Building Globally Competent Engineers: Early-Career Reflections on International Research Experiences

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Abstract

Developing globally competent engineers is critical in today's interconnected professional landscape. This study examines how participation in a National Science Foundation-funded International Research Experiences for Students (IRES) program in the U.K. shaped the professional development and global readiness of early-career engineers from the U.S. Using Social Cognitive Career Theory (SCCT) as a framework, semi-structured interviews were conducted with 16 U.S. alumni who participated in the U.K.-based program and are within 10 years of entering full-time employment. Thematic analysis revealed four interconnected performance domains influenced by IRES participation: (1) Technical Expertise and Knowledge Integration, (2) Global and Cross-Cultural Collaboration, (3) Leadership and Professional Networking, and (4) Adaptability and Independent Work. Participants reported that these experiences had lasting impacts on their career trajectories, confidence, and ability to navigate international professional environments. Findings highlight IRES as a long-term educational intervention that cultivates both technical and global competencies, offering insights for program design, employer engagement, and policy support for international STEM experiences.

Introduction

Engineering practice has long been embedded in global contexts, with engineers routinely collaborating across national, cultural, and institutional boundaries. In response, engineering education has emphasized the need for graduates who possess not only strong technical expertise but also the global competence required for effective international collaboration [1]. One prominent approach for supporting this preparation is participation in International Research Experiences for Students (IRES), which integrate technical research training with sustained engagement in international research environments. Unlike traditional study abroad programs, IRES initiatives immerse engineering students in research-intensive global settings that more closely reflect professional engineering practice.

Funded by the U.S. National Science Foundation (NSF), IRES programs aim to develop a globally engaged STEM workforce while reducing financial and structural barriers that often limit engineering students' access to international experiences [2]. Prior research indicates that participation in IRES programs supports the development of research skills, confidence, cultural awareness, and interest in graduate study [2], [3]. However, this work has largely focused on outcomes during or immediately following program participation, relying primarily on short-term self-reports and post-experience reflections.

As a result, less is known about how former IRES participants understand the influence of these experiences once they have entered the engineering workforce. This gap is particularly important given the long-term goals of IRES programs, including preparing globally competent engineers

and future STEM leaders. The early years of professional practice are a formative stage for examining such outcomes, as engineers begin applying their education in professional contexts, developing career identities, and making consequential career decisions. Retrospective perspectives from early-career engineers provide a valuable lens for assessing whether and how international research experiences translate into sustained professional competencies.

To address this gap, this qualitative study draws on Social Cognitive Career Theory (SCCT) [4] to examine how participation in an NSF-funded IRES program influenced early-career engineers' perceptions of their professional development and global readiness. SCCT emphasizes how learning experiences contribute to career development over time and highlights performance domains and attainments as indicators of lasting professional competence. While SCCT has been widely applied in engineering education research to examine motivation [5], persistence [6], and self-efficacy, it has been used less frequently to investigate how educational experiences manifest as long-term performance outcomes in professional engineering practice.

This study examines early-career U.S. engineers within 10 years of graduation who participated in a United Kingdom–based IRES program as undergraduate or graduate students and who have since entered the engineering workforce. Through semi-structured interviews informed by SCCT, participants reflected on how their IRES experiences shaped the skills, competencies, and professional behaviors evident in their current roles. Drawing on retrospective accounts of professional practice, this study extends prior IRES research and offers insight into how international research experiences function as long-term educational interventions that contribute to lasting professional competencies.

Accordingly, this study addresses the following research question:
How do early-career engineers retrospectively describe the influence of participation in an International Research Experiences for Students (IRES) program on their professional performance domains and global readiness?

