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Framework to Assess the Impact of International Research Experiences in Civil Engineering on Graduate Students

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Abstract: With globalization, the demand for competent engineering graduates with international acumen increases. In order to respond to this rising demand, the National Science Foundation (NSF) funded the International Research Experiences in Civil, Construction, and Environmental Engineering (IRECCCEE) program to understand the impact of international research experiences on students through a multidisciplinary lens. The program provides Ph.D. students in civil engineering disciplines the opportunity to gain valuable international research experience and establish long-lasting collaborations with international researchers. The program funds students to travel and perform research work at an international research institution. For every student, such research experience becomes the intervention. This paper discusses the program and the corresponding research framework with the aim that the research community can leverage such framework. The mixed-method research framework was designed to comprehensively capture the immediate and sustained impact of the program on the students' competencies. With a multidisciplinary approach, the framework captures impacts on students' intercultural competence, professional development, intellectual growth, personal development, and academic development. The data collection includes survey designs and interviews. In order to capture immediate and sustained impacts, data is collected before and multiple times after the intervention.

Keywords: international experience; research abroad; engineering education



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1. Introduction

As a result of ongoing globalization, there is an increased demand for competent engineering graduates with international experiences. Organizations seek employees who are able to work in a diverse, interconnected and rapidly changing world [1]. The best way to develop intercultural competence is to explore different countries and cultures and to engage with people who have different cultural backgrounds. International experiences provide the opportunity to work with multi-national teams, learn new techniques and procedures, and develop long-lasting collaborations [2,3]. However, only 1% of U.S. students participate in international experiences and out of those, only 4% are enrolled in an engineering program. Subsequently, engineering is the most underrepresented field of study in international experiences [4].

Many other academic programs in areas such as business or social work acknowledge the importance of developing intercultural competence and therefore include mandatory international exchanges in their curricula to improve their students' competitiveness in the job market [5]. However, this is not the case for engineering students. As reasons for the disengagement of engineering students with abroad academic experiences, several hurdles were identified including curricular rigidity, lack of tradition, lack of support and negative perception of study abroad [1].

Graduate school provides not only a good opportunity for engineering students to improve their research skills, but also to develop intercultural competence, learn to work with

people from different cultures, and develop long-lasting collaborations. Approximately 20% of science, technology, engineering and mathematics (STEM) graduate students in the U.S. are international students with engineering being the most popular field of study [4]. This substantiates the importance for engineering students to be able to engage effectively in an intercultural work environment.

Study abroad programs are typically designed for undergraduate students and therefore lack integration of the research component [3]. Only 10% of all U.S. students studying abroad are graduate students. Since, in general, only 1% of U.S. students participate in an international experience, the number of graduate students is significantly small [4]. Moreover, student exposure to premier research environments enhances academic progress and career prospects and results in sustained networks of collaborators [6,7]. Thus, there is a need for international opportunities designed to meet the needs of graduate students. Even though needs and benefits of undergraduate abroad experiences have been documented, little research is available on research experiences, which best fit for graduate students [3].

This paper presents the National Science Foundation (NSF)-funded International research experiences in civil, construction and environmental engineering (IRECCEE) program that provides an excellent opportunity for domestic graduate students in civil engineering to perform research abroad and to establish long-lasting collaborations with international researchers. Moreover, a framework has been designed by the research team that is capable of measuring the impact of an international research experience on student development.

The background that follows provides an overview of civil engineering and its sub-disciplines. This is followed by a description of the IRECCEE program.

2. Background

Civil engineering deals with the conception, planning, design, calculation, construction and maintenance of build structures that serve the general public such as buildings, roads, bridges, pipelines, railways, dams, or canals [8]. The broader discipline of civil engineering actually includes civil, environmental, and construction disciplines. Civil engineers combine physical and scientific principles to design and build the environment we live in [9]. The main purpose of civil engineering is to provide the infrastructure necessary for a civilized population [10].

2.1. Overview of Civil Engineering

Civil engineering is one of the oldest and most diverse engineering professions. It is the second oldest engineering discipline after military engineering and was defined to separate non-military from military engineering [8,10]. Even though civil engineering has been practiced since the existence of human civilization, it was first defined in 1828 by Thomas Tredgold for the Institution of Civil Engineer's Royal Charter as the art of directing the great sources of power in nature for the use and convenience of man [9,11].

