

Impact of an International Research Experience on Graduate Student Advancement

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ABSTRACT

The importance of international collaborations and experiences is increasingly evident in the professional development of engineering graduates, preparing them for the global and interconnected nature of their disciplines. This study examines the role of international research experiences in enhancing the professional and intercultural development of engineering graduate students, focusing on participants in the International Research Experiences in Civil, Construction, and Environmental Engineering (IRECCEE) program. Using a mixed-methods approach, data collected from surveys and interviews are analyzed to assess the impact of the program on students' communication, networking, collaboration, independent research abilities, and intercultural competence. Preliminary findings indicate significant improvements in these competencies, highlighting the IRECCEE program as an effective platform for preparing students for successful academic and professional careers in a global context. The study further demonstrates the positive influence of international exposure on students' capacity to navigate diverse cultural and research environments. These insights underscore the importance of international research experiences in graduate education and provide guidance to improve the design and evaluation of such programs.

INTRODUCTION

The dynamic nature of the globalized world calls for well-rounded engineering graduates possessing professional and intercultural competencies to effectively engage and thrive in an increasingly interconnected and competitive job market (Grandin & Hirleman, 2009). International research experiences can play a crucial role in developing these competencies by offering opportunities for students to engage with diverse cultures (Davis & Coryell, 2020; Oda et al., 2020; Richardson et al., 2020), collaborate in multinational teams, and establish long-lasting partnerships (Leak et al., 2018; Lohmann et al., 2006). Furthermore, these experiences promise to significantly enhance students' personal and intellectual growth (Davis & Coryell, 2020; Oda et al., 2020), as well as their professional and academic development (Ingraham & Peterson, 2004; Leak et al., 2018; Waldbaum, 1996).

Graduate school provides an excellent platform for engineering students to refine their research skills while simultaneously cultivating intercultural competence and establishing sustainable research collaborations (Ingraham & Peterson, 2004). However, traditional study abroad programs often focus on undergraduate students and lack a research component, resulting

in a limited number of graduate students participating in international experiences (Black & Duhon, 2006; Clark & Plume, 2011). Consequently, there is a lack of knowledge on how international research opportunities should be tailored to meet the unique requirements of graduate engineering students which arise from their advanced academic progression, the specialized nature of their research, and the growing emphasis on collaborative and interdisciplinary approaches. Although international collaborations and experiences are essential for engineering graduates to enhance their personal and professional competencies in an ever-evolving, interconnected world, limited knowledge exists about the factors contributing to the improvement of these competencies through international academic interventions. Our research endeavors to bridge this gap by exploring the impact of international research experiences on engineering graduate students' progress, career development, and intercultural awareness.

The study is based on the ongoing International Research Experiences in Civil, Construction, and Environmental Engineering (IRECCEE) program, funded by the National Science Foundation (NSF), which offers a unique opportunity for domestic graduate students in civil engineering to conduct research abroad and foster long-lasting collaborations beyond the duration of the IRECCEE program, as evidenced by joint publications, continued communication, or subsequent collaborative projects between students and international researchers. By employing a mixed-methods research approach that includes survey instruments and face-to-face interviews, this study seeks to analyze and capture students' professional advancement and research before and after their international research experience. Additionally, the study aims to assess whether these collaborations are sustained over time, thus validating the 'long-lasting' nature of these interactions. The understanding of students' experiences promises to contribute to the development of a framework capable of measuring the impact of international research experiences on student development more effectively and accurately (Black & Duhon, 2006; Clarke III et al., 2009). Furthermore, this study aims to provide insights that could help better design and evaluate research experiences abroad, addressing the existing barriers to students' advancement in the engineering field. The following sections will provide an overview of the IRECCEE program and the designed framework for evaluating the impact of international research experiences on student development. The results captured from five participants will be explained and discussed.

IRECCEE PROGRAM OVERVIEW

The IRECCEE program is an initiative designed to equip domestic graduate students in civil, construction, and environmental engineering with valuable international experiences. The program, supports the development of intercultural competence and professional skills for up to 75 civil, construction, or environmental engineering graduate students annually by covering airfare, visa, and housing expenses and offering advice and assistance for the international experience and professional development activities through the IRECCEE team. The framework integrates diversity, research, professional development, and cultural competence to generate a globally engaged engineering workforce with world-class skills, thereby contributing to the competitiveness of the participating students.

