	3.90	4.05	3.50	3.26
Small town or Rural	3.61	3.54	3.92	4.08	3.52	3.20

**Significant differences; p<0.01*

Table 16. Descriptive Statistics – Second Language Fluency

	Knowing*	Knowledge*	Identity*	Affect*	Social Responsibility*	Social Interaction*
No	3.55	3.48	3.85	3.99	3.44	3.12
Yes	3.66	3.71	3.99	4.15	3.60	3.49

**Significant differences; p<0.01*

Students who had international experiences prior to and during college scored significantly higher in all GPI subscales compared to students who have not had any international experiences. Moreover, students who have had an international experience either only prior to college or only during college scored significantly higher on all GPI subscales except for Social Interaction. The number and variety of experiences had the largest correlations among the Knowing and Affect subscales, with variety of experiences being marginally higher than the total number of experiences (Table 20).

Table 17. Descriptive Statistics – International Experience Background

	Knowing*	Knowledge*	Identity*	Affect*	Social Responsibility*	Social Interaction*
No International Experiences	3.37	3.46	3.77	3.87	3.37	3.14
Experiences Prior to College Only	3.61	3.57	3.91	4.05	3.53	3.25
Experiences During College Only	3.59	3.54	3.93	4.04	3.53	3.23
Experiences Prior to and During College	3.72	3.65	3.98	4.18	3.56	3.38

**Significant differences; p<0.01*

Table 18. Descriptive Statistics – Number of Experiences

	Knowing*	Knowledge*	Identity*	Affect*	Social Responsibility*	Social Interaction*
None	3.34	3.47	3.76	3.84	3.38	3.17
One	3.51	3.49	3.90	3.98	3.48	3.15
Few (2-3)	3.57	3.61	3.94	4.04	3.54	3.24
Many (>3)	3.71	3.63	3.95	4.16	3.56	3.34

Table 19. Pairwise Comparisons for Number of Experiences

Number of Experiences	vs	Number of Experiences	Significant (p < 0.05)
Many	vs	None	All GPI Subscales
Many	vs	One	Knowing, Knowledge, Affect, Social Interaction
Many	vs	Few	Knowing, Affect
Few	vs	None	Knowing, Identity, Affect, Social Responsibility
Few	vs	One	No differences
One	vs	None	Knowing, Identity, Affect

Table 20. Spearman Rank Bivariate Correlations

	Knowing*	**Knowledge***	**Identity***	**Affect***	**Social Responsibility***	**Social Interaction***
Total XP	0.297	0.148	0.097	0.235	0.125	0.156
Variety XP	0.313	0.138	0.117	0.241	0.151	0.133

4.3.2 Finite Mixture Modelling

4.3.2.1 Model Selection

The analysis for this study utilized the R statistical software package [104] and SPSS [105]. Specifically, the mclust package [106] for model-based clustering in R was utilized to carry out the GFMM analysis [107]. Clusters assumed by this type of model are spherical, diagonal, or ellipsoidal, centered at the mean, and with the other geometric features such as volume, shape, and orientation determined by the covariance matrix amongst the clusters. Parameterizations of the covariance matrices are obtained by means of an eigen-decomposition and the volume, shape and orientation of the covariances can be constrained to be equal or variable across [107]. The optimal cluster solution considered fourteen possible models with different geometric characteristics. Figures 15 and 16 from the R Journal are provided below to better describe the parameterizations of the within-group covariance matrix for multidimensional data.

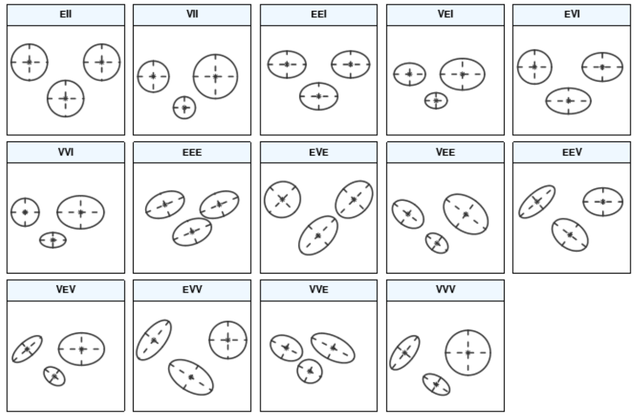


Figure 15. Ellipses of isodensity for each of the 14 Gaussian models obtained by eigen-decomposition in case of three groups in two dimensions [107]

Model	Σ_k	Distribution	Volume	Shape	Orientation
EII	$\lambda \boldsymbol{I}$	Spherical	Equal	Equal	—
VII	$\lambda_k \boldsymbol{I}$	Spherical	Variable	Equal	—
EEI	$\lambda \boldsymbol{A}$	Diagonal	Equal	Equal	Coordinate axes
VEI	$\lambda_k \boldsymbol{A}$	Diagonal	Variable	Equal	Coordinate axes
EVI	$\lambda \boldsymbol{A}_k$	Diagonal	Equal	Variable	Coordinate axes
VVI	$\lambda_k \boldsymbol{A}_k$	Diagonal	Variable	Variable	Coordinate axes
EEE	$\lambda \boldsymbol{D}\boldsymbol{A}\boldsymbol{D}^{\top}$	Ellipsoidal	Equal	Equal	Equal
EVE	$\lambda \boldsymbol{D}\boldsymbol{A}_k\boldsymbol{D}^{\top}$	Ellipsoidal	Equal	Variable	Equal
VEE	$\lambda_k \boldsymbol{D}\boldsymbol{A}\boldsymbol{D}^{\top}$	Ellipsoidal	Variable	Equal	Equal
VVE	$\lambda_k \boldsymbol{D}\boldsymbol{A}_k\boldsymbol{D}^{\top}$	Ellipsoidal	Variable	Variable	Equal
EEV	$\lambda \boldsymbol{D}_k\boldsymbol{A}\boldsymbol{D}_k^{\top}$	Ellipsoidal	Equal	Equal	Variable
VEV	$\lambda_k \boldsymbol{D}_k\boldsymbol{A}\boldsymbol{D}_k^{\top}$	Ellipsoidal	Variable	Equal	Variable
EVV	$\lambda \boldsymbol{D}_k\boldsymbol{A}_k\boldsymbol{D}_k^{\top}$	Ellipsoidal	Equal	Variable	Variable
VVV	$\lambda_k \boldsymbol{D}_k\boldsymbol{A}_k\boldsymbol{D}_k^{\top}$	Ellipsoidal	Variable	Variable	Variable

Figure 16. Parameterizations of the within-group covariance matrices for multidimensional data available in the mclust package of R, and corresponding geometric characteristics [107]

When determining the optimal cluster solution for GFMM, both the number of clusters to be included and the covariance parameterization must be decided. These decisions were evaluated by triangulating the following information criteria: Bayesian Information Criterion (BIC) , Integrated Complete-Data Likelihood Criterion (ICL), and Likelihood Ratio-Testing

(LRTS). The BIC is a common choice in the context of GFMMs and have shown consistent results in a variety of applications. The ICL is a version of BIC, but it penalizes the BIC through an entropy term that measures cluster overlap. For both statistics, better models are indicated by larger values. The model evaluation process also included likelihood ratio-testing (LRTS). It is common procedure in GFMM to test the null hypothesis H_0: $G=G_0$ against the alternative H_1: $G=G_1$ for some $G_1>G_0$, where usually $G_1 = G_0 + 1$. A bootstrap approach to LRTS was conducted to obtain the null distribution and p-values were found. Table 21 and 22 provide a summary of all of the fit statistics used for this study. Plots of BIC and ICL model selection criteria traces are provided in Figure 17. The plots are adjusted to remove models with lower BIC and ICL values, but still remain in the legend.

Table 21. GFMM Goodness-of-Fit Statistics

Model	LL	df	BIC	ICL
3 Cluster	-12902.5	41	-26130.73	-27895.13
4 Cluster	-12825.7	48	-26032.66	-27644.66
5 Cluster	-12667.6	55	-25772.16	-27361.69
6 Cluster	-12628.6	62	-25749.76	-27792.43
7 Cluster	-12589.9	69	-25727.96	-27495.72

Note. LL: Model Log-Likelihood; df: degrees of freedom; BIC = Bayesian Information Criterion; ICL = Integrated Complete-Data Likelihood;

Table 22. Bootstrap Sequential Likelihood Ratio Testing (LRTS) for the Number of Clusters

Number of Clusters	LRTS	p-value
2 vs 3	165.24	0.001
3 vs 4	153.68	0.001
4 vs 5	316.11	0.001
5 vs 6	78.00	0.001
6 vs 7	77.42	0.001

Models positing between three and seven clusters were evaluated. Solutions were determined based on the goodness-of-fit statistics described above, relative sizes of various cluster solutions, and interpretability of the model in the context of global perspectives. Analyzing the BIC and ICL values together yields an optimal model of five clusters. For the BIC index, the values continued to decrease across the range of models considered with the EEE (ellipsoidal distribution, equal volume, equal shape, equal orientation) parameterization yielding the largest values. The largest increase in BIC values occurs between four and five clusters and asymptotes from there, which indicates that a five cluster model might be the parsimonious solution. For the ICL index, the values do not follow a trend like the BIC indices did. The ICL values indicate an optimal solution at five clusters with an EEE parameterization. The BIC and ICL values were consistent in terms of choosing the appropriate number of clusters and parameterizations. The bootstrap likelihood ratio test was significant across all models, but there was a major drop in the LRTS value from five to six clusters, suggesting that the differences between these two models while statistically significant may not be practically significant. Based on this analysis and keeping the number of clusters to a reasonable and interpretable number, a 5-cluster solution was chosen as providing the best representation of the global perspective patterns. This model suggesting five global perspective patterns resulted in clusters with over 5% of the cases in the sample.

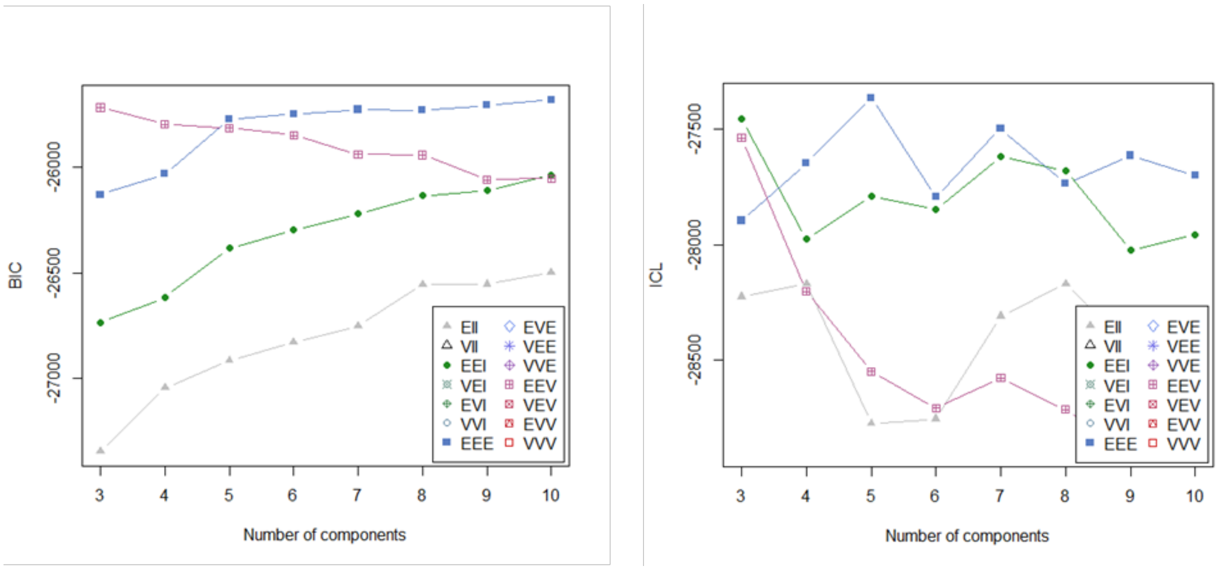


Figure 17. Plots of BIC and ICL model selection criteria

4.3.2.2 Pattern Interpretation

In GFMM, a label is generally assigned to a group of individuals who comprise a particular cluster. The mean GPI subscale scores for each cluster/pattern are presented in Table 23 and Figure 18. Bivariate correlations for each of the patterns are presented in Tables 47-52 in Appendix H. Pattern 1 (*n=209)* is characterized by low Knowledge and Social Interaction scores and average scores across the other GPI subscales. This pattern also exhibited significantly lower correlation between Knowledge and the Interpersonal Domain subscales (Social Responsibility and Social Interaction). Pattern 2 (*n=218)* are characterized by low scores on all GPI subscales, especially in the Intrapersonal Domain (Identity and Affect). This pattern exhibited significantly lower correlations between Identity and all other GPI subscales (except for Knowledge) as well as significantly lower correlations between Knowing and Identity, Affect, and Social Responsibility. In fact, the correlations between Knowing, Identity, and Social Responsibility are negative. Pattern 2 is also the "flattest" of the patterns, with a GPI subscale range of 0.21. Pattern

3 (*n=654)* is the second largest cluster, comprising of over 23% of the study sample. This pattern is characterized by high GPI scores across all subscales and can be labelled the "high scorers". Specifically, the students who follow this pattern outscore their classmates in the Knowing, Affect, and Social Interaction subscales. It is also the only pattern where the Social Interaction subscale scores are noticeably *higher* than the Social Interaction subscale scores. Pattern 3 has significantly lower correlations compared to the average correlations among the Knowledge, Affect, and Social Interaction subscales. Pattern 4 (*n=1583)* comprises more than half of the study sample and the mean GPI subscale scores are close to the overall average and therefore can be seen as "average scorers" that might be typical of an engineering student. One difference from the average, however, is that Pattern 4 has significantly lower correlations between Social Interaction and the other GPI subscales. Finally, Pattern 5 (*n=156)* comprises the fewest students in the study sample (5.5%) and is characterized by extremely low average Knowing scores, extremely high Knowledge scores, slightly above average Identity, Affect, and Social Responsibility scores and high Social Interaction scores. This pattern also has significantly *higher* correlations between Identity and the other GPI subscales, namely Knowledge, Affect, and Social Interaction. Labels for each pattern are given in Table 24.

Table 23. Descriptive statistics of global perspective patterns

	Global Perspective Patterns									
	Pattern 1 N=209		Pattern 2 N=218		Pattern 3 N=654		Pattern 4 N=1583		Pattern 5 N=156	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Knowing	3.40	0.47	3.12	0.34	3.98	0.39	3.62	0.41	2.63	0.32
Knowledge	2.56	0.42	3.10	0.44	3.87	0.53	3.59	0.47	4.14	0.47
Identity	3.98	0.48	3.13	0.43	4.04	0.54	3.92	0.47	4.16	0.53
Affect	4.08	0.46	3.00	0.32	4.41	0.37	4.03	0.38	4.23	0.45
Social Responsibility	3.38	0.59	2.92	0.48	3.69	0.63	3.50	0.57	3.72	0.57
Social Interaction	2.36	0.60	3.05	0.42	4.13	0.38	3.01	0.48	3.78	0.48

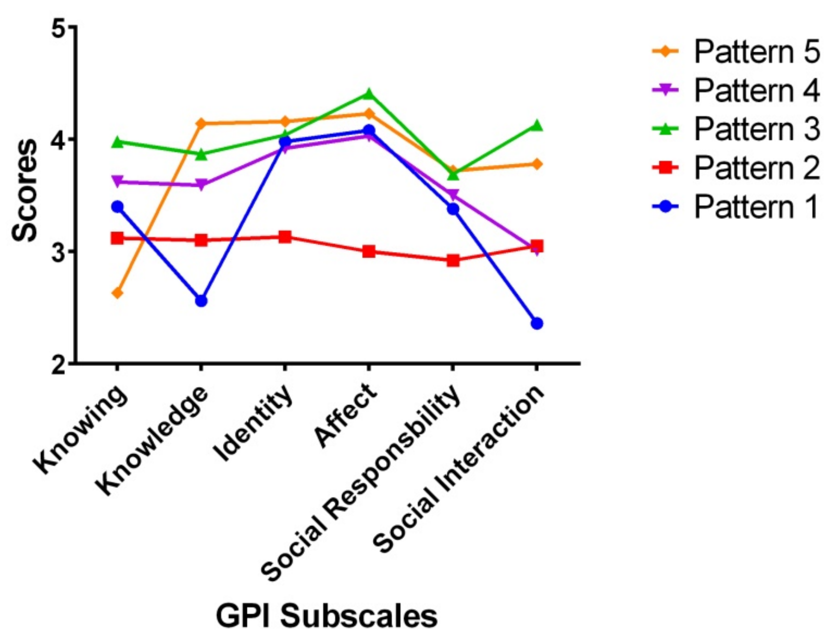


Figure 18. Global Perspective Patterns

Table 24. Global Perspective Pattern Labels

Global Perspective Patterns	Characteristics
Pattern 2	Low Scorers
Pattern 1	Low Knowledge and Social Interaction
Pattern 4	Average Scorers
Pattern 5	Mixed Cognitive Scorers with High Social Interaction
Pattern 3	High Scorers

4.3.2.3 Relations between Backgrounds and Patterns

Proportions of all student background variables for each of the five global perspective patterns are presented in Tables 25 and 26. These variables were also used to predict pattern membership through a multinomial logistic regression. In addition, international experience variables, which include international backgrounds, the frequency of international experiences and their types, were also used to predict and validate the global perspective patterns. Results showed differences in reported GPI subscale scores among the set of background variables across the five patterns. Pearson Chi-Squared Tests for Association were carried out for each variable. The only variable with a non-significant association to pattern membership was a student's parent's educational background. A higher percentage of female engineering students were included in the higher scoring global perspective patterns and the low scoring pattern had a comparatively lower percentage of female students by roughly 13%. This suggests that gender may be a significant predictor of pattern membership, with female students generally outscoring their male counterparts. A similar trend is observed when comparing the patterns across academic level, with senior engineering students having comparatively higher representation in the higher scoring patterns than freshmen engineering students. The highest scoring groups (Patterns 3 and 5) had the largest percentage of minorities compared to the other groups. Patterns 1 and 4 consisted mostly of white engineering students, and the lowest scoring group was a mix of ethnicities with white students being the majority. The patterns with the highest scoring students also had the highest proportion of students who speak more than one language, and the patterns with the lowest scoring students had the highest proportion of students who do not speak more than one language, which suggests second language fluency may be a significant predictor in global perspective patterns. Pattern 3 (high scorers) is representative of a group of students who have an extensive international experience background, participating in a variety of experiences in multitudes before and during college. Pattern 5 is representative of a group of students who have a variety of different international experiences, from no experiences to experiences prior to and during college. Pattern 2 (low scorers) is a representative group of a group of students with little to no international experience background, participating in a few experiences mostly prior to college.