Civil engineering is a broad discipline and consists of several sub-disciplines including structural, construction, geotechnical, transportation, water resources and environmental engineering (Figure 1). Besides the aforementioned, other sub-disciplines such as surveying, earthquake, coastal, or municipal and urban engineering exist.

Structural engineering is concerned with the analysis and design of structures to support external loads. Tasks of structural engineers include the identification of loads such as the weight of a structure and interior, moving loads, or loads caused by nature (e.g., wind, natural disasters, or change in climate). Based on these loads, a structure with the required stiffness and strength is designed while taking safety, esthetics, serviceability, costs and constructability into consideration [10,12].

Construction engineering deals with the design, planning, construction, supervision and management of projects within the construction industry such as buildings and infrastructure. Construction engineers combine problem solving skills with clarity and imagination. They are involved in the development of schedules and costs, resource man-

agement, acquaintance of permits, management of project participants, and monitoring of the project progress [8].

Geotechnical engineering is concerned with the investigation of rocks and soils to analyze underground conditions. Thereby principles of soil sciences, hydraulics, material sciences and mechanics are applied. Geotechnical engineers are involved in the design of foundations, slopes, dams, tunnels, retaining walls or landfills [10,13].

Transportation engineering addresses the movement of people, goods and vehicles in a safe and efficient manner. Transportation engineers deal with the specification, design, construction, operation and maintenance of transportation facilities such as highways, streets, airports, railroads, canals or harbors. Thereby, technology, economy, politics and social factors have to be considered. Transportation engineering includes disciplines such as transportation design and planning, traffic engineering, infrastructure management and urban engineering [8,10].

Water resources engineering is concerned with the design of infrastructure necessary to manage and utilize the supply of water and therefore is responsible for the flow of water. It comprises the water supply as well as the excess management. Water resource management encompasses knowledge of hydrology, environmental sciences, resource management, conservation and meteorology [10,14].

Environmental engineering uses a combination of engineering and scientific principles such as chemistry, biology, mathematics, ecology, hydraulics, geology, microbiology and hydrology to solve problems related to environmental sanitation. Environmental engineers deal with the provision of safe water, management of wastewater, air pollution, recycling, waste disposal, public health and sanitation. They are concerned about the impact of technological progress on the environment and deal with local and global environmental issues [15].

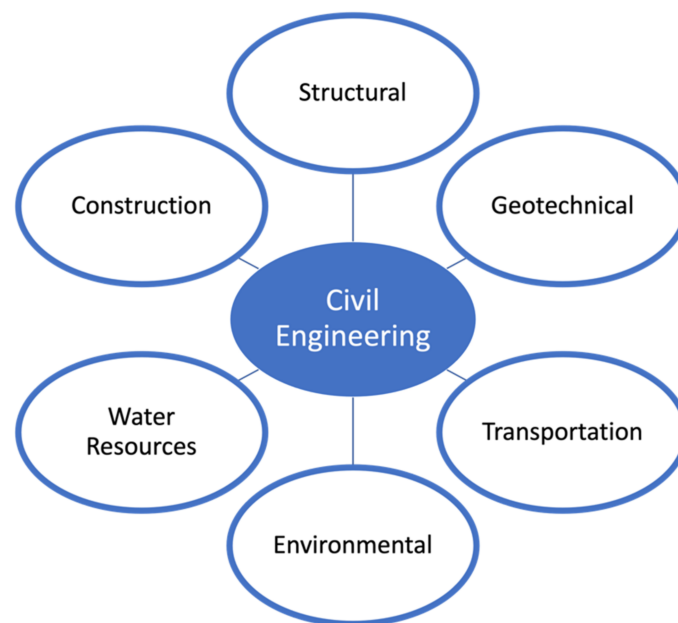


Figure 1. Disciplines of civil engineering.

2.2. Benefits of International Experiences

Research has shown that students can benefit in several ways from an international experience [3,16–24]. Thereby, advances especially in the following areas were reported:

Intercultural competence is defined as the ability to effectively and appropriately interact in cross-cultural environments [16]. Within the ongoing globalization, it becomes even more important to be able to interact with people from different cultures who grew up with different beliefs, values and experiences. University organized international experiences provide the opportunity to explore a foreign country and to learn about another

culture. Experiencing another culture also helps students to extend their worldviews and to better understand their own culture [17,18]. Moreover, students learn to communicate and interact with people who have different cultural backgrounds [19].