Additionally, in partnership with the American Society of Civil Engineers (ASCE), the IRECCEE program provides professional development resources to maximize students' impact. The program is designed as a longitudinal study with a two-year participation, wherein students engage in professional, intercultural, and data collection activities before, during, and after their

international experience. The program collaborates with seven top-tier international universities across four continents, including Israel, China, Canada, Australia, South Africa, Colombia, and India, which have been selected based on academic standing and geographical diversity. This guarantees in-depth experiences for students with flexibility to encompass any international university, as long as there is an established connection between students or their domestic advisors and the host institution, due to COVID-19's impact on global travel.

AN INTERNATIONAL RESEARCH EXPERIENCE DESIGN

As shown in Figure 1 this study comprises a sequence of events and activities for students to engage in before, during, and after their international experience. Before being selected for the program, applicants submit their contact information on the website, accompanied by a complete application package. The competitive and transparent selection process prioritizes PhD candidates, PhD students, and Master's students, evaluating applications based on factors such as proposal quality, research and professional development plans, long-term benefits, and domestic advisor support. Once accepted, before embarking on their international journey, students attend an online general orientation session with their domestic advisor, covering program objectives, expectations, research, and data collection procedures, ASCE collaboration, benefits, timelines, financial support, and logistics. Students also participate in an ethics in engineering class, an online leadership module, a cultural awareness orientation, and a local ASCE Professional Chapter event related to their research topic. During their time abroad, students collaborate with their host mentor and research group, gaining exposure to different work procedures, cultures, and the host institution's resources. They are encouraged to engage with local industry and professional opportunities through training sessions, lectures, visits, or society chapter events. Additionally, students are expected to deliver seminars or presentations about their research at their host institution or local professional meetings. Upon returning to their home institution, students present their international research work at an ASCE Institute, domestic conference, or regional/local professional meeting or workshop. They are also encouraged to publish journal or conference articles about their research, preferably co-authored with their foreign mentor, and to take the Fundamentals of Engineering (FE) exam, the first step in becoming a licensed professional engineer.

EVALUATION PROCESS

The assessment of the impact of international research experiences on students' development employs a mixed-method approach, combining surveys and interviews to provide a comprehensive understanding of the experience (Schneider et al., 2022). The evaluation focuses on five primary competencies: intercultural competence, personal development, intellectual growth, professional development, and academic development. The Student Progress Survey (SPS) was designed to assess the multifaceted impact of an international research experience on participating students' research abilities, professional and personal growth, networking competencies, and future career prospects. This instrument employs primarily closed-ended, Likert-scale questions based on a thorough literature review, encompassing 29 items where participants self-assess their proficiency in areas such as independent research capability, networking, and communication skills, along with additional demographic and program-specific inquiries (Schneider et al., 2022). The Intercultural Development Inventory (IDI) is utilized in

this study due to its proven ability to assess a participant's capacity to understand and appropriately respond to cultural differences and commonalities (Berg, 2009). It operates on a continuum that categorizes individuals' intercultural competence, highlighting stages ranging from a denial of deep-seated cultural differences to an integrated and adaptive cultural perspective. The SPS and IDI are administered to students at four distinct time points: prior to the international experience, immediately upon their return, and at two subsequent intervals, one year and two years after the experience. This repeated and longitudinal administration strategy is purposefully designed to capture both the immediate and sustained impacts of the international research experience on students' intercultural competence and various aspects of their academic, professional, and personal development. The benefit of this longitudinal approach lies in its ability to track the evolution of students' skills and perspectives over time, thereby offering a more comprehensive and nuanced understanding of the long-term effects of the intervention.