Table 25. Percentage (%) of Experiential Variables by Pattern

International Background	Pattern 1 Low Knowledge and Social Interaction	Pattern 2 Low Scorers	Pattern 3 High Scorers	Pattern 4 Average Scorers	Pattern 5 Mixed Cognitive Scorers w/ High Social Interaction
No International Experiences	27.3	47.7	11.6	22.7	38.5
Experience Prior to College Only	28.7	26.1	28.3	31.3	25.0
Experience During College Only	13.9	11.5	11.0	11.7	9.6
Experiences Prior to and During College	30.1	14.7	49.1	34.3	26.9
Number of Experiences					
None	22.5	46.8	10.6	18.5	37.2
One	22.0	20.6	12.2	18.3	22.4
Few (2-3)	6.2	7.3	6.1	7.9	8.3
Many (>3)	49.3	25.2	71.1	55.3	32.1
Variety of Experiences					
Average	1.54	0.88	2.43	1.81	1.11
SD	1.38	1.16	1.80	1.54	1.17

Table 26. Percentage (%) of Background Variables by Pattern

Gender	Pattern 1 Low Knowledge and Social Interaction	Pattern 2 Low Scorers	Pattern 3 High Scorers	Pattern 4 Average Scorers	Pattern 5 Mixed Cognitive Scorers w/ High Social Interaction
Male	58.9	77.5	56.7	64.6	53.8
Female	41.1	22.5	43.3	35.4	46.2
Academic Level					
Freshmen	25.4	32.1	24.9	31.3	19.9
Senior	74.6	67.9	75.1	68.7	80.1
Ethnicity					
White	90.9	63.3	58.0	84.2	45.5
Asian	6.7	20.6	27.4	9.7	30.1
URM	2.4	16.1	14.7	6.1	24.4
Parent's Educational Background					
HS or Associate	14.8	21.1	16.2	15.9	16.7
BS	36.8	36.7	30.7	37.5	35.3
MS or PhD	48.3	42.2	53.1	46.6	48.1
Location Raised					
Urban	5.7	18.3	13.6	8.8	18.6
Suburban	64.1	62.4	63.1	65.1	59.0
Small Town/Rural	30.1	19.3	23.2	26.1	22.4
Multilingual					
No	75.1	72.9	42.4	64.8	55.1
Yes	24.9	27.1	57.6	35.2	44.9

4.3.3 Multinomial Logistic Regression

Results from the multinomial logistic regression in which student background and international experiences variables were used to predict global perspective pattern membership are reported in Table 26. There was a significant prediction of pattern membership by the predictors, χ^2 (64, N=2820) = 664.57, $p < 0.001$, Negelkereke $R^2 = 0.230$. These results show that ethnicity, second language fluency, gender, academic level, variety of experience types, and number of experiences is significantly associated with the probability of global perspective pattern membership. The reference group used for this analysis was Pattern 4 because it is the most representative of the overall average scores of engineering students and therefore can be seen as a proxy for the typical engineering student pattern. Odds ratios (OR) were calculated and reported for each significant predictor variable. Table 27 summarizes the results of the multinomial logistic regression analysis. The full results of the multinomial logistic regression can be seen in Appendix J.

Table 27. Summary of Significant Variables from Multinomial Logistic Regression

Compared to **Pattern 4**: Average Scorers	**Significant Variables**	
	Predictor Name	**OR**
Pattern 1: Low Knowledge and Social Interaction	Male	0.70
	Freshmen	0.62
	White	2.70
	Not multilingual	1.46
	Variety	0.84
Pattern 2: Low Scorers	White	0.35
	Male	1.70
	Urban	2.04
	No experiences	3.05
	Variety	0.78
Pattern 3: High Scorers	White	0.28
	Not multilingual	0.63
	Variety	1.14
Pattern 5: Mixed Cognitive Scores with Low Social Interaction	White	0.17
	Freshmen	0.44
	One experience	2.32
	Variety	0.73
	During college	0.42

4.3.3.1 Pattern 1 vs Pattern 4

The primary difference between these two patterns is that students who were grouped into Pattern 1 have significantly lower scores in the Knowledge and Social Interaction subscales. The results show that gender, academic level, second language fluency, and variety of experience types is significantly associated with the likelihood of falling into Pattern 1 compared to Pattern 4. Males are 30% less likely to fall into Pattern 1 compared to females (*OR* = 0.70, $p = 0.019$). Freshmen are 38% less likely to fall into Pattern 1 compared to seniors (*OR* = 0.62, $p = 0.027$). Students who do not speak a second language are 46% more likely to fall into Pattern 1 (*OR* = 1.46, $p = 0.036$). Finally, for each different experience type a student has participated in a student is 16% less likely to be in Pattern 1 (*OR* = 0.84, $p = 0.042$). Compared to the average engineering student global perspective pattern, students in Pattern 1 includes more senior, female engineering students who do not speak a second language and have participated in fewer types of international experiences.

4.3.3.2 Pattern 2 vs Pattern 4

This pattern is characterized by consistently low GPI scores across all subscales and can be classified as "low scorers". The results show that ethnicity, gender, region raised, number and type of international experiences are significantly associated with the likelihood of falling into the low scoring Pattern 2 compared to Pattern 4. White students are 65% less likely to fall into Pattern 2 compared to URM students (*OR* = 0.35, $p < 0.001$). Males are 70% more likely to fall into Pattern 2 compared to females (*OR* = 1.70, $p = 0.003$). Students raised in urban areas are 2.04 times more likely to fall into Pattern 2 compared to students raised in rural/small town regions (*OR* = 2.04, $p = 0.006$). Students who have had no international experiences are 3.05 times more likely to fall into Pattern 2 compared to students who have had many experiences (*OR* = 3.05, $p = 0.006$). Finally, for each different experience type a student has participated in a student is 22% less likely to be in Pattern 2 (*OR* = 0.78, $p = 0.037$). Compared to the average engineering student group, students in this lowest scoring pattern include more underrepresented minority, male students from urban areas who have had very few international experiences in terms of number and variety.

4.3.3.3 Pattern 3 vs Pattern 4

This pattern is characterized by consistently high GPI scores across all subscales and can be classified as “high scorers”. The results show that ethnicity, second language fluency, variety of international experience types are significantly associated with the likelihood of falling into the high scoring Pattern 3 compared to Pattern 4. White students are 72% less likely to fall into Pattern 3 compared to URM students ($OR = 0.28$, $p < 0.001$). Students who do not speak a second language are 37% less likely to fall into Pattern 3 ($OR = 0.63$, $p < 0.001$). Finally, for each different experience type a student has participated in, a student is 14% more likely to be in Pattern 3 ($OR = 1.14$, $p = 0.002$). Compared to the average engineering student group, students in this highest scoring pattern include more underrepresented minority students who are fluent in a second language and have participated in a variety of different international experience types.

4.3.3.4 Pattern 5 vs Pattern 4

The primary difference between these two patterns is that students who were grouped into Pattern 5 have significantly lower scores in the Knowing subscale and significantly higher scores in the Knowledge and Social Interaction subscales. The results show that ethnicity, academic level, and international experience background are significantly associated with the likelihood of falling into the low scoring Pattern 5 compared to Pattern 4. White students are 83% less likely to fall into Pattern 5 compared to URM students ($OR = 0.17$, $p < 0.001$). Freshmen are 56% less likely to be in Pattern 5 compared to seniors ($OR = 0.44$, $p = 0.001$). Students who have had one international experience are 2.32 times more likely to fall into Pattern 5 compared to students who have had many experiences (*OR* = 2.32, *p* = 0.006). For each different type of international experience a student has participated in, that student is 27% less likely to be in Pattern 5 (*OR* = 0.73, *p* = 0.009). Finally, students who only have international experiences in college are 58% less likely to be in Pattern 5 compared to students who have had international experiences prior to and during college (*OR* = 0.42, *p* = 0.022). Compared to the average engineering student group, students in Pattern 5 include more senior, underrepresented students who have not had very many international experiences of different types and mostly had those experiences during college.

4.4 DISCUSSION

The present study provides a holistic conceptualization of the extent to which various student and international experience backgrounds are important factors in distinguishing between different global perspective patterns. This multidimensional assessment of global perspectives allows for a more comprehensive understanding of the associations among undergraduate engineering global perspective development, student backgrounds, and participation and involvement in international experiences prior to and during college.

The current study aimed to investigate and understand the number of global perspective patterns that emerged from a GFMM analysis and to subsequently examine the nature of each pattern using a number of background and experiential variables that prior research has shown to have an effect on global competency. Based on a number of fit indices and statistical tests, a five-cluster solution was chosen as the best representation of the data. Results based on this five-cluster model revealed five patterns varying in levels of global perspective development.

Students who consistently reported lower scores across all six GPI subscales were classified as low scoring students. This pattern also had the lowest overall variation between the subscale scores, leading to a relatively "flat" perspective pattern. Students whose scores approximated the full sample's averages across the Knowing, Identity, Affect, and Social Responsibility subscales and significantly lower across the Knowledge and Social Interaction subscales were classified into their own pattern which can be viewed as below the average student scores. Students whose scores across all GPI subscales were comparable to the sample's average scores and the reported normative GPI scores [47] were classified as average scoring students. Students whose Knowing scores were significantly lower than average and whose Knowledge and Social Interaction scores were significantly higher were classified into their own pattern, which can be viewed as above average scoring students. Finally, students whose across all six GPI subscales were significantly higher were classified as high scoring students.

Some interesting correlational relationships were found across the perspective patterns. The low scoring pattern group was characterized by several relatively low correlations between the subscales in the Intrapersonal domain and the rest of the GPI subscales. In particular, the low scoring pattern exhibited negative correlations between Identity and Knowing, as well as Social Responsibility and Knowing. This suggests that students with a more limited global perspective display a negative relationship between the importance of cultural context in determining what is important to know/value and level of awareness of one's identity, degree of acceptance, and level of social concern for others. This is consistent with past research on the developmental model of intercultural sensitivity, where those with more ethnocentric views experience their culture as central to reality, either by minimizing differences or being defensive against them [44]. Pattern 1 was characterized by correlations that align with the GPI norms, with a smaller correlation between Knowledge and Social Responsibility. This relationship is possibly due to the lack of international experiences of this group of students, suggesting that students who engage in more international experiences perceive a greater association between the understanding of other cultures and the perceived level of interdependence. Pattern 5 was characterized by relatively higher correlations across all subscale comparisons, with particularly high correlations between Identity and Knowledge, Affect, and Social Interaction. This group of students included more senior, underrepresent minorities who have not at most just one international experience. On average, this group's experience profile looks much more similar to the low scoring group. However, this pattern includes students with extremely high scores in the Intrapersonal domain among others, suggesting that they are developing global perspectives in ways other than participating in international programs and other experiences. This could likely be due to this clusters students' ability to integrate into new academic cultures, given the typical demographic nature of the engineering discipline. The high scoring pattern displayed relatively high correlations between the Affect and Social Responsibility subscales, suggesting those with well-developed global perspectives see a connection between the level of acceptance of cultural perspectives different from one's own, emotional intelligence, level of interdependence, and social concern for others. This is consistent with the description of the ethnorelative orientations of the DMIS, where one's own culture is experienced in the context of other cultures either by accepting it as an equal worldview or expanded to include constructs from other worldviews [44].

Results also showed that significant associations exist between global perspective pattern membership and student background variables. Specifically, ethnicity, gender, academic level and fluency in a second language were significant predictors of pattern membership.

Furthermore, the variety of international experiences in which a student has participated was a significant predictor of pattern membership. The majority of this study sample was white, male students raised in suburban areas. However, being an underrepresented minority, female student (especially one with many different types of international experiences) led to a greater likelihood of being classified into a high scoring global perspective pattern compared to the average scoring pattern. The two highest scoring patterns (Patterns 3 and 5) were both predicted by ethnicity, where underrepresented minority students had relatively more representation than their white student counterparts. The key difference between these two perspective patterns is the average score on the Knowing subscale and the international experience profiles. The highest scoring group (Pattern 3) was significantly predicted by second language fluency and participation in a variety of experience types. On the other hand, students in Pattern 5 had comparatively fewer international experiences on average, which is most likely the reason for the low scores on the Knowing subscale. So why are students in Pattern 5 high scoring if their international experience backgrounds are limited? Pattern 5 consists of relatively greater proportion of senior students who only have one international experience. This may suggest the relative impact of international experiences on engineering students depends on the students' backgrounds (e.g., ethnicity, gender, and academic level).

Similarly, the ethnic breakdown between the lowest (Pattern 2) and highest (Pattern 3) scoring groups are most similar. What makes one group different from the other is that there are comparatively more female students who have had more international experiences of different varieties and who tend to be fluent in a second language in this group. This contrast supports the claim made in the previous paragraph that international experiences (and fluency in another language) may have a greater impact on underrepresented minority engineering students compared to white male students.

Pattern 1 represents a slightly below average group of engineering students, who scored mostly the same as the overall average, but significantly lower in the Knowledge and Social Interaction subscales. This group differs from the average perspective pattern group (Pattern 4) in that it contains comparatively more white, female students who have participated in fewer types of international experiences and who are not fluent in a second language. This would suggest that white engineering students (especially females) have a higher relative global perspective baseline than underrepresented minority engineering students (especially males).

4.5 IMPLICATIONS FOR POLICY AND PRACTICE

The findings from this study suggest that not all engineering students are the same regarding global perspectives. Recognizing and understanding that many different global perspectives typologies exist among our engineering student populations is important for practice and policy. Engineering students are becoming an increasingly diverse and heterogeneous group of college students. The global programs and strategies implemented by engineering schools need to adapt to and address this diversity. Much of the current research and policy approaches to preparing engineering students for the global workforce do not adequately consider the complexity and heterogeneity of engineering students' global perspective development patterns, opting instead for a one-size-fits-all strategy for different international programs and initiatives. This study provides a better understanding of how diversity in backgrounds and experiences affects global perspective development. For international experiences to have the most impact on engineering student populations, an understanding of how different types of students conceptualize global perspectives, and then aligning experience types to students who will benefit most is necessary. Although it is premature to prescribe specific strategies or practice recommendations based on the present findings, the study provides some indication of unique typologies of global perspectives, which point to a potential need for differential global programming strategies. Additional research is needed to replicate and build upon these findings.

5.0 STUDY 3 – IMPACT OF EXPERIENCES

This study leverages an operations research methodology called Data Envelopment Analysis (DEA) to investigate how engineering students utilize international experiences in college and explore the relative efficiency of student's global perspective development as measured by the Global Perspective Inventory (GPI) [47]. DEA is a linear programming based frontier estimation technique for measuring the relative efficiencies of a homogenous set of decision making units (DMUs) having multiple inputs and outputs [108], [109]. The ability to handle multiple inputs and outputs makes DEA an attractive choice of technique for measuring efficiency in an educational setting [110], [111] and has been used in a variety of different higher education applications [110]–[116]. The DMUs for the DEA model in this global engineering context are undergraduate engineering students, the inputs are the number and type of different international experiences that students have participated in, and the outputs are the scores on the dimensions of the GPI. DEA and statistical regressions were used to explore the types of international experiences senior engineering students participated in, the relative efficiency of students' global perspective development, the reasons for inefficiency in international experience engagement, and how efficiency compares against student subgroups. The following research questions are addressed:

1) *What factors are related to the efficiency of global perspective development?*
2) *How can students make the best use of international experiences while in college?*

If engineering schools are to strategically invest in effective international experiences for their students, it is necessary to determine whether these investments produce their intended results and determine what experiences have the biggest impact. Results from this study provide an understanding of how students are engaging with global programming in college, the relative impact these experiences are having on an increasingly diverse engineering student population, and how the international education community can construct benchmarks for assessing global competency.

5.1 CONCEPTUAL FRAMEWORK

5.1.1 Data Envelopment Analysis (DEA) and Efficiency

DEA was developed by Charnes, Cooper, and Rhodes in 1978 [108] as a means of efficiency evaluation in the context of 'not-for-profit entities participating in public programs'. This followed the work by Dantzig [117] and Farrell [118] decades prior. DEA was accorded this name because of the way it "envelops" observations to identify a "frontier" that is used to evaluate observations representing the performances of all of the entities that are to be evaluated [109]. DEA therefore is a non-statistical, non-parametric mathematical programming based approach for estimating a piece-wise linear production function that computes a comparative ratio of outputs to inputs for each DMU, which is reported as the relative efficiency score. There is an implicit assumption that there is a conceptual or experiential relationship between the outputs and inputs in the model (e.g., a relationship between international experiences and global perspectives). A DMU is any entity that produces one or more outputs from one or more inputs.

Using linear programming methods, a production possibility or "best-practice" frontier is created for the measured population. The basic concept is that the efficiency of each DMU is evaluated against its own performance and that of each of the other DMUs in the sample. The DMUs that are most efficient form an efficiency or best-practice frontier and the less efficient DMUs are described by a number that indicates their distance from that frontier [108].

The ratio of outputs to inputs is commonly used to measure efficiency. Efficiency is defined as the ability to produce the outputs or services with a minimum resource level required and measures the extent to which outputs can be increased through higher efficiency without using additional resources (inputs) [115]. Efficient production in the classical sense is defined in terms of Pareto optimality. Pareto optimality states that a DMU is efficient if an output can be increased without raising any of the inputs and without decreasing any other output. A DMU is also not efficient if an input can be decreased without decreasing any of the outputs and without increasing any other input [109]. An efficiency score is expressed as a number between 0 and 1, where a DMU with a score less than 1 is deemed inefficient relative to the other units. DEA identifies the inefficiency of a DMU by comparing it to similar DMUs regarded as efficient, rather than trying to associate a DMUs performance with statistical averages that may not be applicable [115].

The single input, two output problem is easy to analyze graphically and Figure 19, from Avkiran [115], is provided to illustrate the high level principles of DEA. In this example of 10 DMUs, the solid line running from DMU B to DMU D represents the efficiency frontier (scores of 1). DMU A is classified as inefficient because it needs to travel to A' on the frontier before it can also be considered efficient. DMUs C and D on the efficiency frontier are the units for comparison in calculating the input/output configuration for efficiency and is called the reference set or peer group of DMU A.