Personal development is defined as the process of building and experiencing the own identity as well as recognizing and growing own abilities, skills and potential [20]. Having to deal with new and uncertain situations while experiencing a foreign country supports the development of self-confidence [17], self-esteem [18], empathy, and listening skills [21]. While being abroad, students become more mature and independent, and improve their problem-solving skills [19,22]. Additionally, being forced to communicate in a foreign language also improves second language skills [17].

Professional development is defined as the development of skills and knowledge to advance someone's career [23]. Students participating in an international experience showed improved communication, interpersonal and leadership skills [24]. Moreover, these students show a higher interest in internationally oriented careers [3]. While being abroad, students are exposed to an unfamiliar environment, which helps them to gain valuable skills thereby improving their competitiveness in the job market [19,22].

Academic development describes the development of research related skills and knowledge [25]. Participating in an international research experience gains students access to new research tool, laboratories, and facilities as well as unique sources of data, methods and ideas. Such experiences helped students to improve their analytical, writing and presentation skills and to broaden their research perspectives [3,24].

3. International Research Experiences in Civil Construction and Environmental Engineering

Responding to the increasing demand of culturally competent graduates, the IRECCEE program has been initiated to provide domestic graduate students in civil and environmental engineering the opportunity to gain valuable international experience. Therefore, a program has been designed with the objective to broaden the impact on the students. Moreover, a research study has been designed to measure and assess the impact of such an experience on the students and based on that enhance the quality of international experiences for graduate students.

3.1. The IRECCEE Program

The IRECCEE program is part of the International Research Experiences for Students (IRES) program funded by the U.S. National Science Foundation (NSF) in order to provide research focused on international experiences for U.S. engineering and science students. The objective of this program is not only to support students developing their intercultural competence, but also their professional and networking skills [26].

The IRECCEE program was initiated with the main objectives to: (1) provide domestic PhD students in civil engineering the opportunity to develop valuable skills and competences during an immersive international experience; and (2) to understand the synergistic impact of international research experiences coupled with professional development on core graduate student advancement.

The framework of the IRECCEE program was developed based on an extensive literature review [27] with the objective to integrate diversity, research, professional development and cultural competence in order to generate a globally engaged engineering workforce with world-class skills and therefore to contribute to the competitiveness of the participating students.

IRECCEE provides support for a diverse cohort of up to 75 domestic PhD students in civil engineering to conduct research at a premiere international university with an anticipated cohort of 20–25 annually. In order to ensure immersive experiences, seven world-class, tier-1 universities with top civil and environmental engineering departments were chosen based on academic standing and geographical diversity covering four continents (Figure 2). The partner universities are located in Australia, China, India, Canada,

South Africa, Colombia and Israel. Due to the impact of COVID-19 on international travel, especially differing restrictions, the program has been opened to now include any international university. However, in order to maximize the success of the experience and to support long-lasting collaborations, students or their domestic advisors have to have a previously established relationship with the host institution.



Figure 2. Seven premier international research partner institutions.

The international host partners offer engagement with interdisciplinary research, world-class equipment, laboratories and facilities that support the research experience of IRECCEE fellows and complement the exposure and training that they receive at their domestic universities. Moreover, the students are granted access to unique sources of data, ideas and methods and they are provided with the opportunity to engage with local industry and professional development activities, and thus will become better prepared to succeed in a competitive context characterized by pressing global and sustainable challenges. The combination of the students' sustained network of international collaboration with the interdisciplinary nature of civil engineering research (environmental, materials, water resources, transportation, structures, geotechnical, construction) promises the exchange of knowledge among these and other disciplines.

Students select their host university based on relevance of their host partner's research topic and already existing collaborations with the host institution. IRECCEE requires alignment between the student's dissertation and research work during the international experience. Fostering the student's research horizon and development of world-class skills while working on the student's dissertation promises to reduce time to graduation. Such alignment is also likely to result in a sustained impact on each student's dissertation, network, and career. Moreover, the program generates, reinforces and expands sustainable networks of international collaboration. The quality and number of already existing collaborations between the international host partners and the domestic faculties promise to expand with the presence of the IRECCEE fellows and continue beyond the duration of the program.

In addition to the international experience, IRECCEE provides professional development resources through their unique partnership with the American Society of Civil Engineers (ASCE) in order to maximize the impact on the students. ASCE is a non-profit, worldwide operating professional engineering organization that represents civil engineers of all disciplines and career levels with chapters all over the U.S. Effectively all U.S.-based civil engineering programs have an ASCE Student Chapter that participates in various ASCE activities including a national concrete canoe competition and steel bridge competition. Furthermore, ASCE provides state-of-the-art education opportunities such as technical and professional conferences, workshops, webinars and events that foster the development of world-class engineering skills [28].