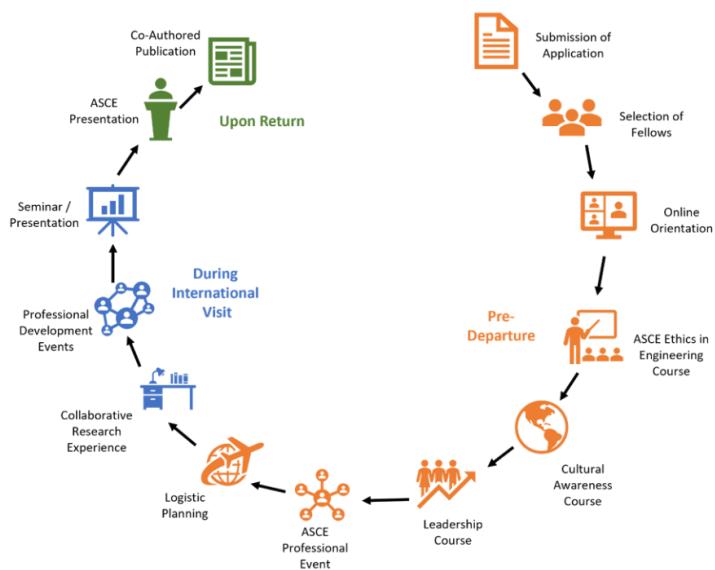


Figure 1. Learning and skill enhancement activities prior to (orange), throughout (blue), and following (green) the international research engagements

To more deeply understand the qualitative aspects of the international experience, post-intervention interviews are conducted with students, providing detailed insights into their unique experiences and development. In addition to student self-assessments, the Mentor Assessment of Student Engagement Survey (MASES) is administered to both domestic and host mentors, contributing an external perspective to the evaluation of student performance and progress. This approach ensures a robust and comprehensive assessment, complementing the students' self-reported data with external evaluations, thereby enhancing the objectivity and depth of the analysis (Schneider et al., 2022).

This comprehensive evaluation approach, which seeks to triangulate evidence from surveys, mentor assessments, and interviews, aims to strengthen validity and minimize bias (Patton, 2002; Schneider et al., 2022). The data collection method, which comprises pre-intervention, post-intervention, and post-post-intervention data, allows for the assessment of long-term impacts (Kumar, 2018; Schneider et al., 2022). Additional objectivity can be introduced by consulting sources close to the participant, such as domestic and host advisors or domestic and international

peer students (Pike, 1995; Podsakoff & Organ, 1986; Schneider et al., 2022). This comprehensive data collection approach helps in understanding and evaluating the program's impact on student development across various competencies.

RESULT

To date, the IRECCEE program has engaged students from various specialties within civil, construction, and environmental engineering, facilitating their research at global institutions such as CSIRO, Kathmandu University, and Friedrich-Schiller University of Jena. At the time of this publication, five students have completed both pre and post surveys, contributing comprehensive data sets for analysis in this study. The results presented herein offer preliminary insights into the program's effectiveness and establish a foundation for continued investigation and analysis as the study progresses. As shown in Figure 2, the results of the Student Progress Survey (SPS), with five participants self-evaluating their proficiency before and after the program in areas such as communication, networking, independent research, and research abilities, demonstrate that the IRECCEE program positively impacted participants' skills in communication, networking and collaboration, independent research, and research methodologies. Post-experience means scores for communication increased from a pre-experience average of 3.53 to 4.08, networking and collaboration improved from 3.21 to 4.08, independent research abilities grew from 3.73 to 4.33, and overall research skills rose from 3.55 to 4.20.

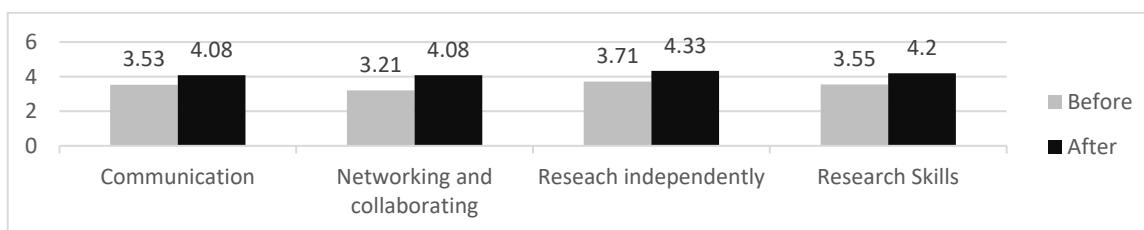


Figure 2. International research experience's effect on academic and professional development

The results suggest that the program effectively contributed to the development of students' abilities to communicate in diverse research settings, provided opportunities for students to connect and collaborate with researchers from various cultural backgrounds, fostered essential skills for independent research and critical thinking, and enhanced their abilities to plan, conduct, and analyze research projects across different fields. Each area will be discussed in detail in the following paragraphs.