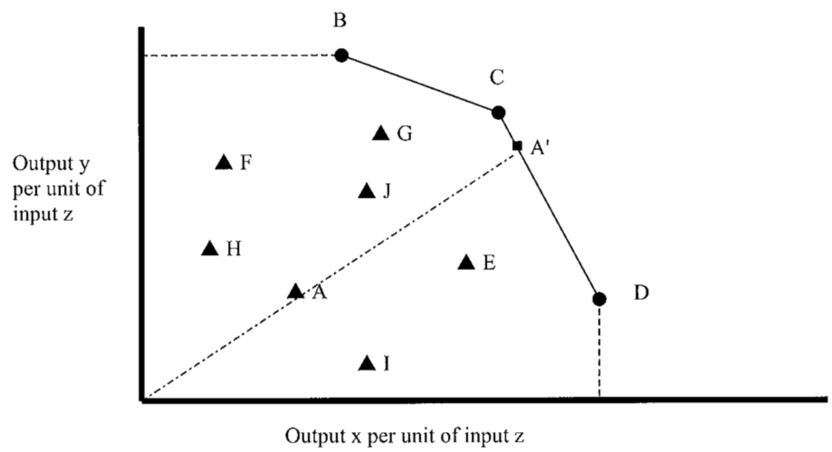


Figure 19. A two-output, one-input efficiency frontier [115]

5.1.2 DEA Model Formulations

There are several ways of formulating a DEA model, that vary in the shape of the efficiency frontier (e.g. constant returns to scale, variable returns to scale), the orientation of the model (e.g., input or output), and the number and type of input and output variables. Regardless of the formulation, a separate optimization is performed for each DMU (e.g., if there are *n* DMUs then *n* different optimizations must be performed). A DMU's efficiency is defined as the sum of weighted outputs divided the sum of weighted inputs. Therefore, each optimization selects the set of weights that results in the highest possible efficiency for the DMU of focus. The set of optimizations share a common set of constraints: when the set of weights are applied to any DMU, it must not result in an efficiency score greater than one (see linear program below).

$$\text{Maximize } e_{j_0}$$
$$\text{subject to } e_j \leq 1$$
$$\text{where } e_j = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \; for\; j = 1, \dots, n, \text{ and}$$
$$u_r, v_i \geq 0, \text{for } r = 1, \dots, s \text{ and } r = 1, \dots, m.$$

Here, n is the number of DMUs in the sample; x_{ij} is the amount of input i to unit j; y_{rj} is the amount of output r from unit j; u_r is the weight given to output r; v_i is the weight given to input r; m is the number of inputs; and s is the number of outputs. This formulation can be converted into a linear program by algebraic manipulation. The entire DEA model, as stated previously, consists of an iteration of this program for DMU in the sample being evaluated. The solution of each iteration is the set of weights that yields the best possible efficiency rating for the evaluated DMU.

The formulation described above was the model proposed by Charnes, Cooper, and Rhodes in 1978 [108] and is called the CCR model. The CCR model assumes a constant return to scale (CRS) of the efficiency frontier. A constant return to scale assumes that there is no significant relationship between the scale of operations and efficiency. That is, students with many international experiences are just as efficient as students with only a few international experiences. We will see that this assumption in the context of the study does not hold, and instead a variable return to scale (VRS) is preferred. Banker, Charnes, and Cooper developed the BCC model [119], which assumes that a rise in inputs is expected to result in a disproportionate rise in outputs. This model measures efficiency as the convexity constraint ensures that the peer group is of similar scale size as the DMU being evaluated. VRS is preferred when a significant correlation between the DMU size and efficiency exists in a large sample. Figure 20 present a diagrammatic representation of CRS and VRS DEA models.

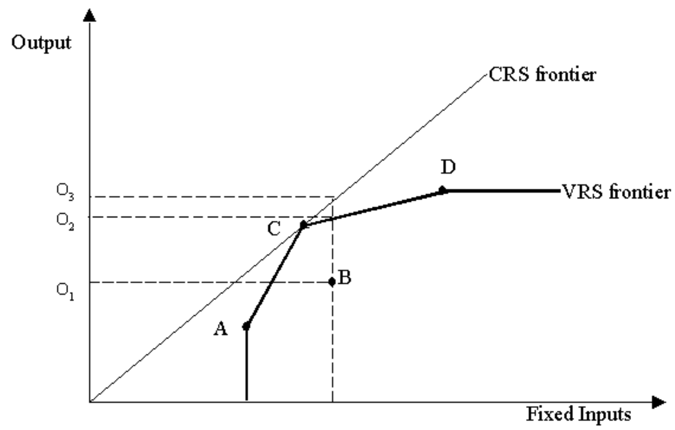


Figure 20. Returns to Scale Illustration [120]

A DEA analysis should clearly identify what is to be achieved. Consider a DEA analysis in the context of international education where the inputs are the number and types of experiences a student has engaged in and outputs are the global perspective measures. If the goal is to identify students that are over-utilizing international experiences, then it would appear that reducing the number of experiences while achieving the same level of global perspective is the central focus. On the other hand, if the goal is to identify students that could improve their global perspectives without participating in any more international experiences, than output enhancement, not input reduction will be the focus [121]. DEA has general guidelines for the number of DMUs required for a given number of inputs and outputs. If the number of DMUs (n) is less than the combined number of inputs and outputs ($m+s$), a large portion of the DMUs will be identified as efficient and discrimination is questionable due to an inadequate number of degrees of freedom [109].

DEA has several advantages compared to other analysis techniques. Because it simultaneously analyzes multiple inputs and outputs, and it generates relative-efficiency information, it provides information not readily available with other techniques. DEA also does not attempt to find the “best-fit” of the data like many statistical techniques attempt to do. Rather, it determines those DMUs that have maximized the use of inputs to create an efficiency frontier. Instead of identifying average performance, it distinguishes the most efficient performance and looks explicitly for the maximal performers in the dataset.

How can the international engineering education community use DEA? This study will classify students as either efficient or inefficient compared to the other students in its peer group, where the peer group is comprised of efficient students most similar to that student in their configuration of international experiences and global perspectives. Knowing which efficient students are most comparable to the inefficient students enables program administrators and facilitators to better understand the relevant inefficiencies in their programming and subsequently rethink how they design their global programming strategies. It will also give insight into the relative impact that international experiences have on different subgroups (e.g. gender, ethnicity, and foreign language fluency).

5.1.3 Applications of DEA in Higher Education

Over the past 40 years, education has been represented as an example of a sector which has been well served by DEA. The application of DEA to universities has generally focused on the efficiencies of university programs or departments [115], [114], [122], whether that is measuring performance and fee-paying enrollments, measuring the efficiency of research output in academic departments, or the teaching effectiveness. Research on school effectiveness started in the 1960’s with the controversial study “Equality of Educational Opportunity” [123]. Results from this report indicated a lack of importance of the school in explaining academic attainment. This counterintuitive finding led to a number of studies whose goal was to prove that schools and the activities therein do make a difference. These studies began to model education as a production process, where student outcomes were a function of a multitude of variables, categorized into family background, peer influences, school inputs, and innate abilities of students[111], [124].

Given the unobserved heterogeneity among college students, assessing the impact of education for any individual student is difficult. The presence of multiple inputs and multiple outputs make DEA an instructive tool in the education space. Because of the hierarchical structure of student data and the difficulty in obtaining such data, there have not been many applications of DEA, with researchers opting for multilevel modeling statistical approaches instead. Thanassoulis and Portela were one of the first to apply DEA to student-level data [125]–[127]. These papers originally attempted to set achievement targets for school children, and later investigated the source of student attainment. To the best of the author’s knowledge, a DEA analysis on college student data has never been published. The practical aspects of DEA on student level data will be drawn. The DEA models typically have assumed a variable returns to scale and are output oriented [111]. The assumption of variable returns to scale is attributed by the fact that attainment are typically percentages or indices and are not expected to follow a strict mutual proportionality. Output oriented DEA models can be feasible in educational contexts as the inputs used are often determined before the assessment. This methodology can highlight where the greatest impact is being made and can help engineering programs maximize the global perspective development of their students while in college.

5.1.4 High-Impact Educational Practices

The Association of American Colleges and Universities (AAC&U) has called for higher education institutions to embrace essential learning outcomes for student success, which were designed to ensure that students gain knowledge, skills, capacities, and competences to engage locally and globally, to solve significant problems, and to interact with diverse others [58]. The AAC&U have named ten "high impact" educational practices based on research suggesting positive benefits to students regarding the outcomes mentioned above. Included in this list of high impact practices were *diversity/global learning experiences*, along with other engineering relevant experiences such as internships, research, and capstone courses and projects. According to Kuh, these high-impact educational practices are effective because they require dedication from students; require students to effectively communicate; expose students to diverse ideas and people with different backgrounds; provide students with regular assessment; enable students to apply their knowledge and skills outside of the classroom; and have a potential to change students' lives [128]. Diversity and global learning (e.g., study abroad) have been tied to numerous college outcomes including the development of intercultural competence [57]. Findings from Kilgo, Sheets, and Pascarella indicate that active and collaborative learning and undergraduate research were the most beneficial to students in relation to the essential learning outcomes. Study abroad was a positive predictor for intercultural effectiveness and internships, capstone courses, and projects were positive predictors for inclination to inquire and lifelong learning [58]. These findings suggest that not all educational practices have the same influence on student learning (including global perspectives) and that institutions should strive to provide students with opportunities to engage in high-impact practices.

5.2 DATA AND METHODOLOGY

5.2.1 Instrumentation

Data for this study were drawn from an ongoing NSF REE project called *Assessing the Spectrum of International Engineering Education Experiences* (EEC-1160404). As part of this project, an instrument was administered to freshmen and senior undergraduate engineering students across 14 participating universities that included the GPI (as described in section 2.3), background questions, and questions related to prior international experiences.

The student background items included academic level, gender, ethnicity, parents' educational background, type of location where the student was raised (e.g., urban, suburban, rural or small town), college GPA and second language fluency. These variables were chosen based on prior research efforts and literature suggesting a relationship to global perspective development. The experiential items included the number and type of international experience students have previously engaged in and when the experiences were had (e.g. before college or during college). Due to the number of possible international experiences, these experiences were further grouped into more general learning experiences (Table 28) and categorized as curricular, co-curricular, or extracurricular in nature. A description of the learning types can be seen in Appendix I. The total number of experiences and the variety was also recorded. The final instrument took approximately seven to nine minutes to complete, dependent on the number of the students' international experiences.

Table 28. International Experience Types Included in Study 3

<table>
<tr><th>International Experiences</th><th>Learning Type</th><th>Educational Type</th></tr>
<tr><td>Personal tourism</td><td>Personal Tourism</td><td>Extracurricular</td></tr>
<tr><td>Second language course</td><td>Second Language Course</td><td rowspan="6">Curricular</td></tr>
<tr><td>Engineering course with a global focus</td><td rowspan="3">Coursework</td></tr>
<tr><td>Non-engineering course with a global focus</td></tr>
<tr><td>US engineering course with an international project</td></tr>
<tr><td>Study abroad</td><td rowspan="2">Study Abroad</td></tr>
<tr><td>Dual degree program with an international university</td></tr>
<tr><td>US based research project that examines a global issue</td><td rowspan="2">Work or Project</td><td rowspan="5">Co-curricular</td></tr>
<tr><td>Internship/co-op/technical research project conducted internationally</td></tr>
<tr><td>University housing with international focus</td><td rowspan="3">Student Organizations</td></tr>
<tr><td>Engineering focused service learning program</td></tr>
<tr><td>Non-engineering focused service learning program</td></tr>
</table>

*Living abroad (e.g., military service, expatriate living, foreign born) were less than 1% of sample and were excluded for analysis

5.2.2 Sample

The survey was administered to students across 14 participating institutions. These institutions were selected based on their interest and activity in international engineering education, geographic location, and affiliation in an effort to be representative of those US institutions that are supportive of such activities. The NSF project this study is derived from collected survey responses from 2,853 students, including students who: had no international experiences, only had international experiences prior to college, only had international experiences during college, and had international experiences prior to and during college. However, the purpose of this study is to examine the relative impact that international experiences have on students in college so that administrators and facilitators can receive actionable information about the global programming strategies being employed. Therefore, only the subset of senior students who had experiences **during college only** was included in the present study. After students with missing data or exceedingly high frequency of international experience frequencies were removed (approximately 7.9% of the sample), the final sample size consisted of 301 senior engineering students. As stated previously, the general rules of thumb for DEA is for *n* to not exceed the number of inputs plus the number of outputs. This study adheres to this rule of thumb (as described in section 5.2.3).

Approximately 62.1% of the students were male and 74.4% were white, with students of color including Asian/Pacific Islander (15.0%), and underrepresented minority groups (10.6%). Nearly one quarter of the students (20.3%) indicated that the highest educational attainment of their parents was a high school diploma or associates degree, and over a third of the students (39.2%) indicated they were fluent in a second language. A full list of descriptive statistics can be found in Appendix H.

5.2.3 Model Formulation

DEA was used to assist in identifying best practice performance in relation to engineering student global perspectives. Data collected on international experiences (inputs) and dimension scores on the GPI (outputs) formed the basis of the analysis. The underlying assumption in the DEA model is that a relationship exists between the experiences a student has engaged in and their overall global perspectives, an assumption held by many in engineering schools across the US. Using non-parametric linear programming methods, DEA was used to compute an international experience "best practice" or efficiency frontier, as well as the relative inefficiencies of those students not on this frontier. DEA will identify 'peer' students for an individual student and then estimate the efficiency of the student's experiences by comparing its global perspective with that of the best practice students chosen from its peers. Mathematically, a student on the frontier will have an efficiency rating of 1, and students not on the frontier will have a rating less than 1, but nonnegative (Figure 21).

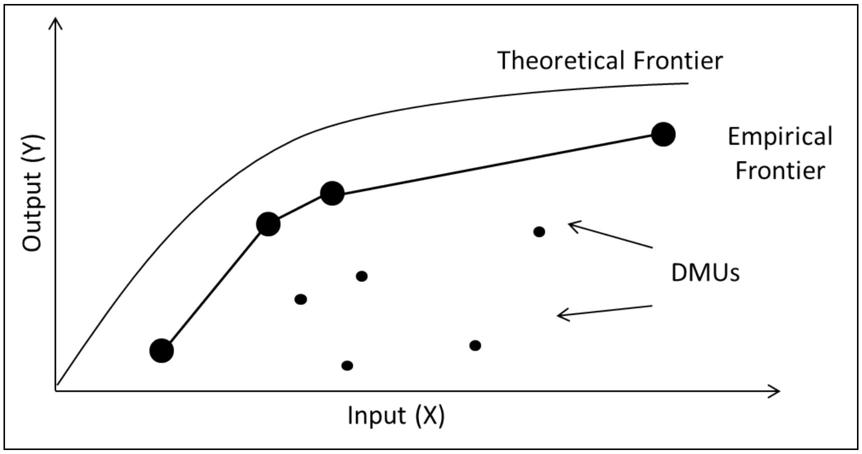


Figure 21. Theoretical and Empirical Efficiency Frontier

For assessment of global perspective development, an input-oriented decreasing returns to scale measure of efficiency BBC model was employed [109], [119]. An input-oriented model was assumed to be more suitable in this context because an institution and its students have more control over the frequency and types of international experiences. Input conservation (reducing the number of experiences a student should participate in and thus the resources required to run them) for given outputs seems more reasonable. Student efficiency in this type of model is broken down into two components: *technical efficiency* and *scale efficiency*. In the context of global perspectives, technical efficiency is a measure by which students are evaluated for their global perspectives relative to the performance of other students in the peer group. Scale efficiency is the extent to which a student can take advantage of returns to scale by changing the number of international experiences toward the optimal amount, defined as the region in which there are constant returns to scale in the relationship between global perspectives and international experiences [129]. Technical and scale efficiency are defined as follows [109]:

$$e_j = \frac{\text{weighted output}}{\text{weighted input}} = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \; for\; j = 1, \dots, n,$$

Where e_j is the technical efficiency score given to student j; x and y represent inputs and outputs and v and u denote input and output weights, respectively; s is the number of inputs (s=1,2,…m), r is the number of outputs (r=1,2,…,n). To solve for technical efficiency under the BCC model, the following linear program (the primal) was formulated [109], [119]:

$$\begin{gathered} \theta_B = \min \theta \\ \text{subject to:} \\ \sum_{j=1}^{n} x_{ij}\lambda_j \le \theta x_{io} \;\text{ for } i = 1, \dots, p \\ \sum_{j=1}^{n} y_{rj}\lambda_j \ge y_{ro} \;\text{ for } r = 1, \dots, q \\ \sum_{k=1}^{n} \lambda_k = 1 \\ \lambda_k \ge 0, \quad k = 1, \dots, n, \end{gathered}$$

Where θ_B is a scalar value that represents the proportional reduction of all inputs of student B and λ_j represents convexity conditions for each student that imposes ways in which the observations for the DMUs may be combined. The BCC primal problem is solved using a two-phase procedure. In the first phase, θ_B is minimized and in the second phase, the sum of the input excesses and output shortfalls is maximized, keeping θ_B at its optimal objective value obtained in phase one [109]. The θ_B will not be less than the optimal objective value of the CCR model since the BCC model imposes one additional constraint regarding the convexity of the frontier. Consequently, scale efficiency (SE) is calculated in the following way for each student:

$$SE = \frac{\theta^*_{CCR}}{\theta^*_{BCC}}$$

where θ^*_{CCR} is the optimal efficiency rating for a student under the CCR model and θ^*_{BCC} is the optimal efficiency rating for a student under the BCC model. The benchmarking software chosen to implement the selected models was OSDEA – i.e., Open Source Data Envelopment Analysis [130].

Figure 22 shows the elements involved in the DEA of engineering students' global perspective development. There are six input variables of interest for this study, which includes the frequency of each type of international experience learning type. The three output variables analyzed are the scores on the GPI dimensions. With a sample of 301 engineering students, the number of variables in the model is well below the recommended maximum. Operational/programmatic elements of international experiences are indicated in Figure 22, even though these were not included in the model. These elements describe the components that qualitatively describe an international program, informed by the work of Besterfield-Sacre et al. [29] and Engle and Engle [22]. These components help describe the potential reasons particular experience types are more impactful but are not studied in detail in this research. As mentioned, an input-oriented model was chosen to investigate how students can reduce the number of international experiences they engage in to attain a specified global perspective level.