The IRECCEE program is designed as a longitudinal study with a two-year participation. In addition to the international research experience, students engage with several professional, intercultural and data collection activities before, during and after their ex-

perience. Student fellows receive financial and logistical support for their short-term international experience. The program covers and supports the organization of airfare, visa and housing. Additionally, advice and assistance in support of the international experience and professional development activities is provided by the IRECCEE team. Since research indicates that the long-term impact of international experiences increases with the duration [29], a length of two months to one semester was chosen.

The students engage in several data collection activities in order to measure the impact of the international intervention on their development and growth. The impact on the students' intercultural competence is measured using the Intercultural Development Inventory (IDI). Additionally, the Student Progress Survey (SPS) focuses on the students' professional, personal and academic development. Students have to fill out the surveys before their international experience in order to generate control data, right after the students' return to measure immediate impacts and additionally 12 and 24 months after the international visit to capture sustained impacts. A third survey about the students' performance and overall development is filled out by the students' host mentor after the research visit. Students also participate in a reflective interview after returning to their domestic campus in order to capture qualitative aspects of their international experiences.

3.2. Sequence of Events

Interested students can find information about the IRECCEE program, the partner universities and the application process on the IRECCEE website. In order to attract the maximum number of applicants, the program and its website were advertised by ASCE nationally through its newsletter. Due to ASCE's existing channels of advertisement and communication, the program is made accessible to a broad and diverse group of domestic graduate students. Additionally, flyers entailing program details were distributed to chairs of domestic civil and environmental departments.

In order to apply for the IRECCEE program, students are required to submit their contact information through the dedicated website. Thereupon, interested students receive further instructions for the application. Each student has to submit a research plan outlining their thesis motivation, objectives, methods, progress and up-to-date results as well as specific research tasks and a proposed schedule for their international experience. The research plan also details specific goals associated with international experience and how the attainment of such goals will contribute to the applicant's research work and thesis after the international experience. The application package also contains a letter of recommendation from the student's domestic advisor that discusses the student's academic achievements, character and goals and that explains of what extent the international experience can contribute to advance the advisor's research vision and goal. Lastly, students have to submit a curriculum vitae as well as a proof of relationship with their foreign mentor, if they plan to travel to a non-partner university.

The student selection process is competitive due to the number of students that have shown an interest in joining IRECCEE. Selection criteria are transparent and well-defined, and support preferences based on student status in this order: (1) Ph.D. candidates (i.e., completed coursework and comprehensive examination); (2) Ph.D. students (i.e., comprehensive examination not completed); and (3) Master's students (i.e., conducting research and considering possible PhD studies). Numerous criteria are considered to ensure that high quality, well-rounded, and diverse student candidates are selected. The selection is merit-based with evaluation including proposal quality, research plan, professional development plan, long-term benefit to the student, and support of the domestic advisor. Students are informed whether they have or not been selected.

The IRECCEE team works directly with the student fellows to assist in finding a host mentor that matches the students research and dissertation work. The students are required to reach out to the host mentors of their choice to confirm their willingness to host them. The IRECCEE team assists in organizing and coordinating logistics for the international experience (e.g., finding housing, the appropriate visa and flights).

As part of the IRECCEE program, there are a number of educational, research, and professional development activities for the students to engage before, during, and after their international experience. Figure 3 illustrates the required steps.