Communication Skills

The self-evaluation results of students' proficiency levels in various communication and research-related skills before and after their experience abroad reveal improvement in communication skills for all students. These enhancements were observed in writing technical papers, publishing conference articles, and delivering oral presentations. For example, one student progressed from being very proficient to highly proficient in writing technical papers that clearly, concisely, and professionally convey research work, studies, and results after

participating in the program. Similarly, another participant improved their ability to write and publish a conference article within their discipline, moving from somewhat proficient to very proficient.

Following their participation in the program, the students demonstrated marked progress in their abilities to deliver oral presentations and engage in scholarly discussions with colleagues, advisors, and external academics. Notably, all five students showcased enhanced skills in articulating their research work, studies, and results in a clear, concise, and professional manner.

These improvements in communication skills, observed across various academic settings, suggest a positive impact of the international research experience on the students' intercultural and professional development. Effective communication is paramount for success in any career, and the data from this study supports the notion that the IRECCEE program equips students with this vital skill, preparing them for successful careers. These advancements are likely attributable to the various activities students engaged in during the program, such as presenting research findings and engaging with international peers and advisors.

Networking and Collaboration

The SPS assessed participants' capacity for domestic and international research collaboration, skill in articulating research to diverse audiences, confidence in formally presenting research knowledge, and ability to cultivate lasting professional and academic connections. According to the self-assessment results, students exhibited marked improvements in research collaboration skills, both domestically and internationally. For example, a majority of the students transitioned to extremely high proficiency levels in collaborating with domestic colleagues, and a similar trend was observed in their collaborations with international counterparts, with notable advancements in proficiency.

Post-program, students notably improved their ability to captivate academic and industry audiences through oral presentations, with most reporting high or extremely high proficiency levels, a marked rise from their initial moderate or high assessments. Additionally, the program substantially enhanced students' confidence in articulating research insights in both formal academic and professional industry settings.

The results revealed that the majority of students attained extremely high proficiency levels in establishing and sustaining collaborative networks with academics and industry professionals. These results underscore the program's effectiveness in not only enhancing communication skills but also empowering students to forge and maintain pivotal professional relationships within their fields, facilitated by program activities such as international peer interactions and team projects.

Research Skills and Research Independently

As a result of their abroad experience, students reported significant improvements in various research skills, including performing comprehensive literature reviews, framing research hypotheses and objectives, developing robust research methodologies, and analyzing data using both qualitative/descriptive and quantitative methods. Moreover, they demonstrated enhanced abilities in troubleshooting theoretical/technical errors during data collection and analysis, validating research results, and articulating the intellectual merit and broader impacts of their research.

In the context of conducting research independently, students demonstrated progress in advancing research with minimal or no supervision from their advisors. While three students maintained their high proficiency levels after participating in the IRECCEE program, the other two students, who were initially very and somewhat proficient, improved to highly proficient levels. This suggests that the program fosters the development of independent research skills among its participants. Furthermore, the ability to provide sound critiques of others' research work, such as reviewing articles, also improved for all students after participating in the program.

Professional Events

During Student's participation in the IRECCEE program, both in the US and abroad, they attended numerous professional development events such as seminars, talks, meetings with industry professionals, faculty members, and other students, as well as industry events hosted at the university and company sites. The frequency of event attendance varied among the students; however, the overall trend showed an increase in attendance during their time abroad.

Most students in the interview reported improvements in their professional development due to their participation in these events. Benefits included enhanced networking, presentation skills, public speaking, and increased knowledge of their respective fields. Additionally, students gained communication skills, particularly when conveying research findings to industry professionals.

Three out of five students noted that attending professional events positively impacted their research planning and performance abilities. They reported better communication of research and an improved understanding of the major research questions in their fields. These improvements can be attributed to the students' increased exposure to cutting-edge research methods and interdisciplinary collaborations.

Career Prospect

During the interview after the international experience all five students indicated that their participation in the IRECCEE program influenced their career plans. They cited increased interest in global issues, expanded networking opportunities, focus on national and international funding, consideration of post-doctoral opportunities, and the desire to gain international experience before pursuing an academic career. Furthermore, the students experienced enhanced vision and motivation regarding their career prospects, with three out of five students reporting positive changes in this regard.