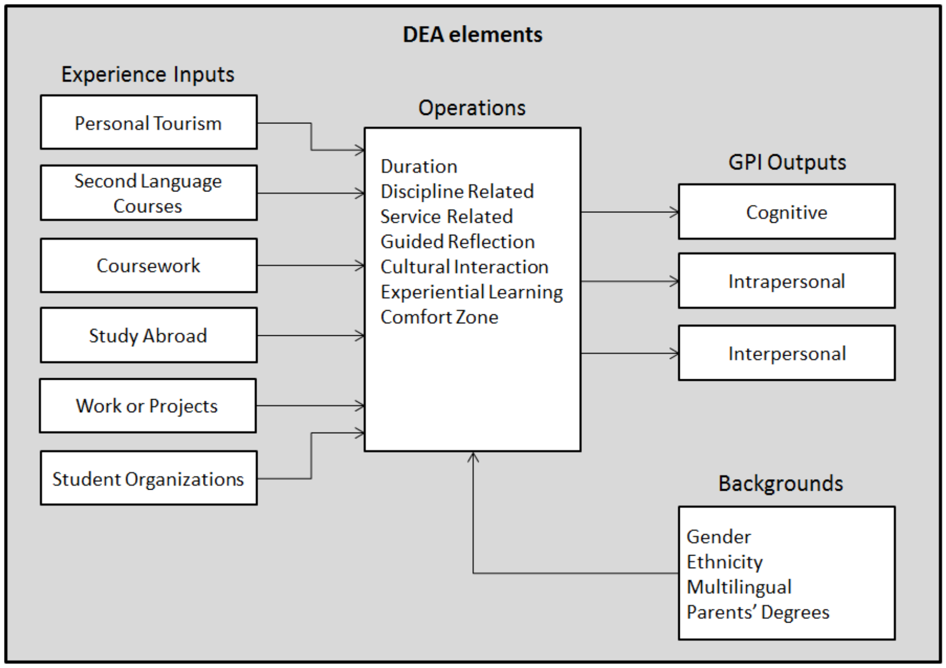


Figure 22. DEA elements for each engineering student

5.2.4 Analytic Strategy

Several analytic methods are used to answer the study's research questions, and are outlined in Figure 23. First, descriptive statistics for all input and output variables are calculated and displayed in Tables 29-31 below. Descriptive statistics for the GPI dimensions are displayed for each subgroup (gender, ethnicity, multilingual, and parents' degrees). The total number and variety of international experiences types, as well as statistics on the educational type of each international experience is reported. Spearman correlations are calculated to get an initial understanding of the relationship between the GPI dimensions and international experience types. Ordinary least squares regressions are then conducted on the GPI dimensions (response). Next, a BCC decreasing return to scale DEA model is employed. Technical and scale efficiency scores are calculated for each student and students deemed technically efficient are contrasted against those deemed inefficient. A deep dive analysis into the most robustly efficient students is explored, and efficiency scores are broken down by student subgroups. Finally, follow-up correlational and logistic regression analyses are carried out to estimate the effect different international experiences have on global perspective efficiency. The international experience types that yield the largest global perspective impact are described in the context of existing international programs that fall into that experience type.

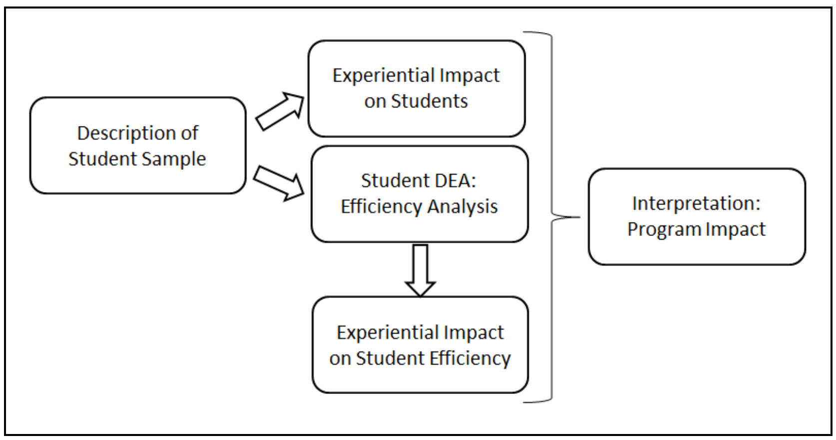


Figure 23. Analytic Plan for Study 3

5.3 RESULTS AND DISCUSSION

5.3.1 Description of Students

5.3.1.1 Inputs

Table 29 shows the frequency of international experiences in the sample of 301 undergraduate senior students who only had experiences during college. The most frequent experience was personal tourism, with almost half (45.5%) of the seniors having this type of experience in college. This is followed closely by coursework (38.5%) and study abroad (37.2%). Work and project experiences are the least frequent (15.9%). Looking closer, assuming a student has had a particular experience type, second language courses (regardless of fluency) and student organizations are the most frequent; and study abroad and work/project experiences are the least frequent. Curricular international experiences were the most common, with almost two-thirds of the sample participating in this type of experience. Co-curricular experiences were the least common, with less than one-third of the sample participating in this type of experience.

Table 29. Inputs – Frequency of International Experiences

Experience Type	**No. of Students**	**Average No.**	**Average (>0)***	**Percent of Total**
Personal Tourism	132	0.85	1.88	45.5%
Second Language	51	0.40	2.35	16.9%
Coursework	116	0.56	1.47	38.5%
Study Abroad	112	0.42	1.14	37.2%
Work or Projects	48	0.22	1.35	15.9%
Student Organizations	95	0.78	2.46	31.6%
Educational Type	**No. of Students**	**Average No.**	**Average (>0)**	**Percent of Total**
Curricular	199	1.39	2.10	66.1%
Co-curricular	94	0.70	2.23	31.2%
Extracurricular	174	1.15	1.99	57.8%

*Average (>0) represents the average number of experiences given a student has had at least 1 of that type

Work by Kilgo, Sheets, and Pascarella has suggested that educational practices such as undergraduate research and study abroad are positive predictors for intercultural effectiveness [58] and prior work by Salisbury, An, and Pascarella found that on-campus diverse interactions and integrative learning also influenced intercultural competence development [57]. Initial findings in this study indicate that most engineering students are not participating in these high-impact practices in large numbers. This is primarily due to participation barriers for these types of experiences, especially in regards to the highly sequenced engineering curriculum [7]. In Table 30, the count of variety of experiences is tabulated. Over half of the sample of college seniors have one type of international experience in college, and only one-third have one experience in college. This implies that the majority of engineering students in this sample are not taking advantage or given the opportunity to participate in high-impact practices related to their global perspectives, nor are they experiencing the breadth of international opportunities available to them.

Table 30. Distribution of Variety of Experience Types

Variety of Experiences	Count	Percentage (%)
1	152*	50.5%
2	82	27.2%
3	39	13.0%
4	15	5.0%
5	12	3.99%
6	1	0.33%

*102 students have only 1 experience; 50 students have more than 1 experience

Spearman correlations were calculated to examine the relationship between the various input measures in the study and the GPI dimension scores. Tables 31 breaks down the correlations between experience types, educational types, total and variety of international experiences. The number of work/projects an engineering student has participated in has positive correlations across all GPI dimensions, and the number of study abroad experiences is positively correlated with the Cognitive dimension. This initially suggests that these types of experiences have the greatest impact on global perspectives. Moreover, the number of curricular and co-curricular international experiences is positively correlated with the Cognitive dimension. The total number of experiences and number of different types of experiences is positively correlated with the Cognitive dimension. More specifically, the number of different types of experiences has a higher correlation with the Cognitive dimension than the raw number of experiences, indicating that participating in a variety of different international experiences has a larger effect on global perspectives related to recognizing the importance of cultural context in judging what is important to know and understanding various cultures and their impact on society

Table 31. Spearman Correlations Between Inputs and GPI Dimensions

Experience Type	**Cognitive**	**Intrapersonal**	**Interpersonal**
Personal Tourism	0.063	0.027	-0.017
Second Language	0.073	0.014	0.091
Coursework	0.068	-0.019	0.046
Study Abroad	0.177*	0.044	0.083
Work or Projects	0.175*	0.152*	0.122*
Student Organizations	0.051	0.062	0.039
Educational Type	**Cognitive**	**Intrapersonal**	**Interpersonal**
Curricular	0.137*	-0.030	0.061
Co-Curricular	0.138*	0.065	0.094
Extracurricular	0.081	0.071	-0.026
Breadth	**Cognitive**	**Intrapersonal**	**Interpersonal**
Total	0.156*	0.030	0.059
Variety	0.241*	0.097	0.101

*Significant at p<0.01

Figure 24 depicts the relative gain in the Cognitive dimension for a unit increase in both the total number of experiences and variety. Data on senior engineering students with no international experiences is included in this table and is from the larger dataset for which this study is based. It initially appears that the variety of international experiences is more indicative of higher GPI scores, particularly in the Cognitive dimension.

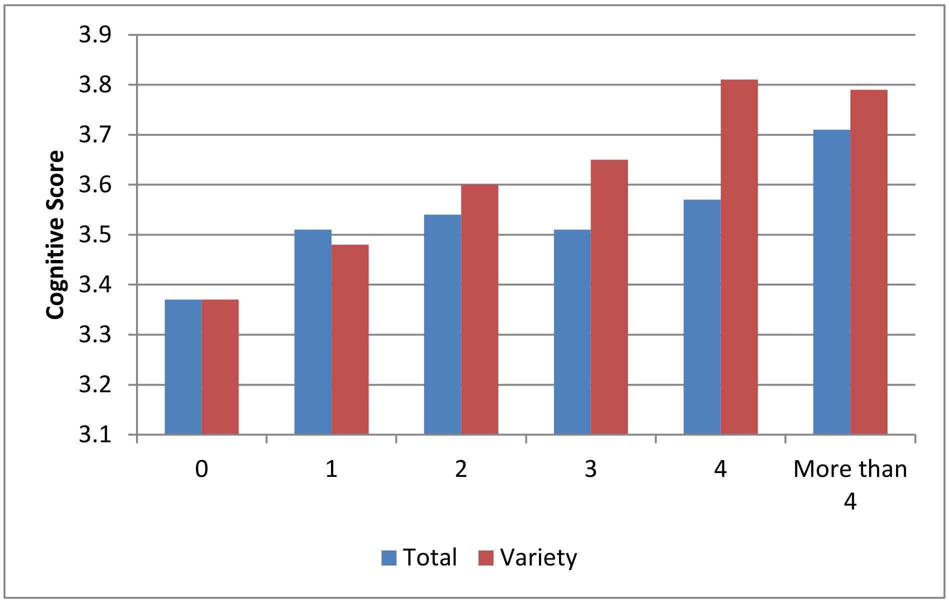


Figure 24. Comparison of Cognitive Scores by Total and Variety

5.3.1.2 Outputs

The GPI dimension scores were calculated for each subgroup in the study (see Table 32). Female engineering students scored significantly higher than males in the cognitive and interpersonal dimensions. Underrepresented minority students and Asian students scored significantly higher than white students in the interpersonal dimension. Finally, engineering students who are multilingual scored significantly higher than students who are not multilingual in the interpersonal dimension. No significant differences in global perspectives exist between first generation college students and those students who have at least one parent with an advanced degree. It initially appears that the difference in global perspectives between subgroups is fairly minimal for those students with international experiences in college only, with significant differences existing mostly in the interpersonal dimension, which describes how students relate to others from different cultures, backgrounds, and who have different values.

Table 32. Outputs-GPI Dimension Averages by Subgroup

All	**n**	**Cognitive**	**Intrapersonal**	**Interpersonal**
Total	301	3.57	3.97	3.40
Gender	**n**	**Cognitive***	**Intrapersonal**	**Interpersonal***
Males	187	3.53	3.98	3.36
Females	114	3.62	3.96	3.46
Ethnicity	**n**	**Cognitive**	**Intrapersonal**	**Interpersonal***
White	224	3.58	4.00	3.34
Asian	45	3.52	3.83	3.54
URM	32	3.51	3.99	3.55
Multilingual	**n**	**Cognitive**	**Intrapersonal**	**Interpersonal***
No	183	3.55	3.94	3.34
Yes	118	3.59	4.02	3.49
Parents' Degree	**n**	**Cognitive**	**Intrapersonal**	**Interpersonal**
HS or Associate	61	3.55	3.95	3.45
BS	122	3.56	3.97	3.35
MS or PhD	118	3.58	4.00	3.42

***Significant at $p < 0.05$

5.3.2 Experiential Impact on Global Perspectives

The Spearman correlations in Table 31 indicate that the strongest relationship between the number of international experience types and GPI scores occurs in the Cognitive dimension. Therefore, when analyzing the experiential impact on student global perspectives, the primary output of interest is the Cognitive score. Ordinary least squares regressions were conducted on this dimension, using the various input measures as predictors. Three models were formulated, one for each set of experience input measures. Table 33 describes the results of the least squares regression analyses. A stepwise regression analysis was conducted on the model using frequency of experience types as a predictor to find the parsimonious combination of international experiences that yields the highest Cognitive scores. The other two regression analyses using educational types and breadth were conducted on all predictors due to the smaller number of variables.

Table 33. Least Squares Regression Results (Inputs with GPI Cognitive Dimension Scores)

	Experience Types $R^2 = .06$				**Educational Types $R^2 = .03$**				**Breadth $R^2 = .06$**		
	β	S.E	p-value		β	S.E	p-value		β	S.E	p-value
Work/Project*	0.13	0.04	0.002	**Curricular**	0.04	0.01	0.01	**Total**	-0.00	0.01	0.82
Study Abroad	0.11	0.04	0.005	**Co-curricular**	0.00	0.01	0.80	**Variety**	0.09	0.03	0.00
				Extracurricular	0.02	0.02	0.14				
Constant	3.49	0.03	0.00	**Constant**	3.49	0.04	0.00	**Constant**	3.39	0.04	0.00

*Only significant predictor of Intrapersonal and Interpersonal scores

The findings from the regression analyses shows that work/projects and study abroad have a small but significant relationship on the cognitive score of the GPI (and the number of work/project experiences was also significant on the intrapersonal and interpersonal scores). Curricular experiences have a significant, but marginal, effect on the cognitive score. Finally, when controlling for the number of international experiences an engineering student has participated in, variety of experience types showed a significant and positive relationship with cognitive scores. Likewise, when controlling for the variety of experience types, the total number of experiences is not significant. This reinforces the finding that students benefit more in terms of their global perspectives when engaged in a variety of international experiences (in contrast to simply having a multitude of them). So while international internships, co-ops, and research projects, along with study abroad, appear to be the most impactful on students' global perspectives, the results stress the importance of engineering schools having a variety of program types in their portfolio. Not all experiences target the same learning outcomes and having a multitude of different types of experiences may allow students to conceptualize what they have previously learned in context and consequently transfer that knowledge to new situations. While the depth of an international experience has been documented [22], [131], [132], the importance of breadth of international experience engagement has been understated in the literature.

Furthermore, there seems to be a misalignment between the types of international experiences that have the most impact, and the actual experiences most students engage in. Engineering programs therefore should prioritize strategies that make study abroad programs and international internships/co-ops/research project more accessible to their respective student populations. The resources and time required for faculty and students alike to be engaged in global programming, let alone a variety of different experiences, is a constraint on the system that cannot be ignored. The empirical effects international experiences have on students' global perspectives are also limited. This underscores the importance of determining which types of international experiences have the most impact on engineering students, so that resources and time can be allocated efficiently. DEA is used to explore this impact and the factors that affect efficiency.

The low R^2 values in Table 33 are noteworthy but not unexpected. The purpose of the modeling is to identify potential relationships between experience types and GPI scores and is not predictive in nature. Based on the results in Chapter 2 and the nature of student development, it is not surprising that the number of experiences alone cannot explain a larger portion of the variation in the Cognitive scores. This dissertation presumes that the development of global perspectives is as much about student backgrounds, institutional practice and culture, and prior exposure to intercultural settings as it is about participation of college international experiences. So while the R^2 value might be lower than desired, it supports the overall premise of the dissertation as well as the previous results.

5.3.3 Data Envelopment Analysis

In this section, the input-oriented efficiency scores obtained from the CCR and BCC models are reported and discussed. It is worth noting that input-oriented efficiency measures address the question: “By how much can input quantities (number of experiences) be proportionally reduced without altering the output quantities (global perspective scores)?” Figure 25 shows the distribution of the technical efficiency scores of the 301 engineering students. Table 34 presents the overall technical efficiency scores (OTE), pure technical efficiency (PTE) scores and scale efficiency (SE) scores. Recall that scale efficiency is the ratio of efficiency with a constant return to scale (OTE) with the efficiency with a variable return to scale (PTE). The average OTE score was 0.502, which suggests that an average student, if producing on the best practice frontier instead of his/her current location, would need only 50% of the inputs currently being used. This suggests that by adopting programmatic best practices, students on average can reduce the number of experiences they participate in by at least 49.8% and still maintain the same global perspective level. However, the potential to reduce the amount of experiences from adopting best practices varies from student to student. Alternatively, students have the scope of scoring 2 times (i.e., 1/0.50) higher from the same number of international experiences.

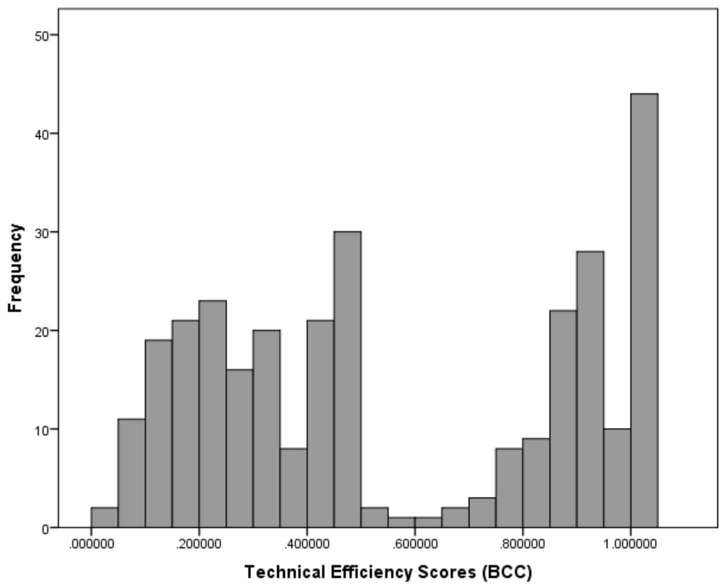


Figure 25. Histogram of Pure Technical Efficiency (PTE) Scores

Overall technical efficiency (OTE) combines the efficiency that is due to pure technical (or operational) efficiency and efficiency that is due scale efficiency (i.e., appropriate number of experiences). PTE scores assume that all inefficiencies directly result from student inefficiency in not getting the most out of their past international experiences or, more likely, not choosing the most optimal experiences.

Table 34. Descriptive Statistics of Efficiency Scores (Technical and Scale)

Statistics	OTE	PTE	SE
N	301	301	301
Average	0.502	0.556	0.937
SD	0.32	0.33	0.19
Average inefficiency (%)	49.8	44.4	6.3

Thirty-six students were found to be “locally efficient” since they had a PTE score of 1 (Table 35). These students together define the best practice frontier under the VRS assumption and form the peer group for inefficient students. Seventeen of these students were found to be “globally efficient” since they had OTE scores of 1. These students defined the best practice frontier under the CRS assumption. So inefficiency in global perspective development is due to both poor experience utilization and failure to operate at the most productive scale size, with the majority of students falling into the former category. The average PTE score has been observed to be 0.556. This implies that 44.4 percentage points of the 49.8 percent of OTE is due to student who are not following best practice and participating in a less than optimal experience combinations. The rest of the OTE is due to students simply going on too many similar experiences that do not lead to an increase in their global perspectives in return. Based on this result, it is posited that the underlying problem is not that students are not going on enough international experiences while in college. Rather, students are under utilizing the experiences they are currently going on by not participating in ones that provide the largest impact. This could be due to the structure and quality of the experience itself, the innate qualities of the student, or simply engaging in low impact experiences.