Literature Review

Engineering study abroad programs have long been recognized for fostering a range of skills beyond technical knowledge, including cultural understanding, global perspectives, cross-cultural communication, and emotional growth [7]. Research on engineering-specific programs further highlights the development of soft skills such as confidence, teamwork, leadership, and flexibility, as well as technical skills gained through exposure to different professional norms and practices in international settings [8], [9]. Employers generally view study abroad experiences positively, particularly those with service-learning or internship components, because of the professional competencies they promote, including communication, openness, creative thinking, and intercultural competence [10], [11], [12]. Within the U.S. context, programs that include internships or structured practical engagement are especially valued, reflecting growing employer recognition of global competition and the need for internationally prepared engineers [13], [14]. Alumni also report that study abroad experiences enhance career competitiveness and

support international or multicultural career paths [7], [15], [16]. Recent quantitative research further links study abroad participation to higher global career outcomes, driven largely by increased self-efficacy [17]. Building on this literature, our study explores how IRES participation influences the development of self-efficacy and other career-relevant performance domains over time.

International Research Experiences for Students (IRES): Bridging Research and Global Competence

While traditional study abroad programs provide important global exposure, they often lack a strong research component important for engineering training and professional preparation. NSF International Research Experiences for Students (IRES) programs address this gap by offering research-based global experiences that combine technical skill development with international collaboration. In addition to fostering research competencies, IRES programs aim to develop a globally engaged workforce while also helping to reduce financial and logistical barriers that can limit students' access to international experiences [18].

Research on IRES outcomes demonstrates that program structure and location significantly shape student learning. For example, Davis et al. [2] found that U.S. students conducting research in China reported increased cultural awareness, while those in Australia emphasized technical skill development and personal growth. Across settings, participants consistently described gains in confidence, research skills, and inclination toward further graduate study, suggesting that both technical and non-technical competencies are cultivated in these programs.

Narrative and qualitative studies further highlight the importance of mentorship and the research environment. Davis and Knight [19] found that students' perceived "fit" with mentors and research groups influenced not only technical skills but also non-technical learning, including independence, self-confidence, and work-life balance. These outcomes reinforced students' long-term academic and career motivations. Additional research identifies best practices for designing effective IRES programs, including aligning research goals with student interests, fostering mentoring relationships, and supporting cultural adaptation [20]. Collectively, these studies suggest that IRES experiences contribute to enduring professional capabilities that extend beyond immediate skill acquisition.

Summary and Research Gap

While prior research demonstrates that study abroad and IRES programs support both skill development and global readiness in engineering students, most studies focus on short-term outcomes or immediate post-program perceptions [3]. Less is known about how early-career engineers retrospectively interpret the impact of IRES participation on their professional trajectories, particularly regarding the development of enduring competencies or performance domains. Performance domains – observable, career-relevant capabilities that reflect sustained

professional competence – provide a useful lens for assessing the long-term impact of IRES experiences.

To address this gap, this study explores how early-career engineering professionals reflect on their participation in an IRES program, examining the influence of these experiences on technical expertise, global preparedness, leadership, adaptability, and other professional competencies over time. By focusing on performance domains, this study situates IRES participation within a framework that captures lasting contributions to professional identity and career development.

Theory

This study draws on Social Cognitive Career Theory (SCCT) [4] to guide the research design and analysis. SCCT, rooted in Bandura's Social Cognitive Theory [21], provides a framework for understanding how learning experiences and personal beliefs shape career development over time. Given this study's focus on the long-term career impact of participation in an International Research Experiences for Students (IRES) program, SCCT offers a particularly relevant lens for examining how educational experiences translate into sustained professional competence. Prior research has applied SCCT to investigate students' motivation [5], persistence [6], and early career outcomes, including how undergraduate learning experiences relate to early career trajectories and professional competencies among engineering alumni [5], [22], [23].

While SCCT includes multiple interconnected constructs, the present study is intentionally focused on *Performance Domains and Attainments*, which represent individuals' demonstrated capabilities and competencies in career-relevant activities. Performance domains are especially well-suited for examining early-career engineers' retrospective reflections, as they capture how participants interpret the lasting outcomes of prior learning experiences within their current professional roles. In this paper, Performance Domains serve as the primary analytic construct through which participants' IRES experiences are examined.