Intercultural Competence

The International Research Experience on the Intercultural and Professional Development of Graduate Students was designed to evaluate the influence of an international research experience on participating students' intercultural competence. The Intercultural Development Inventory (IDI) assessed students' perceived orientation (PO), developmental orientation (DO), and orientation gap (OG) before and after the experience. An elevated PO score signifies enhanced self-perceived intercultural skills. A rise in DO reflects genuine advancement in understanding cultural variances, with higher scores denoting deeper comprehension. A decline in OG indicates better alignment between perceived and real intercultural expertise. Table 1 displays the results.

Table 1. Intercultural Development Inventory result

Student Number		1	2	3	4	5
Pre - Experience	Perceived Orientation (PO)	119.8	119.14	114.96	121.76	121.33
	Developmental Orientation (DO)	83.28	85.11	71.33	95.43	90.05
	Orientation Gap (OG)	36.52	34.03	43.63	26.33	31.28
Post - Experience	Perceived Orientation (PO)	124.64	115.65	118.16	120.61	120.55
	Developmental Orientation (DO)	98.01	78.58	80.87	90.46	86.89
	Orientation Gap (OG)	26.63	37.07	37.29	30.15	33.66

The findings demonstrate that all five students underwent changes in their intercultural competence levels following their international research experience. In particular, three out of five students displayed increased perceived orientation (PO), reflecting an enhancement in their self-assessment of intercultural competence. After the experience, all students remained at or advanced to the Acceptance stage, signifying an elevated ability to recognize and appreciate cultural differences. Regarding developmental orientation (DO), a general improvement was observed among the students, with two transitioning from Polarization (Reversal) to Minimization, and one moving from Minimization to Polarization (Reversal). These changes indicate that the students' actual intercultural competence levels were positively affected, with most shifting to more adaptive orientations. The decreased orientation gap (OG) for students, signifies a closer correspondence between their perceived and actual intercultural competence levels. This improvement indicates that the international research experience contributed to a more accurate understanding of their intercultural competence and skills.

DISCUSSION

The study's primary objective was to explore the program's influence on the intercultural and professional development of students in civil, construction, and environmental engineering fields. The findings suggest that this study positively enhanced participants' communication skills, networking, collaboration, research abilities, professional development, and intercultural competence. These improvements underscore the vital role of international research experiences in preparing students for successful careers in engineering. Key elements of the study, such as presenting research findings, engaging with international peers, and working on team projects, contributed to students' development in communication and networking, equipping them with the necessary tools to establish valuable professional connections.

The study also demonstrated the enhancement of students' research skills, equipping them to conduct independent research and to effectively evaluate and critique scholarly work. Professional development emerged as another critical area of growth, with students experiencing enhanced networking, presentation skills, public speaking, increased knowledge in their respective fields, and improved communication skills when conveying research findings to industry professionals. Additionally, the IRECCEE program positively impacted students' intercultural competence levels, fostering their capacity to effectively engage in and navigate diverse cultural contexts. This study highlights the significant value of international research experiences in the comprehensive development of engineering graduate students.

CONCLUSIONS

This study explored the influence of the IRECCEE program, an international research experience, on the intercultural and professional growth of graduate students in civil, construction, and environmental engineering. Our findings demonstrate that the program significantly contributed to the participants' development across various competencies, including communication skills, networking and collaboration, research abilities, professional development, and intercultural competence. The results highlight the importance and potential benefits of incorporating international research experiences into graduate education, as these experiences can foster essential skills and competencies needed for successful academic and professional careers. Furthermore, the IRECCEE program's positive influence on intercultural competence emphasizes the value of exposing students to diverse cultural and research contexts, which can enhance their ability to work effectively in multicultural settings.

However, it is important to note that this ongoing study has limitations, primarily the small sample size of five students and the reliance on self-evaluation without external validations. As the study continues, further analysis will be required to validate and expand upon these initial findings. Future research could also investigate the long-term effects of international research experiences on students' career trajectories and explore additional factors that may influence the effectiveness of such programs.

In conclusion, this study indicates that international research experiences can play a crucial role in the intercultural and professional development of graduate students in civil, construction, and environmental engineering. These findings support integrating international experiences in graduate education to prepare students for a globalized professional landscape.

ACKNOWLEDGEMENT

The material in this article is based upon work supported by the National Science Foundation under Grant #1855799. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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