Table 35. Experience Averages of Efficient and Non-Efficient Students

Student Groupings	Efficient	Not Efficient
n	36	265
Inputs		
Personal Tourism	0.83	0.86
Second Language	0.33	0.41
Coursework	0.36	0.59
Study Abroad	0.33	0.43
Work or Projects	0.42	0.19
Student Organizations	0.47	0.82
Outputs		
Cognitive	3.98	3.51
Intrapersonal	4.48	3.91
Interpersonal	4.03	3.31

To fully describe the 36 efficient students, a separation method used by Kumar and Gulati [133] was adopted. This uses the frequency of the peer groups to distinguish between them. The frequency with which an efficient student shows up in the peer groups of inefficient students represents the extent of robustness of that student relative to other efficient students. A student that appears frequently in the peer groups of inefficient student is likely to be a student who is efficient with respect to a large number of factors, and can be considered a "well-rounded performer." Efficient students who rarely appear in the peer groups are likely to possess a very uncommon input/output mix and are not suitable examples for other students to emulate. Students with zero frequency in the peer groups are termed "efficient by default" because they do not possess characteristics which must be followed by other inefficient students. Table 36 provides the summary of efficient students.

Table 36. Breakdown of Scores of Efficient Students

	Personal Tourism	Second Language Course	Coursework	Study Abroad	Work/Project	Student Organizations
n*	16	7	12	10	10	11
Efficiency Average	0.83	0.33	0.36	0.33	0.42	0.47
Efficiency Average (>0)	1.88	1.71	1.08	1.2	1.5	1.55
Total Average	0.85	0.40	0.55	0.42	0.22	0.78
Total Average (>0)	1.88	2.35	1.47	1.13	1.35	2.46
Difference in Average	-0.02	-0.07	-0.20	-0.09	0.20	-0.31
Difference in Average (>0)	-0.00	-0.64	-0.38	0.07	0.15	-0.92

*Number of students who have participated in that type of experience

Students who were categorized as efficient have, on average, less experiences of every type except for work/project experiences. When looking at the students who had a particular experience at least once, those categorized as efficient, on average, have less experiences of every type except for work/projects and study abroad. Personal tourism only had a very slight change in differences in averages. Consequently, second language courses, coursework, and student organizations are not associated with efficient students, which suggest their impact on global perspectives may be more limited when done in isolation compared to higher impact experiences such as study abroad and work/project experiences. Personal tourism does not appear to have much of an effect on efficiency one way or the other. Out of the 36 efficient students, 4 were categorized as well-rounded performers and 11 were categorized as efficient by default. The well-rounded performers all have only 1 experience, each with a different experience and slightly different background. The experiences included in this subset include personal tourism, coursework, study abroad, and student organizations. The well rounder performers are the benchmark for which inefficient students should try to meet, since their experience combination is more easily attainable. The most robust student (i.e., the student who was included in 34% of the peer groups, the highest of any student) was a white, male student with a study abroad experience in college. This experience was 1-3 months in duration, was not engineering related, nor had any journaling or service components. The 18 efficient by default students had more experiences, on average, than the rest of the efficient students in the sample especially personal tourism, work/project experiences, and student organizations. These students were not included in any of the peer groups, and were not used as a reference for efficiency. The experience patterns these students exhibited is difficult to replicate by others and there are other students in the efficiency group that had more representative experiences

Efficiency scores were also broken down by subgroups (Table 37). The average PTE scores across subgroups are only marginally different, with slight advantages occurring for males, URM students, multilingual students, and students with parents' highest education level of HS, Associates, or BS. This initially suggests that the efficiency of global perspective development among engineering students is not primarily due to the backgrounds of the students, but instead potentially due to a combination of other factors, including the experience type and quality, the innate characteristics of the student, and previous life experiences and general upbringing.

Table 37. Efficiency Scores by Subgroup

	n	PTE	SD	% efficient
Gender				
Male	187	0.58	0.33	12.3
Female	114	0.52	0.33	11.4
Ethnicity				
White	224	0.56	0.33	11.6
Asian	45	0.52	0.33	11.1
URM	32	0.59	0.33	15.6
Multilingual				
No	183	0.58	0.33	10.9
Yes	118	0.52	0.33	13.6
Parents' Education				
HS or Associate	61	0.56	0.35	13.1
BS	122	0.58	0.33	13.1
MS or PhD	118	0.53	0.32	10.2

*12% of students deemed efficient

5.3.4 Experiential Impact on Student Efficiency

Table 38 describes the results of the correlation analysis between the number of experiences and PTE scores. Naturally, all of the correlations are negative because as a student participates in more experiences, efficiency of global perspective development will decrease by definition. In fact, all of the experience types have a significantly negative correlation with PTE scores, with the exception of work/project experiences. Study abroad had the second lowest correlation. This supports the results from above that indicate work/project experiences and study abroad are the experiences that provide the biggest impact to students' global perspectives.

Table 38. Spearman Correlations Between Inputs and Efficiency

Experience Type	Rho
Personal Tourism	-0.299
Second Language	-0.255
Coursework	-0.294
Study Abroad	-0.172
Work or Projects	-0.036[€]
Student Organizations	-0.372

€ Only not significant correlation ($p < 0.05$)

Table 39 describes the results of the logistic regression analysis. Work/project experiences came out as the only significant predictor of efficiency. On the basis of these findings, it can be concluded that efficiency of engineering students' global perspective development is positively influenced by the amount of international internships, co-ops, and research projects. International experiences are not created equal, with certain types of experiences being more impactful than others. It is worth mentioning the low Nagelkerke R^2 value, which indicates that approximately 6% of the variation in whether or not a student is on the efficiency frontier of the DEA model is due to the linear combination of experiences a student has had. This points to the notion that a student's global perspective is a result of more than just the experiences they have engaged in, but also family backgrounds, peer influences, the learning environment, and innate abilities and desires.

Table 39. Logistic Regression Analysis on Efficiency

	Experience Types Nagelkerke R^2 = .06			
	β	**S.E**	**Odds Ratio**	**p-value**
Personal Tourism	-.44	.14	.96	.76
Second Language Course	.00	.18	1.0	.99
Coursework	-.41	.27	.67	.13
Study Abroad	-.28	.34	.76	.42
Work or Projects*	.60	.26	1.82	.02
Student Organizations	-.13	.15	.88	.38
Constant	-1.8	.30	0	.00

*Significant at $p < 0.05$

5.4 IMPLICATIONS

The primary objective of this study was to apply DEA to examine the relative impact that certain types of international experiences have on engineering students' global perspectives. The preliminary findings indicate that engineering students are not engaging in the types of international experiences that provide the largest impact on global perspectives as measured by the GPI. More specifically, the least frequent experience type of internships, co-ops, or technical research projects conducted abroad also had the highest association with the GPI dimensions, and DEA revealed that these types of experiences are also associated with global perspective development efficiency. This is not surprising given the logistic hurdles of sending engineering students abroad, which includes a content-full, highly sequenced curriculum, risk in delaying graduation, and finding suitable partners abroad. The DEA findings also indicated that the inefficiencies in global perspective development are mostly due to students not getting as much out of the opportunity as their peers, caused either by what the student is bringing to the experience or the structure of the experience itself. Inefficiencies were only marginally caused by economies of scale (i.e., students engaging in a large number of experiences without the expected global perspective return). The educational strategy around this finding should be to encourage students who have not had any international experiences to participate in one, since the largest impact on global perspectives happens when a student goes on their first international experience/program (Figure 24). But more importantly, design global programming strategies around a variety of high-impact practices and encourage students to engage in these types of experiences, specifically international work or research opportunities. Students who want to maximize their global perspective development in college should therefore (1) seek out high-impact global programming programs and (2) participate in varied experience types that are curricular and co-curricular in nature. This benchmarking analysis also points to a means by which global perspectives *should* be developed in students. Instead of designing programming with the goal of turning the entire student population into high scoring students, engineering schools should instead attempt to improve the global perspectives of students to what is empirically possible given the experiences available to them.

Besides experience types, what other factors affect the development of global perspectives? This study found that for students who come to college with no prior international experiences, background characteristics mainly affect the interpersonal dimension, which consists of interdependence, social concern for others, engaging with others who are different, and being culturally sensitive. Females, underrepresented minority students, and those who are fluent in another language scored significantly higher in this dimension. For females, the GPI norms suggest the increase in the interpersonal dimension compared to males is due to social responsibility. No significant differences were found for first generation college students. Even though the subgroups included in this study had a significant effect on one of the GPI dimensions, the DEA revealed no significant differences in efficiency by subgroup. This initially suggests the difference in impact that international experiences between student groups is minor, at least for those students who all have similar upbringings. Future research is needed to further explore this phenomenon, including how students' precollege experiences affect their global perspective development while in college. Given the increasing diverse student population entering the engineering discipline, global programming strategies should make concerted efforts to attract a diverse set of students to participate in international experiences and design programming portfolios around the multitude of student needs and interests.

Internships, co-ops, and research projects conducted internationally emerged as the most impactful type of experience both in terms of associations with the scores of the GPI dimension and efficiency. While the connection between impact and particular international programs was not explored, an overview of the programs that fit into this experience type from the sample are described and can be viewed as "exemplary programs" of high-impact practice in international engineering education (Table 40).

Table 40. Engineering International Internship and Research Projects included in Study 3

Program Name	Source
Global Internship Program (GIP)	oie.gatech.edu/gip
Global Internships and Education Abroad	egr.msu.edu/global/map/international-presence
Researching Fresh Solutions to the Energy/Water/Food Challenge in Resource Constrained Environments (REFRESCH)	thirdcentury.umich.edu/refresch/
International Internship Program	seas.virginia.edu/admin/pdf/international_internship.pdf
Interactive Qualifying Project (IQP)	wpi.edu/academics/undergraduate/project-based-learning/interactive-qualifying-project

5.5 CONCLUSIONS

This research study was conducted to explore how engineering students utilize international opportunities in college and determine which types of programs have the most impact on a student's global perspectives. DEA and statistical analyses were used to explore the types of international experiences senior engineering students participated in, the relative efficiency of student experience patterns, the reasons for inefficiency in international experience engagement, and the differences in global perspective development among subgroups. This study provided initial empirical evidence on the differential impact of international experiences for engineering students, giving global engineering program facilitators a better understanding of where to focus their programming efforts and how to advise students to best take advantage of the international opportunities while in college. To prepare future engineering student populations to be globally competent, an understanding of the most impactful strategies and programs, given a relative crowded engineering curriculum, is critical. As engineering schools and institutions continue to invest time and resources into global education, it is important to determine how students can get the most "bang for their buck", especially as students are presented with more and more options as to the types of activities and educational practices they can engage in during college.

6.0 SUMMARY AND CONTRIBUTIONS

Several contributions to the global engineering education literature can be derived from this research study. These contributions are divided into two sections: those regarding the type of analyses conducted, and those regarding empirical findings and implications.

6.1.1 Contributions of the type of study

The effect that international experiences and programs have on students' global competency has been studied by engineering education and international education researchers. In general, past research has studied the effects that particular programs have on students by measuring global competency before and after the experience. Additionally, program success has been largely measured by the number of students who have participated in it, or the growth of the program by those same metrics. While these types of studies are valuable in mapping the landscape of the types of programs that exist and how programs can increase participation in international experiences, they fall short in a couple of respects. First, measuring the impact of an international program by assessing students before and after undermines the developmental nature of global competency. Global education research should analyze experiences, perspectives, cognition, and behaviors. In general, students learn best when they can link new knowledge to prior experiences and to the questions they now have. Therefore, global education should be integrated into multiple aspects of their education, allowing them to reflect and conceptualize what they have previously observed. This requires a more comprehensive evaluation strategy for global engineering education beyond pre- and post-assessments. Second, these studies are restricted to smaller samples in a single program or usually do not account for other factors that have been shown to have an effect on global competency. Based on these shortcomings, this research approaches global engineering education in a systematic way, with the premise that it takes more than international experiences alone to develop globally competent engineers. It simultaneously investigates strategies, backgrounds, and experiences using varied analytical tools. This was done by involving a set of schools that have a history in engaging in global programming efforts and drawing on their collective experiences. It also collected student data from more than a dozen institutions across the country and analyzed experience types instead of programs unique to particular institutions. Further, this study is the first to cluster students based on their global perspective scores. Finally, most research on the impact of international experiences has been isolated to a particular program type. The research presented here is one of the first studies that empirically investigates and compares the relative impact of a multitude of experience types, as well as the factors related to this impact.

6.1.2 Empirical contributions to the literature

Several results are found that contribute to the international education literature and specifically to the literature devoted to global engineering education.

Currently, no operational model exists that guides engineering programs to make informed decisions on how to internationalize the curriculum or prepare students in a sustainable way. As outlined in the first study, a contextually relevant GEP model was developed that engineering schools can use in the design and management of their global programs, policies, and initiatives. It broadens the scope of strategies beyond international experiences to aspects such as supportive structures, change agents, program models, and management for sustainability. The most important target areas are ‘Student Funding, Affordability, and Access’, ‘Generating Faculty Buy-In’, and ‘Student-Focused Program Models’. However, the model also describes what areas are most useful in strategic program development, which have the highest likelihood of success, and which should be prioritized in strategic planning. Practitioners can use the GEP model to evaluate their current global programming efforts by identifying which areas they are supporting (or not supporting).

Study 2 provided a holistic conceptualization of the extent to which student and international experiences backgrounds are distinguished between different global perspective patterns. The results suggest that there are many global perspective typologies that exist among engineering students, and are affected by a number of factors, many of which have nothing to do with their international experiences in college. An understanding of the different typologies is important for practice and policy (especially in reference to the use of the GEP model). Global programming strategies need to adapt to the increasingly diverse group of students that are choosing the engineering discipline, eliminating a one-size-fits-all strategy for preparing students. This research provides an understanding of how different types of students conceptualize global perspectives. It is posited that programs, policies, and initiatives will have the most impact if they are aligned with student needs and perspectives. The unique typologies identified in this study support the need for differential global programming strategies and experience portfolios.

Findings from Study 3 indicate that engineering students are not necessarily participating in the types of international experiences that provide the largest impact on global perspectives. Internships, co-ops, and technical research projects conducted abroad have the strongest relationship with global perspectives and were shown to get the most “bang for your buck” compared to other experience types. The findings from this study also suggest that “inefficiencies” in global perspective development is mostly due to students not getting as much out of the experiences as their peers, most likely due to personal traits of the student or of the quality of the experience itself. Further, inefficiencies were only marginally caused by engaging in too many experiences. The educational implications for this include encouraging students to seek out high-impact international experiences of multiple types while in college. It also means that engineering programs should attempt to improve the global perspectives of students to what is empirically possible given their background and the experiences available to them, instead of a theoretical maximum.

Overall, this research provides foundational evidence on how engineering schools can better prepare their student populations to be successful in the global workforce, as well as provide knowledge regarding how schools can develop sustained, school-wide global programming strategies. Further, this research points out that global education should be comprehensive, systematic, and seen as a core piece of students’ college education. Former University of Pittsburgh senior international officer William Brustein echoed this point, stating “if we are to achieve global competence, then we are obliged to internationalize the educational experience…to develop a comprehensive and coherent curriculum that will train students to become globally competent critical thinkers.” [134] Global engineering education, therefore, requires consideration of how students conceptualize global competency, the experiences that provide the largest impact, as well as the college environments and strategies that support sustainable student growth for 21st century.

7.0 LIMITATIONS AND FUTURE WORK

7.1 LIMITATIONS

The data source for Study 1 was 60-90 minute interviews of the SMEs. Supporting documents were not obtained from the schools that outline their internationalization strategic plan or the organizational structure for which these programs operate. Because many schools did not have an articulated strategic plan or if they did, the plan was proprietary in nature, there was some information loss when translating strategies schools are actually adopting. Individuals were interviewed one-on-one from each institution (with the exception of our home institution). However, each person interviewed is an expert on international education at his/her respective institution. Some of the SMEs are housed in the engineering school, while others were part of the study abroad office of the university. This was due to the organizational infrastructure of international education at the institution. Even though we collected data from 9 institutions and 10 SMEs in a selective fashion, these institutions have a long track record of successful global programming initiatives and high student participation. Notwithstanding these limitations, the results of this study are of high quality because measures were taken to ensure validity and reliability throughout.

Studies 2 and 3 also presume the importance of global perspectives to engineering programs. While this is certainly an outcome most in the community agree is important, what outcomes engineering programs value in terms of policy making can vary. Future work should include these other important metrics, especially those tied to engineering career trajectories and overall human development. Furthermore, global perspectives were identified and defined based on a single, self-report instrument measured at a particular point in time. This limitation is not uncommon in international education research, due to the complex nature in assessing this latent trait. And although the sample used in this study is representative of the engineering student population and broad in scope, it precludes any causal conclusions from being inferred. To fully understand how engineering students develop global perspectives, a longitudinal assessment is needed. This type of data is often difficult or impossible to obtain (especially after graduation), thus, a longitudinal analysis could not be the primary focus of the study.

7.2 FUTURE WORK

Future work will expand and strengthen the generalizability of the findings for Study 1 by collecting data from a more varied collection of engineering schools and leveraging supportive documentation. This work can be extended by further analyzing and coding the interview data regarding GEP resources, output metrics, outcomes (student and program), and assessment strategies. The qualitative findings, along with the results from this study, can aid in the development of a GEP logic model (Appendix E) for future engineering program evaluation efforts. A resulting GEP evaluation instrument would be designed around the GEP Model and logic model, which will broadly measure internationalization efforts by engineering programs and create a benchmark for areas of improvement for the discipline.

The findings from Study 2 provide several implications for future research. First, this study is one of the first to systematically examine engineering student global perspective patterns through the lens of background and overall international experience variables. The findings indicate the heterogeneity among students' global perspectives based on the variables selected for the study. Future research will attempt to replicate these findings to determine whether the global perspective patterns discovered in this investigation hold up using other data sets and other variables. Future research would also attempt to describe these patterns in a qualitative fashion, so that the research community can get a more nuanced and contextual understanding of the differential nature of these perspective patterns. Continuing to examine, refine, and add to these findings is important to better understand how engineering students develop global perspectives and how global programming strategies interact with this development. Future research should explore the longitudinal trajectory of different global perspective patterns, as well as a more in-depth analysis into the relative impact international experiences such as study abroad have on different engineering population subgroups. Finally, the findings from this study can be utilized to better inform global programming research. Identifying different global perspective patterns of engineering students could assist international education researchers in examining whether there are differential effects of experiences and programs based on different global perspective groups. Research is currently lacking the specificity of being able to identify which international experiences have the most impact and for whom. This study provides a foundation for which we can begin to address this question.