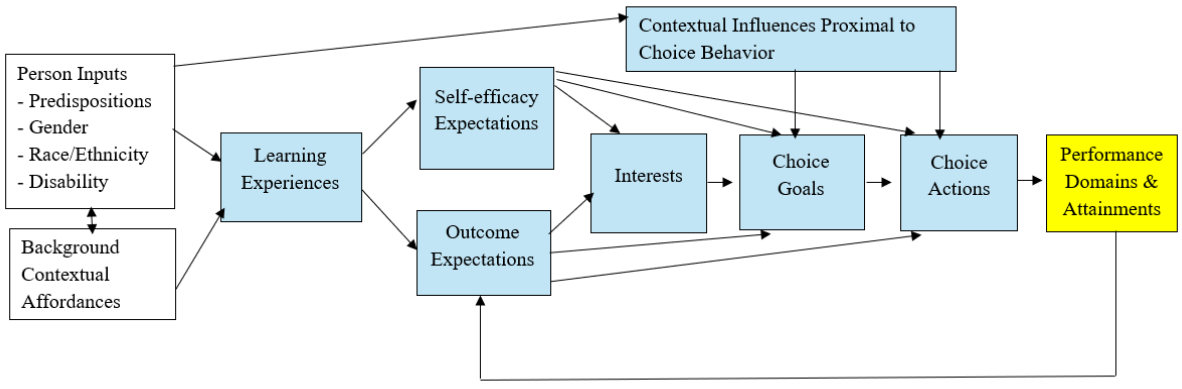

Fig. 1. Social Cognitive Career Theory. *Based on work by Lent and Brown* [24]

Figure 1 illustrates the full SCCT model [24], highlighting the relationships among learning experiences, self-efficacy, goals, actions, and performance outcomes. Although engineering education researchers have often focused on a subset of SCCT constructs when examining undergraduate global experiences [17], this study uses SCCT to contextualize how IRES participation functions as a formative learning experience that contributes to later performance outcomes. Performance Domains & Attainments is highlighted in yellow, as it is the focus of the discussion of this paper.

In the design of the interview protocol, multiple SCCT constructs were considered in order to support rich reflection. Specifically, questions were informed by Learning Experiences, Self-Efficacy Expectations, Choice Goals, Choice Actions, and Performance Domains and Attainments. This approach allowed participants to describe their IRES experiences holistically, including how those experiences influenced their confidence, decision-making, and professional trajectories. However, consistent with the purpose of this paper, analysis and reporting focus exclusively on Performance Domains, as these domains represent the most direct evidence of long-term educational impact in participants' early careers. Other SCCT constructs, such as Outcome Expectations, Interests, and Choice Goals and Actions, were included in the codebook to capture contextual nuance but are not presented as standalone findings.

Within SCCT, learning experiences shape self-efficacy – individuals' beliefs about their capabilities – which in turn influence goals and actions [4], [24]. Through repeated engagement in career-related activities, individuals develop performance domains and attainments that reflect their strengths, competencies, and professional growth. In this study, participants' accounts of their current professional practice are interpreted as evidence of these performance domains, which they explicitly attributed to their IRES participation. By centering performance domains, this analysis emphasizes how international research experiences function as long-term educational interventions that contribute to lasting professional competencies rather than short-term attitudinal outcomes.

Methods

This qualitative study used semi-structured interviews and thematic analysis to examine how participation in an International Research Experience for Students (IRES) program influenced early-career engineers' professional development and global competencies.