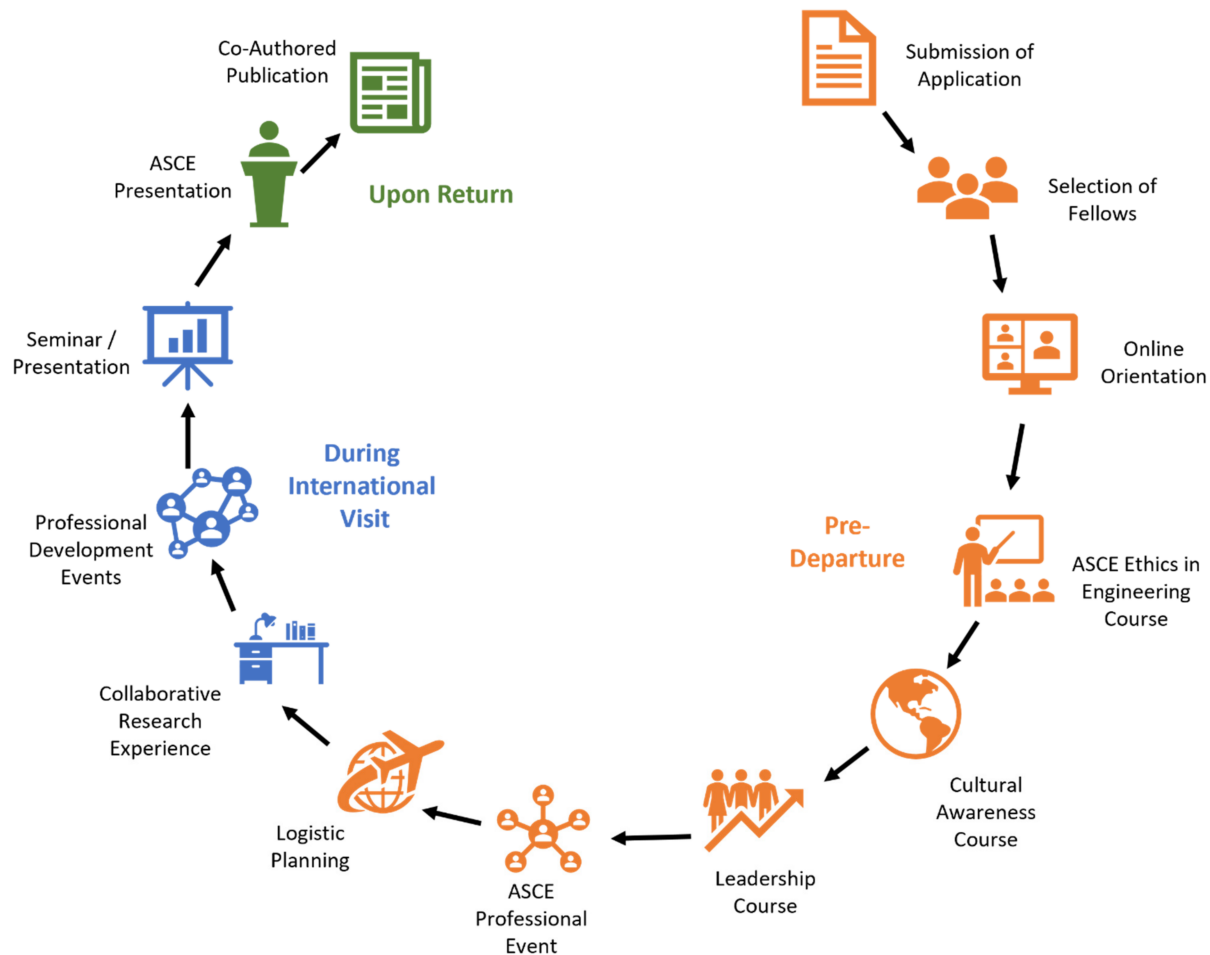


Figure 3. Educational and professional development activities before (orange), during (blue), and after (green) the international research experiences.

3.2.1. Pre-Departure Activities

Before the students travel to their host institution, they, together with their domestic advisor, are required to attend an online general orientation session that provides information about the objectives and expectations of the program, research and data collection measures associated with the participation, collaboration with ASCE, potential benefits of participating, a timeline of events, financial support and logistic planning.

Ethics and leadership represent an essential professional development nugget of knowledge that all civil engineering students should understand. Thus, students will attend an ethics in engineering class hosted by ASCE that discusses ethical obligations and the critical role of ethical principles in practicing engineering. An online leadership module is provided by the IRECCEE team that teaches students about different leadership styles as well as skills and traits of successful and strong leaders and how to gain and improve such skills.

In order to prepare the students for their international experience, an online cultural awareness orientation is offered by IRECCEE. This course focuses on cultural sensitivity and diversity and local customs. It also provides valuable travel tips and recommendations on how to behave in a foreign country.

Lastly, students are required to attend and participate in at least one local ASCE Professional Chapter event within the general area of the student's research topic. This

provides the students the opportunity to engage with local industry and to expand their professional network.

3.2.2. During the International Visit

During their international visit, students work together with their host mentor and research group in a collaborative way. This provides the students not only the opportunity to learn about different work procedures and culture but also to use the host institution's expertise, equipment, laboratories and facilities.

Students are encouraged to engage with local industry and professional opportunities and events through training opportunities, lectures, visits, or society chapter events. The host mentors and graduate peers assist the students with the identification of suitable events.