The findings from Study 3 also provide several implications for future research. This study is the first to examine engineering student global perspective development through a benchmarking approach. Due to the increasing heterogeneity among engineering students, future research efforts should be conducted that compare students with similar experience patterns, so the desired gains in global perspectives can be realistic instead of theoretical and based on the "average student". Future research should also attempt to describe inefficiencies and experiential impact in a qualitative way, so the global engineering education community can begin to understand what aspects of the global engineering education system are most influential in attracting students to engage in high-impact educational practices and the characteristics that help students get the most out of their international experiences. Finally, the methodology of this study can be utilized to formulate long-term assessment plans for the internationalization of engineering programs in the form of cost-benefit analyses, which dovetails with future efforts from Study 1 (more detail can be read in Appendix E). Instead of the DMUs being students, a DEA analysis of engineering programs resource utilization regarding their global programming strategies can be conducted. As the need to prepare engineering students for the global workforce continues to be emphasized, research will be needed on how factors such as organizational infrastructures, financial structures, student costs, levels of staffing, and dedicated space, are being utilized to achieve the desired outputs and outcomes of their global programming strategies. These outputs could focus on global perspective development, but may also include metrics such as participation rates, overall growth, and employability. This study provides a methodological foundation for which these types of questions can begin to be addressed.

APPENDIX A

NSF GRANT INSTRUMENT USED IN CHAPTER 2 AND 3

Q1.1 **Assessing International Experiences – University of Pittsburgh Survey**

Q1.2 This questionnaire should take an estimated time of 7-15 minutes to complete. It consists of the following five sections: Part 1. Your Background: 7 questions (1-2 min) Part 2. Educational Background: 3 questions (< 1 min) Part 3. Global Perspective Inventory: 35 questions (3-5 min) Part 4. International Background: 3 questions (1-2 min) Part 5. International and Intercultural Experiences: 7 questions (2-5 min). We suggest that you complete the survey in one sitting as you will not be able to exit the survey and return later. Thank you ahead of time for your participation!

Q2.1 Part 1. Your Background (1-2 min)

Q2.2 What is your gender? (Select one)

- Male
- Female
- Other
- Prefer not to answer

Q2.3 Please indicate your academic level by selecting the option which mostly closely matches your level. (Select one)

- First year (Freshman)
- Second year (Sophomore)
- Third year (Junior)
- Fourth year (Senior)

Q2.4 Which of the following most accurately describes your country of birth and citizenship status? (Select one)

- At least one of my grandparents, my parents and I were born in the U.S.
- At least one of my parents and I were born in the U.S.
- I was born in the U.S. but not my parents
- Foreign born
- Citizen of another country, student or visa
- Other (please explain) ____________________

Q2.5 How long have you lived in the United States? (Select one)

- Less than 1 year
- 1-5 years
- 6-10 years
- 11-15 years
- 15+ years

Q2.6 Have you lived outside of the U.S? (Select one)

- Yes (how long?) ____________________
- No

Q2.7 Please indicate the location that best describes where you were raised. (Select one)

- Urban Setting
- Suburban Setting
- Small Town Setting
- Rural Setting

Q2.8 How do you identify yourself racially/ethnically? (Select all that apply)

- ❑ African descent
- ❑ Asian descent (including the Indian subcontinent)
- ❑ Pacific Island descent
- ❑ Indigenous Person (Aboriginal, Alaskan Native, Maori, Native American, etc.)
- ❑ Hispanic, Latino/Chicano descent
- ❑ Arab or Middle Eastern descent
- ❑ Caucasian European descent, not Hispanic
- ❑ I choose not to self-identify

Q3.1 Part 2. Educational Background (< 1 min)

Q3.2 Please indicate your major field(s) of study. (Select all that apply)

- ❑ Bioengineering
- ❑ Chemical Engineering
- ❑ Civil and Environmental Engineering
- ❑ Computer Engineering
- ❑ Electrical Engineering
- ❑ Engineering Physics
- ❑ Industrial Engineering
- ❑ Materials Science and Engineering
- ❑ Mechanical Engineering
- ❑ Freshman Year Program
- ❑ Other Non-Engineering Major (e.g. chemistry, business) ____________________

Q3.3 What is your current Grade Point Average (GPA)? For entering students, indicate "no college GPA". (Select one)

- ❍ < 2.00
- ❍ 2.00-2.49
- ❍ 2.50-2.99
- ❍ 3.00-3.49
- ❍ 3.50-4.00
- ❍ Freshman - no college GPA

Q3.4 Please indicate your parent(s)/guardian(s) highest degree achieved. If your parents/guardians have different degrees, please indicate the highest level achieved. (Select one)

- ❍ Less than High School
- ❍ HS Diploma
- ❍ Associate's Degree (2 years)
- ❍ Bachelor's Degree (4 years)
- ❍ Master's Degree
- ❍ Doctoral Degree/M.D/D.D.S

Q4.1 **Part 3. Global Perspective Inventory (3-5 min)**

Q4.2 Please indicate the extent to which the items most closely describe you by marking the response that most closely matches your experiences and/or self-perception. Please be candid in your responses, as no individual will be identified from the index.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
When I notice cultural differences, my culture tends to have the better approach.	❍	❍	❍	❍	❍
I have a definite purpose in my life.	❍	❍	❍	❍	❍
I can explain my personal values to people who are different from me.	❍	❍	❍	❍	❍
Most of my friends are from my own ethnic background.	❍	❍	❍	❍	❍
I think of my life in terms of giving back to society.	❍	❍	❍	❍	❍
Some people have a culture and others do not.	❍	❍	❍	❍	❍
In different settings what is right and wrong is simple to determine.	❍	❍	❍	❍	❍
I am informed of current issues that impact international relations.	❍	❍	❍	❍	❍
I know who I am as a person.	❍	❍	❍	❍	❍
I feel threatened around people from backgrounds very different from my own.	❍	❍	❍	❍	❍
I often get out of my comfort zone to better understand myself.	❍	❍	❍	❍	❍
I am willing to defend my own views when they differ from others	❍	❍	❍	❍	❍
I understand the reasons and causes of conflict among nations of different cultures	❍	❍	❍	❍	❍
I work for the rights of others.	❍	❍	❍	❍	❍
I see myself as a global citizen.	❍	❍	❍	❍	❍
I take into account different perspectives before drawing conclusions about the world around me.	❍	❍	❍	❍	❍
I understand how various cultures of this world interact socially.	❍	❍	❍	❍	❍
I put my beliefs into action by standing up for my principles.	❍	❍	❍	❍	❍
I consider different cultural perspectives when evaluating global problems.	❍	❍	❍	❍	❍
I rely primarily on authorities to determine what is true in the world	❍	❍	❍	❍	❍
I know how to analyze the basic characteristics of a culture.	❍	❍	❍	❍	❍

I am sensitive to those who are discriminated against.	❍	❍	❍	❍	❍
I do not feel threatened emotionally when presented with multiple perspectives.	❍	❍	❍	❍	❍
I frequently interact with people from a race/ethnic group different from my own	❍	❍	❍	❍	❍
I am accepting of people with different religious and spiritual traditions.	❍	❍	❍	❍	❍
I put the needs of others above my own personal wants.	❍	❍	❍	❍	❍
I can discuss cultural differences from an informed perspective.	❍	❍	❍	❍	❍
I am developing a meaningful philosophy of life.	❍	❍	❍	❍	❍
I intentionally involve people from many cultural backgrounds in my life.	❍	❍	❍	❍	❍
I rarely question what I have been taught about the world around me	❍	❍	❍	❍	❍
I enjoy when my friends from other cultures teach me about our cultural differences.	❍	❍	❍	❍	❍
I consciously behave in terms of making a difference.	❍	❍	❍	❍	❍
I am open to people who strive to live lives very different from my own life style.	❍	❍	❍	❍	❍
Volunteering is not an important priority in my life.	❍	❍	❍	❍	❍
I frequently interact with people from a country different from my own.	❍	❍	❍	❍	❍

Q5.1 **Part 4. International Background (1-2 min)**

Q5.2 Please indicate the percentage(%) of time you work with international students in your academic program.

______ Percentage of Time (%)

Q5.3 Do you know one or more second languages? (Select one)

❍ Yes
❍ No

Q5.4 Please indicate your fluency of your best foreign language. (Select one)

	Yes	No
I am able to converse/take direction in that language	❍	❍
I can take an academic course in that language	❍	❍

Q5.5 Do you own a U.S. passport? (Select one)

- ❍ Yes
- ❍ No

Q6.1 **International and Intercultural Experiences (2-5 min)**

Q6.2 In which of the following international/global experiences have you participated? (Select all that apply). Note: these experiences may have occurred prior to or during college at your present institution or at another institution. If you have an experience that is not listed or you are unsure, please select 'Other'.

- ❑ Personal tourism
- ❑ Second language course
- ❑ University housing with international focus
- ❑ Engineering course with a global focus (e.g. Engineering for a Better Environment: Brazil, Engineering the German Way, INNOVATE)
- ❑ Non-engineering course with a global focus (e.g. Plus 3, Honors: Cambridge, API)
- ❑ U.S. based research project that examines a global issue
- ❑ Engineering focused service learning program (e.g. Engineers without Borders, Engineers for a Sustainable World)
- ❑ Non-engineering focused service learning program
- ❑ Study abroad (e.g. Engineering: Arcadia in Rome, Global E3, Engineering Exchange - Semester in Brazil)
- ❑ U.S. engineering course with an international project
- ❑ Dual degree program with an international university
- ❑ Internship/co-op/technical research project conducted internationally (e.g. Serius, UAS7, UROP)
- ❑ Other ____________________
- ❑ No international experiences

Q6.3 Please indicate how many times (or terms) you participated in each type of experience

	Number of times (or terms) participated	Was this experience:	
	Times/Terms	Pre-college	During college
Personal tourism	❑	❑	❑
Second language course	❑	❑	❑
University housing with international focus	❑	❑	❑
Engineering course with a global focus (e.g. Engineering for a Better Environment: Brazil, Engineering the German Way, INNOVATE)	❑	❑	❑
Non-engineering course with a global focus (e.g. Plus 3, Honors: Cambridge, API)	❑	❑	❑
U.S. based research project that examines a global issue	❑	❑	❑
Engineering focused service learning program (e.g. Engineers without Borders, Engineers for a Sustainable World)	❑	❑	❑
Non-engineering focused service learning program	❑	❑	❑
Study abroad (e.g. Engineering: Arcadia in Rome, Global E3, Engineering Exchange - Semester in Brazil)	❑	❑	❑
U.S. engineering course with an international project	❑	❑	❑
Dual degree program with an international university	❑	❑	❑
Internship/co-op/technical research project conducted internationally (e.g. Serius, UAS7, UROP)	❑	❑	❑
Other	❑	❑	❑
No international experiences	❑	❑	❑

Q6.4 For your most recent experience of each type, please indicate the duration spent abroad.

	Did not travel abroad	Less than 2 weeks	Between 2 weeks & 1 month	1-3 months	3-5 months	5-9 months	More than 9 months
Personal tourism	❍	❍	❍	❍	❍	❍	❍
Second language course	❍	❍	❍	❍	❍	❍	❍
University housing with international focus	❍	❍	❍	❍	❍	❍	❍
Engineering course with a global focus (e.g. Engineering for a Better Environment: Brazil, Engineering the German Way, INNOVATE)	❍	❍	❍	❍	❍	❍	❍
Non-engineering course with a global focus (e.g. Plus 3, Honors: Cambridge, API)	❍	❍	❍	❍	❍	❍	❍
U.S. based research project that examines a global issue	❍	❍	❍	❍	❍	❍	❍
Engineering focused service learning program (e.g. Engineers without Borders, Engineers for a Sustainable World)	❍	❍	❍	❍	❍	❍	❍
Non-engineering focused service learning program	❍	❍	❍	❍	❍	❍	❍
Study abroad (e.g. Engineering: Arcadia in Rome, Global E3, Engineering Exchange - Semester in Brazil)	❍	❍	❍	❍	❍	❍	❍
U.S. engineering course with an international project	❍	❍	❍	❍	❍	❍	❍
Dual degree program with an international university	❍	❍	❍	❍	❍	❍	❍
Internship/co-op/technical research project conducted internationally (e.g. Serius, UAS7, UROP)	❍	❍	❍	❍	❍	❍	❍
Other	❍	❍	❍	❍	❍	❍	❍
No international experiences	❍	❍	❍	❍	❍	❍	❍

Q6.5 For your most recent experience of each type was it:

	Engineering related?		Credit bearing?	
	Yes	No	Yes	No
Personal tourism	❍	❍	❍	❍
Second language course	❍	❍	❍	❍
University housing with international focus	❍	❍	❍	❍
Engineering course with a global focus (e.g. Engineering for a Better Environment: Brazil, Engineering the German Way, INNOVATE)	❍	❍	❍	❍
Non-engineering course with a global focus (e.g. Plus 3, Honors: Cambridge, API)	❍	❍	❍	❍
U.S. based research project that examines a global issue	❍	❍	❍	❍
Engineering focused service learning program (e.g. Engineers without Borders, Engineers for a Sustainable World)	❍	❍	❍	❍
Non-engineering focused service learning program	❍	❍	❍	❍
Study abroad (e.g. Engineering: Arcadia in Rome, Global E3, Engineering Exchange - Semester in Brazil)	❍	❍	❍	❍
U.S. engineering course with an international project	❍	❍	❍	❍
Dual degree program with an international university	❍	❍	❍	❍
Internship/co-op/technical research project conducted internationally (e.g. Serius, UAS7, UROP)	❍	❍	❍	❍
Other	❍	❍	❍	❍
No international experiences	❍	❍	❍	❍

Q6.6 For your most recent experience of each type, did it:

	Require journaling/written reflections?		Include a service component?	
	Yes	No	Yes	No
Personal tourism	❍	❍	❍	❍
Second language course	❍	❍	❍	❍
University housing with international focus	❍	❍	❍	❍
Engineering course with a global focus (e.g. Engineering for a Better Environment: Brazil, Engineering the German Way, INNOVATE)	❍	❍	❍	❍
Non-engineering course with a global focus (e.g. Plus 3, Honors: Cambridge, API)	❍	❍	❍	❍
U.S. based research project that examines a global issue	❍	❍	❍	❍
Engineering focused service learning program (e.g. Engineers without Borders, Engineers for a Sustainable World)	❍	❍	❍	❍
Non-engineering focused service learning program	❍	❍	❍	❍
Study abroad (e.g. Engineering: Arcadia in Rome, Global E3, Engineering Exchange - Semester in Brazil)	❍	❍	❍	❍
U.S. engineering course with an international project	❍	❍	❍	❍
Dual degree program with an international university	❍	❍	❍	❍
Internship/co-op/technical research project conducted internationally (e.g. Serius, UAS7, UROP)	❍	❍	❍	❍
Other	❍	❍	❍	❍
No international experiences	❍	❍	❍	❍

Q6.7 To what extent did your most recent experience of each type meet your expectations? Note: you may have to scroll to the right to see all parts of this question.

	Academics			Personal Development			Cultural Understanding			Career/Professional Development		
	Exceeded	Met	Not met	Exceeded	Met	Not met	Exceeded	Met	Not Met	Exceeded	Met	Not Met
Personal tourism	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Second language course	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
University housing with international focus	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Engineering course with a global focus (e.g. Engineering for a Better Environment: Brazil, Engineering the German Way, INNOVATE)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Non-engineering course with a global focus (e.g. Plus 3, Honors: Cambridge, API)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
U.S. based research project that examines a global issue	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Engineering focused service learning program (e.g. Engineers without Borders, Engineers for a Sustainable World)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Non-engineering focused service learning program	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Study abroad (e.g. Engineering: Arcadia in Rome, Global E3, Engineering Exchange - Semester in Brazil)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
U.S. engineering course with an international project	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Dual degree program with an international university	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Internship/co-op/technical research project conducted internationally (e.g. Serius, UAS7, UROP)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Other	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
No international experiences	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍

Q6.8 What was your level of comfort?

	During the first few days?			At the end of experience?		
	Comfortable	Somewhat comfortable	Not comfortable	Comfortable	Somewhat comfortable	Not comfortable
Personal tourism	❍	❍	❍	❍	❍	❍
Second language course	❍	❍	❍	❍	❍	❍
University housing with international focus	❍	❍	❍	❍	❍	❍
Engineering course with a global focus (e.g. Engineering for a Better Environment: Brazil, Engineering the German Way, INNOVATE)	❍	❍	❍	❍	❍	❍
Non-engineering course with a global focus (e.g. Plus 3, Honors: Cambridge, API)	❍	❍	❍	❍	❍	❍
U.S. based research project that examines a global issue	❍	❍	❍	❍	❍	❍
Engineering focused service learning program (e.g. Engineers without Borders, Engineers for a Sustainable World)	❍	❍	❍	❍	❍	❍
Non-engineering focused service learning program	❍	❍	❍	❍	❍	❍
Study abroad (e.g. Engineering: Arcadia in Rome, Global E3, Engineering Exchange - Semester in Brazil)	❍	❍	❍	❍	❍	❍
U.S. engineering course with an international project	❍	❍	❍	❍	❍	❍
Dual degree program with an international university	❍	❍	❍	❍	❍	❍
Internship/co-op/technical research project conducted internationally (e.g. Serius, UAS7, UROP)	❍	❍	❍	❍	❍	❍
Other	❍	❍	❍	❍	❍	❍
No international experiences	❍	❍	❍	❍	❍	❍

APPENDIX B

STUDY 1 – SEMI-STRUCTURED INTERVIEW PROTOCOL

Opening/Explanation:

We are conducting interviews as part of research on investigative evidence-based approaches for global engineering education programming. Specifically, we are looking to comprehensively map out the global engineering education programming strategies (implicit and explicit) being used at engineering schools and the outcomes/goals they intend to support. This interview will be followed by a Group Concept Mapping exercise that will further explore the global engineering education programming strategies used at your institution. This will give you a chance to collaborate and share your ideas with the other participants of the study.