Participants

Our participant pool consisted of early-career professionals who had participated in the IRES program as undergraduate or graduate students. All attended a large, public, research-intensive university in the southeastern United States and completed IRES research in partnership with a research-intensive university in the United Kingdom. While most IRES programs are funded for three to four years, this program operated continuously for 10 years (2014–2024) through an initial three-year grant, a one-year supplement, and a subsequent second round of funding. Early

career status was defined as having zero to ten years of full-time work experience following completion of the degree pursued during the IRES program, consistent with NCSES [25] definitions.

A total of 48 alumni were invited to participate. Cohorts affected by COVID-19 disruptions (2020-2021) were excluded. Sixteen alumni completed interviews (response rate = 33%), including 10 males, 5 females, and one non-binary participant. Participants represented a range of engineering disciplines, providing diverse perspectives on the program's influence on early-career outcomes.

Participant Demographics and Employment

Employer types were categorized following sector distinctions commonly used in workforce and STEM education research, consistent with National Academies definitions [26]. Academic institutions include colleges and universities that award at least a two-year degree; government employers comprise public-sector agencies at the federal, state, or local level; and industry includes private for-profit companies and businesses. These categories align with standard labor and STEM workforce research definitions, facilitating comparison with national employment patterns. Based on these definitions, most participants are employed in industry (7), followed by academia (5) and government (4).

Participants' academic standing at the time of the IRES program is reported as "Undergraduate" or "Graduate," and "Years of Full-Time Work Post-University" indicates the number of years since completing that degree. Table 1 summarizes each participant's academic status, post-graduation work experience, and current employment sector.

Table I

Participant academic status, post-graduation work experience, and current employment sector

Participant ID	Academic Standing while Participating in IRES	Years of Full-Time Work Post-University	Current Employment Sector
Participant 1	Graduate	1	Industry
Participant 2	Undergraduate	1	Academic
Participant 3	Undergraduate	1	Government
Participant 4	Graduate	7	Industry
Participant 5	Graduate	5	Government
Participant 6	Undergraduate	2	Academic
Participant 7	Undergraduate	1	Academic
Participant 8	Graduate	1	Government
Participant 9	Undergraduate	0	Academic
Participant 10	Graduate	7	Academic
Participant 11	Graduate	9	Government

Participant 12	Undergraduate	6	Industry
Participant 13	Graduate	3	Industry
Participant 14	Graduate	10	Industry
Participant 15	Undergraduate	7	Industry
Participant 16	Undergraduate	9	Industry

Data Collection

Semi-structured interviews, lasting approximately 60 minutes, were conducted via Zoom. Interviews explored participants' career trajectories and the perceived impact of IRES on technical and professional development, global preparedness, and career choices. The interview protocol was guided by Social Cognitive Career Theory (SCCT), with questions designed to elicit reflections on learning experiences, self-efficacy, choice goals, choice actions, and performance domains. Additional questions addressed alignment with the National Science Foundation's stated goal of developing globally competent STEM leaders. All interviews were audio-recorded and transcribed for analysis. The full interview protocol can be found in the Appendix.

Data Analysis

Thematic analysis [27] was used to identify patterns in participants' retrospective accounts. The research team collaboratively developed an initial codebook informed by SCCT, with a focus on Performance Domains and Attainments as a primary analytic construct.

Team members independently coded a subset of interviews and met to resolve discrepancies, refine code definition, and confirm alignment between performance domains and SCCT constructs. A final review was completed to ensure consistent coding across all transcripts. By connecting each performance domain to SCCT, the analysis illustrates how IRES participation functions as a long-term formative experience shaping competence and career behaviors.

Positionality Statement

Two of the researchers on this project have previously led or coordinated IRES programs, providing firsthand insight into program structure, goals, and challenges. While this experience informed interview design and analysis, reflexivity was maintained to minimize potential bias.