Moreover, fellow students are required to deliver one or more seminars or presentations about their research work at their foreign university or at local professional meetings or events.

3.2.3. Upon Return to the Domestic University

Once the students return to their domestic university, they are required to present their research work abroad at an ASCE Institute or domestic conference or at an ASCE regional or local professional meeting or workshop. Each of the nine Institutes of ASCE host an annual specialty conference that features technical paper presentations. Presentations at such dissemination outlets aim to enhance the student's scientific and professional self-dependence, communication skills, and expand their professional network.

Students are also encouraged to publish one or more journal or conference articles about their research work abroad; preferably co-authored with their foreign mentor.

Additionally, the IRECCEE program promotes taking the Fundamentals of Engineering (FE) exam, which is the first step in the process of becoming a licensed professional engineer.

3.3. Research Framework

In order to measure the impact of such an international research experience on the students' development, a research framework has been developed [27]. The mixed method approach is applied to reflect the complexity of such an international research experience. Data is collected through a mix of surveys and interviews to capture not only quantitative, but also qualitative aspects that were not covered by the surveys. The data collection measures focus especially on the five main competencies impacted by international experiences identified by Schneider et al. [27]: intercultural competence, personal development, intellectual growth, professional development, and academic development. Three different instruments were administered to the students before, after, and years after the international experience. In addition to the self-evaluation of the students, a survey is filled out by the host mentors to increase objectivity. Figure 4 illustrates a timeline of the data collection measures.

3.3.1. Student Progress Survey

The Student Progress Survey (SPS) was developed by the researchers in order to measure the impact of an international research experience on the students' abilities and skills in conducting research and producing research outcomes, professional and personal development, networking skills, and career prospects. The survey was developed as an online survey based on the literature review conducted by Schneider et al. [27]. The SPS is administered to the participating students prior to their international experience (pre) as well as three times after the return to their domestic universities, including directly after their return (post) and up to two years later (post-post) in order to measure immediate as well as sustained impacts on the students (see Figure 4). The pre and post/post-post surveys are administered to the same students to measure the students' development.

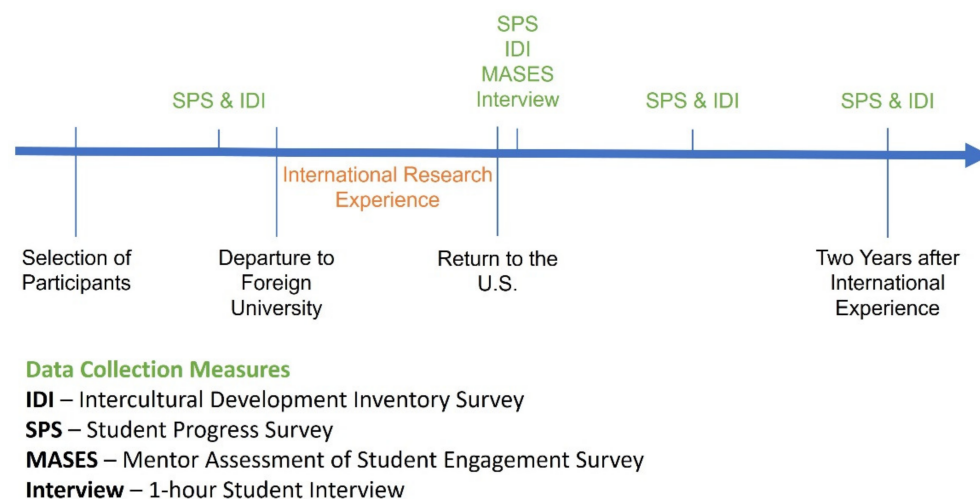


Figure 4. Data Collection Measures Before and After the International Research Experience.

Mostly closed-ended questions were chosen for the SPS to make the data more comparable. The main body of the instruments consists of four Likert-scale questions comprising 29 items on which the participants self-evaluate the current level of proficiency regarding their research skills, ability to perform research independently, networking and collaboration skills, and communication skills. For each question, students are given the opportunity to add additional aspects/skills that were impacted by their experience. In addition to the main body, students are asked to provide demographic information, information about previous international experiences, foreign language skills, and their motivation to participate in the program as part of the pre survey. The post/post-post survey additionally inquires about the students' experience and collaboration with their host institution, research outcomes, professional development activities, and career prospects. Finally, as part of the post survey, students are asked to evaluate the program.