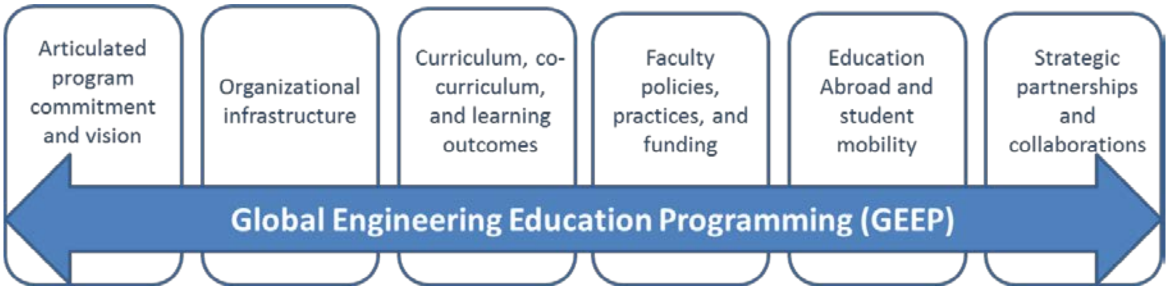
During this interview, I would like to take notes and record your responses to ascertain accuracy when coding and consolidating the final results. Do I have your permission to do so? Do you have any questions/clarifications before we begin? I am interviewing: _____________ (say subject matter experts name and affiliation)

Warm-up Question:

1. Can you describe the organizational structure of the international programs and strategies at your university? Where do you fit into this organizational structure? Does your school and/or institution have an internationalization strategic plan?

Introduce Adapted GEP Framework:

I've provided you a Global Engineering Education Programming (GEEP) framework, which has been adapted from the Center for Internationalization and Global Engagement (CIGE)'s Model for Comprehensive Internationalization. It includes six interconnected dimensions for initiatives, policies, and programs geared towards engineering schools:



- Articulated Program Commitment and Vision
  - Mission statements, strategic plans, and formal assessment mechanisms
- Organizational Infrastructure
  - Resources programs provide to support and promote GEEP (e.g. dedicated office space, human resources, communication and technology support, reporting structures and staff/office configurations)
- Curriculum, Co-Curriculum, and Learning Outcomes
  - Availability of for-credit, undergraduate academic offerings with an international focus (e.g. foreign language learning, globally focused general education requirements and course offerings)
  - Co-curricular activities, clubs, and programs
  - Specified learning outcomes
- Faculty Policies, Practices, and Funding
  - Professional development opportunities available to faculty to help them increase their international skills and knowledge
  - Funds earmarked for international education programs and activities
  - Funds to support international activities by faculty
  - Hiring guidelines, tenure and promotion policies
- Education Abroad and Student Mobility
  - Education abroad programs offered (e.g. study abroad, international internships, research abroad) and support for participation (e.g. address potential barriers such as cost and delaying of graduation)
  - International student recruitment and support (e.g. number of international students in program, funding to recruit international students, educate students abroad)
  - Program support for unscripted learning (e.g. existence of programs aimed at providing opportunities for U.S. and international students to learn from one another outside the classroom)
- Strategic Partnerships and Collaborations
  - Joint-degree or dual/double degree programs, branch campuses, and other offshore programs.

Please use these dimensions as a 'frame of reference' as you think about and answer the proceeding questions regarding your school's global engineering education programming (GEEP) strategies and outcomes. Keep in mind your school's strategies can contain any combination of elements from all six GEEP dimensions.

Strategies:

2. Tell me about the global programming strategies that have been adopted at your school. These can be either explicit or implicit. Are there any specific to the engineering school? What makes the engineering school strategies different from other colleges and/or institutional strategies? For example, Pitt's unwritten strategy focuses on "creating a series of attractive, short-term programs to increase participation; the current strategy is to augment that with increasing the number of students who go on semester long programs. Pitt has also focused on providing students with international research opportunities over the summer." – Larry Shuman

3. What is your reaction to the GEEP as it relates to your institution? To what extent do the dimensions exist on your campus? And where do these dimensions sit (e.g. institution level, school level). Where is the domain of control for the GEEP domains at your institution? How does your school or institution leverage third party providers?

4. Can you describe the relationship between the engineering school strategies and the larger university internationalization strategy? Is their coordination? Is the school's strategy part of a larger university strategy?

5. How does ABET overlay on your international programs and school strategies? How do you incorporate ABET into your GEEP strategies? How is ABET interpreted at your school regarding international programs and school strategies?

6. Tell me about the history of your international programs strategies and how they were developed. Who was involved? What was going on at the time? Why were these things done? How did it happen? How did it relate to the institution at large? Based on this, how do schools move away from one-off programs to creating a committed and sustained school-wide global programming strategy?

7. Who are the champions/influencers of your international programs and strategies? Who are the opponents? Why do you think this is?

Outcomes and Assessment:

8. What outcomes and/or goals do these strategies intend to support? (send students abroad, faculty partnerships, further higher level strategies) What are program outputs and/or measures of success of these strategies? Does your school have any formal assessment mechanisms in place to assess the outcomes of the international programs and school strategies? And if so, can you describe how the success of your strategies and/or programs are assessed?

9. How important do you believe it is to monitor (or otherwise track) these measures of program success? Which program outputs/outcomes are valued most highly? What program output metrics should be tracked, but aren't?

10. What conditions and factors should be considered when adopting global engineering education programming strategies? What factors, either positive or negative, affect the success of GEEP strategies? How can schools develop a more articulated global engineering education programming strategy?

11. Does your school adopt international programs or school strategies that specifically target certain demographic groups? (e.g. males, under-represented minorities, low socio-economic students) What percentages of your incoming freshman are international? And how do you strategies leverage this?

DEA - Efficiency of GEEP Resources:

As part of our research on investigative evidence-based approaches for global engineering education programming, we are also looking at how engineering schools are utilizing their resources regarding international programs and overall strategies. Specifically, we are interested in measuring the 'efficiency' of your school's GEEP, where highly efficient programs employ strategies that result in high levels of output metrics, with relatively low levels of input metrics. The following set of questions attempt to determine the most *important* and *attainable* program inputs and outputs for engineering schools, and the *uncontrollable factors* that are plausibly related to levels of those program outputs.

12. What are the most important and attainable **inputs** to your international programs/GEEP strategies?
For example, potential important inputs could be *total cost of programs to institutions, total cost of programs to students, resources required, and/or number of high quality programs offered.*

13. What are the most important and attainable **outputs** to your international programs/GEEP strategies?
Potential important outputs could be *the number of students who participate in the international programs, the number of students who participate in high quality programs and/or overall global competency attainment.*

14. Open Doors, published by the Institute for International Education, capture the total number of study abroad students that earned at least 1 credit per year at a particular institution. This number is also broken down by:

- Academic level
- Gender
- Ethnicity
- Destinations
- Duration
- Academic credit for internship, volunteer, or work abroad as part of study abroad experience
- Number of study abroad students who studied under institutionally organized programs (regardless of whether credit was given)
- Number of students with non-credit internships, volunteer, or work experience
- Number of study abroad students for the following year (possibly an estimate)

Which outputs do you feel are the most important to capture regarding strategy and/or program success?

15. What **uncontrollable factors** contribute to the success of adopted international programs and strategies?
Potential uncontrollable factors could be *size of the engineering program, budget, and student backgrounds*

16. What are some of the most important **intangible benefits** to your school and/or institution regrading global programming strategies? Potential intangible benefits could be *impact on recruitment, impact on retention, and impact on institutional/school reputation*

17. Do you have any hypotheses regarding the relationship between program inputs and factors with program outputs and measures of success (both tangible and intangible)? If so, what are they? What makes an engineering school's global programming strategy successful?
18. Is there anything you'd like to add about anything we've talked about today?

Closing:

Thank you for your time. Please feel free to contact me, if you have any questions or further clarifications. If I have any further questions or need clarifying information, can I contact you?

The next part of this study involves an approach called Group Concept Mapping. GCM is a participatory, mixed methods approach for organizing the ideas of diverse groups of stakeholders and aiding in the development of a conceptual framework. The approach incorporates qualitative individual and group process with multivariate statistical analyses to help a group of individuals describe ideas on any topic of interest and represent these ideas visually through a series of related two-dimensional maps. You and your colleagues can participate in this research activity to help develop an operational framework for global strategies, policies, and programs geared towards engineering schools. The activity is facilitated completely online, and should require no more than 45 minutes to complete. You will receive step-by-step instructions throughout the activity. Do you agree to participate in this part of the study?

APPENDIX C

STUDY 1 - SUBJECT MATTER EXPERT AND INSTITUTION BACKGROUNDS

Table 41. Subject Matter Expert (SMEs) Backgrounds

SME	Institution Characteristics*	Job Title
A	Private, Large, Higher Research Activity	Director, Weidman Center for Global Leadership
B	Private, Large, Higher Research Activity	Assistant Vice Provost for International Programs and Director of Drexel's Study Abroad Program
C	Public, Large, Highest Research Activity	Executive Director of International Education
D	Public, Large, Highest Research Activity	Director of Global Engineering Office
E	Public, Large, Highest Research Activity	Associate Vice Provost for International Affairs and Director of Study Abroad
F	Public, Large, Highest Research Activity	Assistant Vice Provost for Global and Engaged Education
G^1	Public, Large, Highest Research Activity	Director of Study Abroad Office
G^2	Public, Large, Highest Research Activity	Director of International Engineering Initiatives
H	Public, Large, Higher Research Activity	Executive Director of the International Engineering Program (IEP)
I	Private, Medium, Higher Research Activity	Senior International Officer

G^1 and G^2 from same institution;
*Defined according to Carnegie Classification of Institutions of Higher Education

APPENDIX D

D.1 STUDY 1 - FULL LIST OF GROUP CONCEPT MAPPING STATEMENTS AND AVERAGE RATINGS

Table 42. Complete list of GCM Statements

Number	Statement	Usefulness	Likelihood of Success	Priority
1	Leverage international activities using functional areas of excellence at the University	3.7	3.8	3.3
2	Create programs with faculty rotation, which can be used as a form of faculty professional development	3.3	3.3	3.1
3	Establish flagship programs to garner wide faculty and student interest	3.8	4.2	3.9
4	Design global programming that enhances faculty research	3.7	3.4	3.7
5	Pick study abroad locations based on student service matches	2.6	3.1	2.9
6	Leverage external industry partners to grow new technology and provide internships/research opportunities abroad	3.9	3.9	3.7
7	Offer an international minor for engineers	3	2.8	2.9
8	Offer long-term immersion opportunities	3.1	3.2	3.1
9	Establish partnerships and joint programming with schools abroad	4.1	3.9	3.8
10	Provide scholarships to go abroad based on financial need	4.9	4.4	4.4
11	Change college culture regarding global engineering education	4.4	3.7	4.1
12	Adopt transfer credit model	4	3.7	3.8
13	Provide resources to faculty to help support their efforts to grow international curricula	4.2	3.7	3.9
14	Leverage national international education initiatives (e.g, IIE's Generation Study Abroad) to give international education more visibility and traction within engineering schools	2.9	2.9	2.4
15	Sustain a few key partnerships	3.8	3.9	4

Table 42 (continued)

Number	Statement	Usefulness	Likelihood of Success	Priority
16	Offer short-term, preparatory abroad programs as a primer for semester long, immersive trips	3.4	3.7	3.5
17	Design global programs that are consistent with institution/college, and/or program missions	4.2	4	4.5
18	Provide subsidies for students to help offset the cost of studying abroad	4.8	4.4	4.3
19	Offer globally-focused classes in the engineering curriculum	4.2	3.5	3.6
20	Offer international collaboration grants for faculty	3.9	3.7	3.7
21	Enact friendly rules regarding faculty salary structures for developing and leading programs abroad	4.3	3.6	3.8
22	Consider curriculum integration in student exchanges when establishing partnerships abroad	4	3.9	3.8
23	Think about what countries are strategically important to the institution in terms of research and faculty development	3.7	3.7	3.8
24	Encourage student exchanges	3.4	3.5	3.4
25	Establish strategic partnerships with international universities	4.1	4.2	4
26	Design programs that have international and domestic students engaging with each other	3.8	3.7	3.5
27	Create sustainability by having many faculty and staff involved in global programming efforts	4.6	3.6	3.9
28	Ensure affordability by tapping into more industry partners who can support programs	3.9	3.5	3.7
29	Provide scholarships to go abroad based on project-based experience (e.g., marketing videos)	3.3	3.2	2.3
30	Leverage external funding opportunities for strengthening internal partnerships	3.5	3.3	3.7
31	Offer dual degrees with foreign languages	2.8	2.1	1.8
32	Offer different price points in global programming portfolio	4.2	4.3	3.8
33	Leverage local resources for domestic programming with international focus	3.1	3.1	3.2
34	Develop programs accounting for the presence of area studies experts who could help collaborate	3.2	2.5	2.7
35	Increase the number of short-term, faculty-led offerings that fulfill engineering requirements	4.3	3.8	4.2
36	Offer seed grants for faculty to help them internationalize and build strategic partnerships	4	3.7	3.8
37	Offer global programs and activities that engineering students care about	4.5	4	4.2
38	Move beyond traditional study abroad models which don't scale and don't have much faculty involvement	4.1	4.1	3.8
39	Align global programming learning outcomes with UN Sustainable Development Goals	2.2	2.3	2.1
40	Offer faculty-led, thematically-driven short programs	4	3.8	4.2

Table 42 (continued)

Number	Statement	Usefulness	Likelihood of Success	Priority
41	Offer short-term immersion opportunities	3.8	4	4.1
42	Leverage the co-curricular space for global learning (e.g. design teams, service-learning, student organizations)	4.2	4	3.9
43	Market global programming opportunities before and during college	3.7	3.2	3
44	Offer credit-bearing international internships	3.7	3.9	3.7
45	Generate administrative buy-in	4	3.8	3.9
46	Develop programs accounting for the number of faculty with experience in a particular region	2.8	2.7	2.8
47	Recruit globally-organized faculty	3.2	3.1	2.8
48	Encourage faculty engagement in global programming	4.4	3.8	3.9
49	Think more broadly about the types of international experiences, not just what works best for students	3.2	3.1	3.2
50	Build a small subset of international programs and rotate faculty	2.9	2.7	2.8
51	Ensure affordability to increase institutional funds for scholarships	4.3	3.4	3.8
52	Create appropriate programming for what your student population needs	4.1	4.1	3.7
53	Generate faculty buy-in	4.2	3.5	4.1
54	Increase global footprint via satellite campuses	1.8	2	2.1
55	Focus on programs that scale and cut programs that don't	3	3.2	3.5
56	Integrate international experiences into the engineering majors	4.4	3.8	4.1
57	Leverage international alumni relationships to grow global programming	3.6	3.5	3.5
58	Pick study abroad locations based on curricular matches	4	3.9	3.6
59	Increase global footprint via encouraging faculty to attend conferences abroad	2.7	2.9	3
60	Leverage the presence of international graduate students and faculty	3.2	3.2	3.2
61	Attract faculty participation by creating programs that bring in revenue from students that pay for faculty involvement	3	3.2	3.2
62	Frame international experiences as a core educational piece, and not as an alternative to education	4.6	3.9	4.1
63	Build a global learning toolkit that offers a variety of assessment options and faculty case studies	3.8	3.1	3
64	Work to align geographic foci on top of industry or strategic research foci	3.2	2.7	2.5
65	Provide students with international research opportunities	4.1	4	3.7
66	Develop program models around strategic geographic regions	3.6	2.9	3.5
67	Offer global internship programs	4.4	4.2	4.2

Table 42 (continued)

Number	Statement	Usefulness	Likelihood of Success	Priority
68	Require globally-focused engineering classes	3.6	2.6	2.7
69	Develop a global programming portfolio that has variety and meets different student needs	4.2	4.2	4.1
70	Generate institutional buy-in	4.2	3.4	4.1
71	Provide scholarships to go abroad based on diversity (e.g., minorities, females, new locations, new majors)	4.4	3.9	3.9
72	Align institutional, faculty, and student needs	4	3.4	3.9
73	Build international programs around globally strategic goals and the college and University level	4.1	3.7	4
74	Join a big consortium of global exchange programs (e.g., GE3)	3.2	3.6	2.9
75	Balance faculty-led programs with programs that don't require faculty from year to year	4	4	3.7
76	Encourage faculty engagement with promotion and/or tenure policies that better recognize global activities	4	2.7	3.1
77	Increase global footprint via liaising with colleagues abroad	3.3	3.5	3.5
78	Create a series of attractive, short-term programs to increase global programming participation	4.1	3.9	4
79	Develop thematically-based programs that are related to topics of interest to engineering students	4	4	4.2
80	Offer global certifications/distinctions	3.4	3.3	2.7
81	Design student leadership workshops for freshmen	2.6	2.9	2.2
82	Utilize third party providers	2.5	2.8	2
83	Develop programs accounting for the areas that make sense in terms of the school's research interests	3.4	3.1	3.1
84	Craft bilateral exchanges using faculty partnerships	2.6	2.8	2.9
85	Make global programming connected to the curriculum	4.6	4.2	3.9
86	Establish strategic partnerships with corporations abroad	3.7	3.8	3.5
87	Design degree-long, curricular integration initiatives	3.5	3.1	3.1
88	Shift away from reliance on third party providers and increase faculty engagement with homegrown programs	3.6	3	2.9
89	Pick study abroad locations based on calendar matches	3.2	3	2.8
90	Develop programs accounting for capacity for language support at your home institution	3.4	2.8	3.2

D.2 GROUP CONCEPT MAPPING STATEMENTS BY CLUSTER

Table 43. List of GCM Statements by Cluster

Cluster 1: Student Funding and Program Affordability
10. Provide scholarships to go abroad based on financial need
18. Provide subsidies for students to help offset the cost of studying abroad
28. Ensure affordability by tapping into more industry partners who can support programs
29. Provide scholarships to go abroad based on project-based experience (e.g., marketing videos)
30. Leverage external funding opportunities for strengthening internal partnerships
51. Ensure affordability to increase institutional funds for scholarships
71. Provide scholarships to go abroad based on diversity (e.g., minorities, females, new locations, new majors)
Cluster 2: Leverage External Partnerships and Faculty Funding Opportunities
4. Design global programming that enhances faculty research
6. Leverage external industry partners to grow new technology and provide internships/research opportunities abroad
11. Change college culture regarding global engineering education
13. Provide resources to faculty to help support their efforts to grow international curricula
14. Leverage national international education initiatives (e.g, IIE's Generation Study Abroad) to give international education more visibility and traction within engineering schools
20. Offer international collaboration grants for faculty
36. Offer seed grants for faculty to help them internationalize and build strategic partnerships
47. Recruit globally-organized faculty
57. Leverage international alumni relationships to grow global programming
59. Increase global footprint via encouraging faculty to attend conferences abroad

Table 43 (continued)