Limitations

This study is limited to a single IRES program conducted in the United Kingdom, a country with relatively low cultural distance from the U.S. [28]. Outcomes may differ in programs located with countries with greater cultural distance; however, this enables the focus of this study to be around performance and working culture. Additionally, participants' prior global experiences were not examined, limiting insight into how prior exposure may have influenced motivation or career trajectories. Consequently, the study does not claim a direct causal relationship between

IRES participation and career outcomes. The study's relatively small and context-specific sample drawn from a single IRES program in the United Kingdom limits the ability to generalize findings to other programs or settings. A single-site sample may not capture the diversity of participant experiences, institutional structures, or cultural environments present across IRES programs globally. As a result, the findings may reflect program-specific dynamics rather than broader trends.

Results: Performance Domains Attributed to IRES Participation

Analysis of interview data revealed that participants consistently described the long-term impact of their IRES participation through a set of career-relevant performance domains, as conceptualized within Social Cognitive Career Theory (SCCT). These performance domains represent areas in which participants perceived sustained competence and professional capability that they directly attributed to their international research experience.

Across interviews, eleven distinct performance domains emerged and were grouped into four overarching categories: (1) Technical Expertise and Knowledge Integration, (2) Global and Cross-Cultural Collaboration, (3) Leadership and Professional Networking, and (4) Adaptability and Independent Work. Participants frequently described these domains as interconnected and cumulative, with IRES serving as an early performance accomplishment that continued to influence their professional practice years later. See Figure 2 for these performance domains.

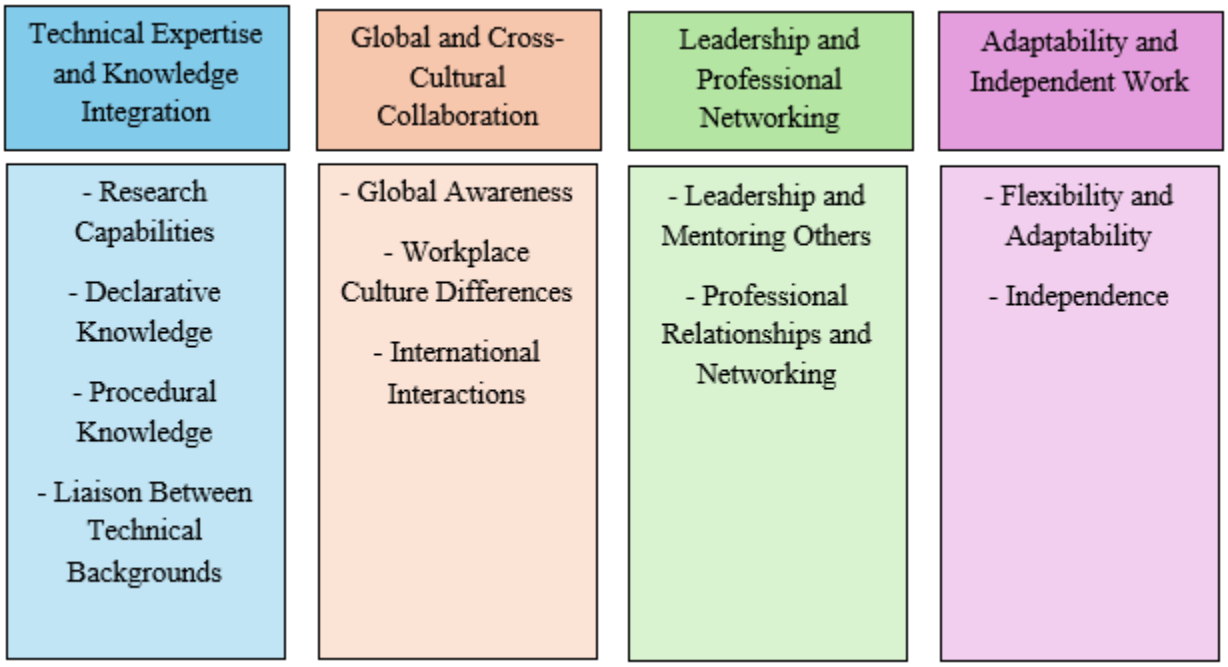

Fig. 2. Description of results themes and subthemes

1. Technical Expertise and Knowledge Integration

Participants described IRES as a critical experience for developing and integrating technical expertise in ways that extended beyond disciplinary knowledge gained in coursework. Four interrelated performance domains emerged within this category: research capabilities, declarative knowledge, procedural knowledge, and serving as a liaison between technical backgrounds.