3.3.2. Intercultural Development Inventory

The Intercultural Development Inventory (IDI) is used to evaluate the students' ability to shift their cultural perspectives and accommodate their behaviors to cultural differences and commonalities. It measures the stage of intercultural competence along the intercultural development continuum which ranges from denial over defense, minimization, acceptance, and adaptation to integration. The IDI has been psychometrically tested and results in strong validity and reliability across diverse cultural groups [30,31]. As the SPS, the IDI is administered to the participating students four times: prior to the international experience, directly after, and twice up to two years later (see Figure 4).

The IDI was developed based on the Developmental Model of Intercultural Sensitivity (DMIS). Students rate their agreement with the 50 statements presented in the online questionnaire on a five-point Likert scale. After filling out the questionnaire, a profile report of the participant's intercultural competence is generated, detailing the participant's developmental stage based on the intercultural development continuum [30,31].

3.3.3. Mentor Assessment of Student Engagement Survey

In addition to the self-reported data collected through the SPS and IDI, the students' host mentors evaluate their students' performance via the Mentor Assessment of Student Engagement Survey (MASES). Collecting data from different sources helps with triangulation and therefore, enhances objectivity, consistency and validity [32]. The online MASES was developed by the research team and is administered at the end of the students' international experience.

On a five-point Likert scale, mentors are asked to evaluate their student's research skills and knowledge, resilience and motivation, communication skills and behavior, time

management, potential, and intercultural behavior. In the form of open-ended questions, mentors are also asked to identify the student's main areas of improvement, positive aspects and benefits of the collaboration, as well as the most challenging aspects occurred during the research visit. Finally, the mentors have the possibility to provide feedback and recommendations to improve the IRECCEE program.

The Student Progress Survey (SPS) and Mentor Assessment of Student Engagement Survey were meticulously crafted, with the development process initiated by a comprehensive literature review [27]. This review was conducted to identify potential survey items relevant to the study's objectives. These identified items were then evaluated and refined by a panel of field experts, ensuring their relevance and applicability to the constructs being measured. A pilot test was subsequently administered to a group of students who had international research experience. This test was essential to assess the clarity and reliability of the surveys. The pilot test feedback helped in identifying and rectifying any potential biases, errors, or ambiguous items in the surveys. For ensuring their validity, rigorous statistical methods were employed, which confirmed that the surveys accurately measured the intended constructs.

3.3.4. Interviews

One-hour interviews are conducted with the students after their return to their domestic universities to complement the quantitative data collected through the surveys. In comparison to the surveys, students are provided the opportunity to expand and explain their responses, talk about individual experiences, express feelings, and make meaning of their experiences. The interviews are conducted via video calls, recorded and transcribed. An interview protocol was developed by the research team with the intention to complement and further explore the survey questions.

During the interviews, students are asked to talk about their international experience, their relationship and collaboration with the host institution, the impact on their research, skills and career prospects, research outcomes, problems and surprises during their research visit, and their life outside of the university. Finally, students have the opportunity to give feedback and recommendations for improving the IRECCEE program.

4. Results

A total of six students who participated in the IRECCEE program were selected for this study. The Student Progress Survey (SPS) was developed and administrated to evaluate the participants' abilities before and after the program. The SPS included questions related to communication, networking and collaborating, research independently, and research skills.

The results shown in Table 1 indicated that the participants' abilities in communication, networking and collaborating, research independently, and research skills improved after participating in the IRECCEE program. The mean scores for communication increased from 3.63 pre-program to 3.94 post-program, networking and collaborating increased from 3.44 pre-program to 3.85 post-program, research independently increased from 3.83 pre-program to 4.11 post-program, and research skills increased from 3.68 pre-program to 4 post-program.

The survey results suggest that the IRECCEE program positively impacted the research abilities and skills of the participants, as well as their personal and professional development, networking and collaboration skills, and career prospects. The increase in communication skills is particularly noteworthy, as effective communication is essential for conducting successful research projects and collaborating with colleagues. The improvement in networking and collaborating skills is also significant, as it suggests that the participants are better equipped to work in diverse teams and build relationships with colleagues from different backgrounds. The improvement in research independently skills indicates that the participants are better equipped to work independently and take ownership of their research projects. Finally, the improvement in research skills suggests

that the participants have a better understanding of the research process and are better able to produce high-quality research outcomes.

Table 1. International research experience's effect on academic and professional development.