60. Leverage the presence of international graduate students and faculty
61. Attract faculty participation by creating programs that bring in revenue from students that pay for faculty involvement
64. Work to align geographic foci on top of industry or strategic research foci
86. Establish strategic partnerships with corporations abroad
Cluster 3: Generate Faculty Buy-In and Involvement
23. Think about what countries are strategically important to the institution in terms of research and faculty development
27. Create sustainability by having many faculty and staff involved in global programming efforts
48. Encourage faculty engagement in global programming
53. Generate faculty buy-in
76. Encourage faculty engagement with promotion and/or tenure policies that better recognize global activities
77. Increase global footprint via liaising with colleagues abroad
Cluster 4: Institutional Strategic Alignment
1. Leverage international activities using functional areas of excellence at the University
17. Design global programs that are consistent with institution/college, and/or program missions
25. Establish strategic partnerships with international universities
39. Align global programming learning outcomes with UN Sustainable Development Goals
45. Generate administrative buy-in
70. Generate institutional buy-in
72. Align institutional, faculty, and student needs
73. Build international programs around globally strategic goals and the college and University level
83. Develop programs accounting for the areas that make sense in terms of the school's research interests
Cluster 5: Curricular Structures and Integration
7. Offer an international minor for engineers
12. Adopt transfer credit model
19. Offer globally-focused classes in the engineering curriculum
22. Consider curriculum integration in student exchanges when establishing partnerships abroad
31. Offer dual degrees with foreign languages

Table 43 (continued)

32. Offer different price points in global programming portfolio
33. Leverage local resources for domestic programming with international focus
42. Leverage the co-curricular space for global learning (e.g. design teams, service-learning, student organizations)
56. Integrate international experiences into the engineering majors
62. Frame international experiences as a core educational piece, and not as an alternative to education
63. Build a global learning toolkit that offers a variety of assessment options and faculty case studies
68. Require globally-focused engineering classes
80. Offer global certifications/distinctions
81. Design student leadership workshops for freshmen
85. Make global programming connected to the curriculum
87. Design degree-long, curricular integration initiatives
Cluster 6: Student Focused Program Models
5. Pick study abroad locations based on student service matches
8. Offer long-term immersion opportunities
16. Offer short-term, preparatory abroad programs as a primer for semester long, immersive trips
24. Encourage student exchanges
26. Design programs that have international and domestic students engaging with each other
34. Develop programs accounting for the presence of area studies experts who could help collaborate
35. Increase the number of short-term, faculty-led offerings that fulfill engineering requirements
37. Offer global programs and activities that engineering students care about
40. Offer faculty-led, thematically-driven short programs
41. Offer short-term immersion opportunities
44. Offer credit-bearing international internships
46. Develop programs accounting for the number of faculty with experience in a particular region
52. Create appropriate programming for what your student population needs
58. Pick study abroad locations based on curricular matches
65. Provide students with international research opportunities
67. Offer global internship programs

Table 43 (continued)

75. Balance faculty-led programs with programs that don't require faculty from year to year
79. Develop thematically-based programs that are related to topics of interest to engineering students
90. Develop programs accounting for capacity for language support at your home institution
Cluster 7: Management for Sustainability
2. Create programs with faculty rotation, which can be used as a form of faculty professional development
3. Establish flagship programs to garner wide faculty and student interest
9. Establish partnerships and joint programming with schools abroad
15. Sustain a few key partnerships
21. Enact friendly rules regarding faculty salary structures for developing and leading programs abroad
38. Move beyond traditional study abroad models which don't scale and don't have much faculty involvement
43. Market global programming opportunities before and during college
49. Think more broadly about the types of international experiences, not just what works best for students
50. Build a small subset of international programs and rotate faculty
54. Increase global footprint via satellite campuses
55. Focus on programs that scale and cut programs that don't
66. Develop program models around strategic geographic regions
69. Develop a global programming portfolio that has variety and meets different student needs
74. Join a big consortium of global exchange programs (e.g., GE3)
78. Create a series of attractive, short-term programs to increase global programming participation
82. Utilize third party providers
84. Craft bilateral exchanges using faculty partnerships
88. Shift away from reliance on third party providers and increase faculty engagement with homegrown programs
89. Pick study abroad locations based on calendar matches

APPENDIX E

LOGIC MODEL CREATED VIA INTERVIEWS AND GCM ACTIVITY

Theory-driven evaluation has become a part of mainstream evaluation practice and has been credited with improving program conceptualizations, supporting sound implementation, creating value for stake holders, and improving evaluation design [135]. Coryn et al. denote that theory-driven evaluation is an "evaluation strategy or approach that explicitly integrates and uses stakeholder, social science, some combination of, or other types of theories in conceptualizing, designing, conducting, interpreting, and applying an evaluation" [136]. Although its origins can be traced to Tyler in the 1930s, it was not until 1990 that theory-driven evaluation resonated more widely in the evaluation community [136]. Such evaluation approaches have been widely adopted in many contexts, including community change initiatives, health and human services, public health programs, international development settings, and humanitarian efforts [136].

A requirement of theory-driven evaluation is the development and articulation of a program theory. A simple example of a program theory model is shown in Figure 4 (note, real models are often more complex). Program theory often includes inputs, activities, outputs, initial outcomes, intermediate outcomes, and long-term outcomes [136]. Inputs include various types of resources necessary to implement a program (e.g. human, physical, and financial). Activities are the actions (e.g. training and service delivery) undertaken to bring about a desired end. Outputs are the immediate result of an action. Outcomes are the anticipated changes that occur directly or indirectly as a result of inputs, activities, and outputs. Initial outcomes are expressed as a change in knowledge, skills, and abilities; whereas intermediate outcomes are often classified as behavioral changes that are thought to produce changes in long-term outcomes. GCM can contribute to the specification of program theory and can improve evaluation by providing a systematic mechanism for articulating and visually representing interrelationships of concepts [135].

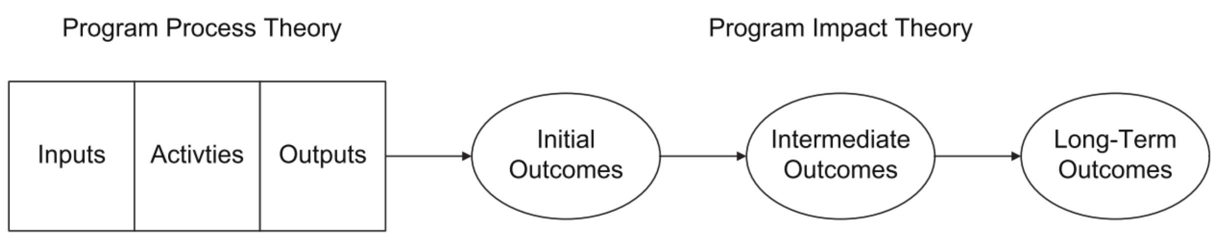


Figure 26. Linear Program Theory Model

Using theory-driven evaluation theory [137] and guided by participant interpretation, the qualitative analysis and final GEP model in Chapter 3 was used to develop a draft logic model for sustained global program development (Table 40). Logic models are consistent with this emphasis, and typically show environmental factors, resources, activities, outputs, and outcomes for a program in a graphic form [138]. The logic model will be used to identify and develop GEP outcome evaluation questions; a resulting GEP evaluation instrument will be generated to elicit the opinions and evaluative assessments of the GEEP strategies regarding the entire range of outcome markers. Confirmatory factor analysis will be used to validate the scales of the instrument. The participants of the GCM activity will assist in generating potential survey items.

Table 44. Logic Model of Sustainable Global Program Development

<table>
<tr><th rowspan="2">Resources</th><th rowspan="2">Strategies</th><th rowspan="2">Outputs</th><th colspan="2">Outcomes</th></tr>
<tr><th>Student</th><th>Program</th></tr>
<tr>
<td>• Organizational structure
• Financial structure
• Costs to students
• Levels of staffing
• Dedicated space</td>
<td>• Provide student Funding and Program Affordability
• Generate faculty buy-in and involvement
• Develop student focused program models
• Align programs to institutional goals and missions
• Curricular integration
• Leverage partnerships and funding opportunities
• Manage for sustainability</td>
<td>• Participation rates
• Employability
• Overall growth
• Growth in diversity
• Growth in first gen students</td>
<td>• Global competency
• Humility
• Greater sense of identity and broader sense of engineering community
• Be able to attack global challenges</td>
<td>• Increased access
• Increased reputation
• Increased recruitment
• Increased retention
• Enhancing local and global partnerships
• Globally engaged faculty
• Holistic engineering education</td>
</tr>
<tr><th colspan="5">Assessment</th></tr>
<tr><td colspan="5">Satisfaction surveys
Course evaluations
Developed instruments (GPI, IDI, AAC&CU Values Rubric)
Qualitative feedback (student interviews, focus groups)
Language proficiency assessments
Self-reflections
International research comparisons</td></tr>
</table>

APPENDIX F

DESCRIPTIVE STATISTICS FOR PARTICIPAINTS IN STUDY 2

Table 45. Descriptive Statistics on Backgrounds for Participants in Study 2

Gender	**Count**	**Percentage (%)**
Male	1769	62.7
Female	1051	37.3
Academic Level	**Count**	**Percentage (%)**
Freshman	813	28.8
Senior	2007	71.2
Parent's Educational Background	**Count**	**Percentage (%)**
High School or Associate	461	16.3
BS	1007	35.7
MS or PhD	1352	47.9
Location Raised	**Count**	**Percentage (%)**
Urban	310	16.3
Suburban	1805	35.7
Small town or Rural	705	47.9
Second Language Fluency	**Count**	**Percentage (%)**
No	1704	60.4
Yes	1116	39.6
Ethnicity	**Count**	**Percentage (%)**
White	2111	74.9
Asian	439	15.6
URM	270	9.6

Table 46. Descriptive Statistics on Experiences for Participants in Study 2

International Experience Background	Count	Percentage (%)
No International Experiences	656	23.3
Experience Prior to College Only	837	29.7
Experience During College Only	326	11.6
Experiences Prior to and During College	1001	35.5
Number of Experiences	**Count**	**Percentage (%)**
None	569	20.2
One	496	17.6
Few (2-3)	207	7.3
Many (>3)	1548	54.9
Variety of Experiences	**Count**	**Percentage (%)**
None	569	20.2
One	809	28.7
Two	690	24.5
Three	386	13.7
Four	212	7.5
Five	113	4.0
Six	41	1.5

APPENDIX G

GLOBAL PERSPECTIVE INVENTORY SUBSCALE CORRELATIONS

* Note: Highlighted correlations significantly different from total sample; $p<0.01$

Table 47. GPI Subscale Correlations – Total Sample

	Knowledge	Identity	Affect	Social Responsibility	Social Interaction
Knowing	0.160	0.169	0.470	0.209	0.173
Knowledge		0.424	0.366	0.323	0.360
Identity			0.413	0.426	0.158
Affect				0.444	0.347
Social Responsibility					0.284

Table 48. GPI Subscale Correlations – Pattern 1

N=209	Knowledge	Identity	Affect	Social Responsibility	Social Interaction
Knowing	0.062	0.142	0.445	0.212	0.078
Knowledge		0.440	0.356	0.114	-0.074
Identity			0.301	0.283	0.187
Affect				0.332	0.265
Social Responsibility					0.293

Table 49. GPI Subscale Correlations – Pattern 2

N=218	Knowledge	Identity	Affect	Social Responsibility	Social Interaction
Knowing	0.054	-0.118	0.128	-0.138	0.042
Knowledge		0.387	0.201	0.198	0.067
Identity			0.038	0.221	-0.055
Affect				0.328	0.444
Social Responsibility					0.120

Table 50. GPI Subscale Correlations – Pattern 3

N=654	Knowledge	Identity	Affect	Social Responsibility	Social Interaction
Knowing	0.102	0.033	0.429	0.188	-0.124
Knowledge		0.439	0.251	0.299	0.067
Identity			0.222	0.354	0.115
Affect				0.409	0.138
Social Responsibility					0.243

Table 51. GPI Subscale Correlations – Pattern 4

N=1583	Knowledge	Identity	Affect	Social Responsibility	Social Interaction
Knowing	0.120	0.151	0.454	0.175	-0.051
Knowledge		0.395	0.229	0.224	-0.018
Identity			0.152	0.349	0.059
Affect				0.307	0.115
Social Responsibility					0.229

Table 52. GPI Subscale Correlations – Pattern 5

N=156	Knowledge	Identity	Affect	Social Responsibility	Social Interaction
Knowing	0.237	0.281	0.361	0.153	0.282
Knowledge		0.587	0.478	0.433	0.338
Identity			0.575	0.476	0.342
Affect				0.333	0.414
Social Responsibility					0.233

APPENDIX H

DESCRIPTIVE STATISTICS FOR PARTICIPAINTS IN STUDY 3

Table 53. Descriptive Statistics on Backgrounds for Participants in Study 3

Gender	Count	Percentage (%)
Male	187	62.1
Female	114	37.9
Parent's Educational Background	**Count**	**Percentage (%)**
High School or Associate	61	20.3
BS	122	40.5
MS or PhD	118	39.2
Second Language Fluency	**Count**	**Percentage (%)**
No	183	60.8
Yes	118	39.2
Ethnicity	**Count**	**Percentage (%)**
White	224	74.4
Asian	45	15.0
URM	32	10.6

APPENDIX I

DESCRIPTION OF EXPERIENCE TYPES

In addition to the grouping of experience types from the survey, students who marked ‘Other’ on the survey and wrote a description of their experience were grouped according to the following criteria:

1. **Personal Tourism –** any trip abroad that served little to no educational value. For example, research conferences abroad, visiting friends, etc.
2. **Second Language Course –** any course where the primary learning outcome related to second language fluency
3. **Coursework –** any curricular course for credit that had a global focus (whether it was engineering related or not)
4. **Study abroad –** in addition to traditional study abroad models, student exchanges were included in this group
5. **Work/Projects –** any experience that involved hands-on, authentic work in an international setting, including research projects abroad or on a global issue, and work experiences abroad (e.g. internships or co-ops)
6. **Student Organizations –** this includes any formal student organizations (e.g., Engineers Without Borders), service organizations (e.g., Engineers for a Sustainable World), and internationally engaged communities (e.g., international roommates)

APPENDIX J

STUDY 2 – MULTINOMIAL LOGISTIC REGRESSION RESULTS

**Pattern 4 (Average Scoring Students) were used as the reference group for the results below*

Reference groups: Seniors, Females, URM, BS/PhD, Rural or Small town, Multilingual, Experiences Before and During college, and Many experiences (>3)

Table 54. Multinomial Logistic Regression Results

Pattern 1	**B**	**SE**	**Wald**	**p-value**	**OR**
Intercept	-2.42	0.58	17.55	0.00	--
Freshmen	-0.48	0.22	4.88	0.03	0.62
Male	-0.36	0.16	5.55	0.02	0.70
White	1.01	0.47	4.46	0.04	2.70
Asian	0.60	0.54	1.22	0.27	1.82
HS/Associate	-0.18	0.23	0.61	0.43	0.84
BS	-0.16	0.16	0.94	0.33	0.85
Urban	-0.40	0.34	1.38	0.24	0.68
Suburban	-0.10	0.17	0.35	0.55	0.91
Not multilingual	0.38	0.18	4.41	0.04	1.46
No experiences	0.12	0.37	0.11	0.74	1.13
Experiences prior to college	0.16	0.26	0.38	0.54	1.18
Experiences during college	0.18	0.27	0.44	0.51	1.20
No experiences	-0.12	0.37	0.12	0.73	0.88
One experience	-0.06	0.24	0.05	0.82	0.95
Few experiences	-0.36	0.32	1.25	0.26	0.70
Variety	-0.17	0.08	4.12	0.04	0.84
Pattern 2	**B**	**SE**	**Wald**	**p-value**	**OR**
Intercept	-2.17	0.48	20.36	0.00	--
Freshmen	-0.13	0.19	0.48	0.49	0.88
Male	0.53	0.18	8.90	0.00	1.70

Table 54 (continued)

White	-1.04	0.23	19.84	0.00	0.35
Asian	-0.03	0.28	0.01	0.92	0.97
HS/Associate	0.01	0.21	0.00	0.97	1.01
BS	-0.05	0.17	0.09	0.77	0.95
Urban	0.71	0.26	7.68	0.01	2.04
Suburban	0.23	0.19	1.45	0.23	1.26
Not multilingual	0.29	0.18	2.62	0.11	1.34
No experiences	-0.12	0.41	0.09	0.77	0.89
Experiences prior to college	0.18	0.29	0.39	0.53	1.20
Experiences during college	0.18	0.32	0.32	0.57	1.20
No experiences	1.12	0.41	7.54	0.01	3.05
One experience	0.49	0.27	3.44	0.06	1.64
Few experiences	0.48	0.32	2.29	0.13	1.61
Variety	-0.25	0.12	4.33	0.04	0.78
Pattern 3	**B**	**SE**	**Wald**	**p-value**	**OR**
Intercept	0.38	0.26	2.15	0.143	--
Freshmen	-0.05	0.16	0.08	0.78	0.95
Male	-0.12	0.10	1.28	0.26	0.89
White	-1.28	0.17	58.93	0.00	0.28
Asian	-0.01	0.19	0.00	0.97	0.99
HS/Associate	-0.16	0.15	1.26	0.26	0.85
BS	-0.13	0.11	1.38	0.24	0.88
Urban	0.13	0.18	0.56	0.46	1.14
Suburban	-0.06	0.12	0.28	0.60	0.94
Not multilingual	-0.46	0.11	19.31	0.00	0.63
No experiences	-0.58	0.30	3.65	0.06	0.56
Experiences prior to college	-0.14	0.18	0.56	0.46	0.87
Experiences during college	-0.15	0.18	0.68	0.41	0.86
No experiences	0.08	0.30	0.06	0.80	1.08
One experience	-0.17	0.17	0.92	0.34	0.85
Few experiences	-0.20	0.21	0.91	0.34	0.82
Variety	0.13	0.04	9.79	0.00	1.14
Pattern 5	**B**	**SE**	**Wald**	**p-value**	**OR**
Intercept	-0.04	0.48	0.01	0.925	--
Freshmen	-0.83	0.25	10.80	0.00	0.44
Male	-0.45	0.18	6.36	0.01	0.64
White	-1.79	0.24	53.68	0.00	0.17
Asian	-0.28	0.27	1.09	0.30	0.76
HS/Associate	-0.47	0.26	3.33	0.07	0.63
BS	-0.11	0.20	0.32	0.57	0.90
Urban	0.47	0.29	2.67	0.10	1.60
Suburban	-0.01	0.22	0.00	0.96	0.99
Not multilingual	-0.38	0.20	3.79	0.05	0.68
No experiences	-0.30	0.46	0.41	0.52	0.74
Experiences prior to college	-0.11	0.31	0.13	0.72	0.90
Experiences during college	-0.86	0.37	5.26	0.02	0.42
No experiences	0.70	0.49	2.10	0.15	2.02
One experience	0.84	0.30	7.63	0.01	2.32
Few experiences	0.56	0.35	2.51	0.11	1.75
Variety	-0.31	0.12	6.74	0.01	0.73

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