Research Capabilities

Among our participants, all but one identified IRES as their first experience engaging in the full research process, including problem formulation, experimental design, data collection, analysis, and dissemination. For many participants, the experience directly informed later dissertation work, professional research roles, or continued engagement in research-intensive careers. One participant who participated as an undergraduate student and then pursued a PhD explained, "I went on to go to grad school and get a whole PhD in [my IRES research field], because I was exposed to this experience doing research in an academic setting through IRES" (Participant 16).

Participants emphasized that the autonomy and expectations associated with conducting research in an international setting accelerated their development as independent researchers. An undergraduate participant who later pursued a master's degree noted, "previously in undergrad, I'd only taken over projects in research, but I'd never had a chance to start from scratch and go through all of the steps to the finish. So [IRES] really made me understand what the research procedure really looks like, and that helped with my master's research" (Participant 2).

This pattern extended to those who participated as graduate students. As one participant who participated as a PhD student explained. "I think it gave me really good exposure on the research side of different topic areas. It also showed me the end-to-end research process. So even though I had done a lot of research as an undergrad, I had never done it end-to-end" (Participant 10).

All early-career engineers described how skills developed during IRES reappeared in graduate research or industry research roles, noting that they felt better prepared to navigate uncertainty, revise research plans, and communicate findings. Participant 15, currently an analyst at a large company, expressed, "[IRES] has opened a lot of opportunities and curiosity for me, seeing how a research project is run from start to finish. I saw that when I was in the IRES program, and then I've used that knowledge for projects while working, which has been really helpful." Participants often characterized IRES as a foundational research experience that "set the standard" for how they approached research thereafter.

Declarative Knowledge

Participants also described developing declarative knowledge – deep content expertise that positioned them as subject-matter resources in later roles. This included familiarity with specific technologies, methods, or application areas introduced during IRES, including topics from human factors, electrical circuits, and materials science. Some participants reported that this

expertise allowed them to contribute authoritatively in professional settings, including advising colleagues, contributing to technical decision-making, or teaching and mentoring others.

For example, Participant 3, now a researcher at a national laboratory, described how he drew on simulation experience gained during IRES to address a technical challenge in his current role:

> I was doing a lot of computer simulations in IRES, working on thermal mechanical strain. In my current job, we encountered a different issue that we had to figure out. I remembered a tool I used in the U.K. and realized it could be applied here, since I had seen it used for power electronics. And we were actually able to get some pretty good and conclusive results that helped further the project (Participant 3).

Half of the participants noted that their IRES topic became a recognizable component of their professional identity, shaping how colleagues perceived their expertise even years after the program. In one case, a participant also described how their IRES experience served as a valuable talking point in interviews:

> When it came to interviews, I had more to talk about, which improved my performance. Interviewers were often curious about my experience in the U.K., particularly my work in human factors and XR in transportation, and how it differed from U.S.-based work. This gave me a strong talking point and led to more in-depth conversations (Participant 2).

This example highlights how declarative knowledge from international research can also function as a form of professional signaling, enhancing visibility and engagement in career contexts beyond immediate technical tasks.

Procedural Knowledge

Beyond content knowledge, participants emphasized procedural knowledge related to how engineering work and research are conducted. This included learning different approaches to experimental design, project management, documentation, and research workflows. For example, Participant 9 described training on specialized equipment in the U.K.:

> They have a lot of equipment there that we don't have access to at my home university, so I learned and got trained on a few new pieces of equipment while I was there.