Students Number	Communication		Networking and Collaborating		Research Independently		Research Skills	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	4.13	3.50	3.00	3.13	4.33	5.00	3.75	4.25
2	4.25	4.75	3.75	4.63	4.00	5.00	4.25	4.88
3	3.75	4.00	3.71	4.63	4.67	4.67	3.50	4.25
4	3.13	3.88	2.57	3.00	2.67	3.00	3.88	3.63
5	2.38	4.25	3.00	5.00	3.00	4.00	2.38	4.00
6	4.25	3.25	4.63	2.75	4.33	3.00	4.33	3.00

Table 2 presents data from the international experience program's six participating students. The data shows their scores on the Intercultural Development Inventory (IDI), which measures intercultural competence and developmental stages along the intercultural development continuum. The IDI was administered before and after the international experience. Each student has two rows in the table, representing their pre-experience and post-experience scores.

Table 2. Intercultural Development Inventory result.

Student Number		1	2	3	4	5	6
Pre Experience	Perceived Orientation (PO)	119.8	119.14	114.96	121.76	121.33	117.41
	Developmental Orientation (DO)	83.28	85.11	71.33	95.43	90.05	83.38
	Orientation Gap (OG)	36.52	34.03	43.63	26.33	31.28	34.03
Post Experience	Perceived Orientation (PO)	124.64	115.65	118.16	120.61	120.55	123.73
	Developmental Orientation (DO)	98.01	78.58	80.87	90.46	86.89	96.14
	Orientation Gap (OG)	26.63	37.07	37.29	30.15	33.66	27.59

Perceived Orientation (PO) is a numerical score indicating the student's self-reported perception of their intercultural competence. Developmental Orientation (DO) is a categorical stage along the intercultural development continuum that indicates the student's level of intercultural competence. Orientation Gap (OG) is a numerical score calculated by subtracting the DO score from the PO score. It indicates the discrepancy between the student's perception of their intercultural competence and their actual developmental stage.

Upon analysis of the data, it is apparent that most students had higher PO scores after the international experience compared to before. Three out of the six students had higher DO scores after the international experience compared to before experience.

Importantly, the OG decreased for most students (1, 4, 5, 6), indicating an increased alignment between their perceived and actual intercultural competence. However, for Students 2 and 3, the gap widened, suggesting an increasing divergence between their self-perception and actual competence.

Overall, the data suggests that the international experience program had a positive impact on the students' intercultural competence. They reported a higher perception of their intercultural competence after the program, and their developmental stages improved for the majority of the students. However, some students still had a discrepancy between their perceived and actual intercultural competence, indicating an area for further improvement.

In sum, the results of the survey suggest that the IRECCEE program is an effective way to enhance students' academic and professional development, research skills, and intercultural competence. The program provides opportunities for students to collaborate with colleagues at domestic and international colleges or universities, raise interest in research through oral presentations, and develop self-confidence in communicating research knowledge, judgment, and abilities. The findings highlight the importance of international research experiences in enhancing the skills and experiences of students in the field of civil, construction, and environmental engineering, as well as their potential to open up new avenues for collaboration and networking.

5. Conclusions and Additional Research Efforts

The literature indicates that the design of studies on international research experiences often fails to capture the impact of such experiences, often because neither the extent nor the timeline of the design can complex the complex and time-dependent impact of such experiences. To that end, an international research program and the corresponding research design to evaluate its impact were proposed. Initially, the IRECCEE program was implemented (1) to provide domestic Ph.D. students in civil engineering the opportunity to develop valuable skills and competencies during an immersive international experience, and (2) to understand the synergistic impact of international research experiences coupled with professional development on core graduate student advancement.

Complementing the program, a multidisciplinary research framework was designed to capture the impact on students' intercultural competence, professional development, intellectual growth, personal development, academic development, and career prospects. The initial results of surveys indicate that the IRECCEE program effectively enhances students' academic and professional development, research skills, and intercultural competence. The program fosters improved communication, networking, and collaboration skills, enabling students to excel in diverse teams and successfully conduct research projects.

The proposed data collection and analysis extend over time to capture the impact changes through time, i.e., immediate, intermediate, and sustained impacts on the students. Such a research framework becomes the long-lasting contribution of this study to the research community. Indeed, the proposed framework aims to provide a reference to researchers so that the impact of interventions based on student-centered research experiences can be evaluated and compared.

At the moment of this publication, several students have already participated in the IRECCEE program and spent up to a semester-long international research experience at a premier international university. Future studies should leverage such a research framework to evaluate the impact of international research experiences on the participating students.

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