This familiarity with new equipment led their home professor to request their assistance in helping another graduate student with setup the following semester. Such experiences directly contributed to the participant's confidence and ability to support research activities even as an undergraduate.

Exposure to alternative procedural norms in the international research environment prompted participants to critically evaluate and refine their own work practices. Participant 13 described learning "structured problem solving and how to frame technical challenges effectively," a skill

they later applied to break down tasks into clear goals, define measurable success criteria, and track progress in their professional career.

Participants described transferring these procedural approaches into later academic and professional contexts, often blending practices learned abroad with those encountered in U.S. institutions or industry settings.

Liaison Between Technical Backgrounds

Half of participants described acting as technical liaisons in their current roles, able to translate, integrate, or connect ideas across disciplines, teams, or contexts. The interdisciplinary and international nature of IRES positioned participants to bridge gaps between collaborators with different technical training or problem-solving approaches. One participant, an undergraduate during the program, noted that IRES taught them how to clearly communicate data, a skill they now applied as a sustainability analyst at a large, multinational company (Participant 15).

As participants transitioned into early-career positions, their ability to act as technical liaisons enabled them to navigate and integrate perspectives across distinct technical domains, particularly in roles involving cross-functional teams, international collaboration, or systems-level engineering challenges. One participant now working for a national laboratory stated:

> In my current job I work with cybersecurity. Since I have a little more background on the engineering side, it's kind of a cross-disciplinary position. Sometimes I describe myself as a glorified translator – I speak the language of both sides (Participant 8).

Overall, these experiences suggest that IRES develops participants' capacity to serve as bridges between disciplines, enhancing both their technical versatility and effectiveness in collaborative, cross-functional and international engineering contexts.

2. Global and Cross-Cultural Collaboration

A second major category of performance domains related to participants' ability to work effectively in global and cross-cultural contexts. Three domains emerged: global awareness, navigating workplace cultural differences, and engaging in international interactions.

Global Awareness

Participants consistently described increased awareness of how engineering work is shaped by social, cultural, and institutional contexts. This global awareness extended beyond knowledge of a single host country and influenced how participants approached international collaboration more broadly. Participant 15 shared, "Traveling helps you build and grow as a person, because it shows you that there are many different kinds of people in the world who think differently and have different kinds of regulations than we do." They noted that their IRES experience shaped how they navigate international collaboration in their current role, where European suppliers place greater emphasis on sustainability and regulatory compliance than American suppliers.

Many participants noted that IRES altered their assumptions about professional norms, expectations, and priorities in engineering work, leading them to approach global projects with greater attentiveness and openness.

Workplace Cultural Differences

Participants highlighted their ability to recognize and adapt to differences in workplace culture, including communication styles, work-life balance, hierarchy, and collaboration. Two participants contrasted U.S. work norms with those observed during IRES and described how this comparison shaped their expectations for healthy and productive work environments. Participant 3 commented how the more casual approach to work hours they observed in the United Kingdom affects their work now:

> In the U.S., I'd come into the lab randomly on a Friday night because I forgot something and one of our PhD students would be there. I'm like, you gotta go home, this isn't healthy. [In the U.K.] it was like, if I stayed ten minutes past, five professors would come to me like you gotta get out of here (Participant 3).

Importantly, participants framed this domain as an active skill rather than passive exposure—one that involved interpreting cultural cues, adjusting behavior, and reflecting on how culture influences engineering practice.

International Interactions

Participants reported increased confidence and competence in engaging with international colleagues, whether through in-person collaboration, conferences, or virtual global teams. Even participants whose current roles did not include formal international assignments described drawing on their IRES experience when working with colleagues from different countries or cultural backgrounds. One participant, now seven years after graduating and employed at a large multinational company, noted that “having that experience of working with people from other countries helped me now because I'm still working with people from other countries and who speak a completely different language” (Participant 15).

One participant observed that others recognized their international experience through their communication style, cultural sensitivity, or collaborative approach, highlighting the lasting professional visibility of this skill. Participant 11, who had never been out of the country prior to IRES and is now employed at a government agency, described a coworker who recognized their international experience in how he “worked with and talked to other people.”

Taken together, these accounts suggest that IRES fosters enduring intercultural competence, enabling participants to navigate diverse professional contexts and enhancing their effectiveness in global collaborations.

3. Leadership and Professional Networking

Leadership and professional networking emerged as a third category of performance domains, reflecting participants' ability to influence, support, and connect with others in professional settings.

Leadership and Mentoring Others

Participants described how IRES contributed to their development as leaders, particularly in mentoring and supporting junior colleagues. Exposure to mentoring relationships during IRES—both as mentees and, in some cases, as peer mentors—shaped how participants later approached leadership roles. One participant, a graduate student during the program who served as a mentor for two undergraduate participants, reflected on her experience 10 years later:

> I learned a lot about mentoring...and got a huge amount of mentoring experience that I really liked. I learned what I didn't like about myself as a mentor, and I also learned that I really love mentoring and kind of how do I balance that and how do I do better? And so mentorship is something that has definitely been a key driving factor of job changes, career choices and everything since [IRES] (Participant 10).

Five early-career engineers described intentionally modeling leadership behaviors observed during IRES, such as inclusive collaboration, respect for diverse perspectives, and attentiveness to work-life balance. Participants in supervisory or managerial roles emphasized mentoring as a key component of their professional identity. One participant, reflecting on 10 years of professional experience since IRES, explained:

> I want to play a role as a mentor with junior engineers – not necessarily as a manager, but to oversee the bigger picture of a project and guide people...I want to be more of a subject matter expert and guide younger engineers of the future (Participant 14).

Overall, these experiences suggest that IRES fosters both leadership and mentoring skills that participants continue to apply and value throughout their professional careers.

Professional Relationships and Networking

Participants frequently cited professional relationships formed during IRES as enduring and impactful. These connections included faculty mentors, graduate students, peers, and international collaborators. For many, these relationships extended beyond the program, supporting graduate school applications, research collaborations, and ongoing professional development. Participant 16, who participated in IRES as an undergraduate, noted:

> [My graduate student mentor] was instrumental to me ending up in grad school. [My faculty mentor] was also very helpful; he ended up writing one of my recommendation letters throughout the admissions process and helping me understand where I can go to

> graduate school. I continued working in his lab as an undergraduate researcher through my senior year, until I graduated.

Participants also emphasized that IRES taught them the importance of networking as a professional practice, broadening their understanding of how relationships support career development in engineering.

4. Adaptability and Independent Work

The final category of performance domains focused on participants' capacity to adapt and work independently – skills that were repeatedly described as essential in early-career engineering roles.

Flexibility and Adaptability

Participants emphasized that navigating a new country, research environment, and professional culture required substantial flexibility. They described adapting to unfamiliar technologies, expectations, and social norms, often with limited guidance. This adaptability was frequently cited as transferable across roles and sectors, helping participants respond effectively to changing job responsibilities, organizational shifts, and unexpected challenges. Participant 1 noted:

> The first thing I learned during IRES is that you shouldn't be afraid of learning new things at a fast pace. So, it was probably the same condition when I started my career here as when I started IRES...that was one of the things that I learned during IRES that I have used in my current career (Participant 1).

The flexibility and independence developed during IRES were repeatedly cited as transferable skills, enabling participants to navigate diverse technologies, work environments, and organizational changes.

Independence

Among our participants, ten of them described IRES as a turning point in their development as independent professionals. The expectation to take ownership of research tasks, manage time effectively, and solve problems autonomously contributed to increased confidence in their ability to function independently in later roles. Participant 10, a graduate student during the program, explained that the experience helped them appreciate the value of organization and self-direction in research, noting that "when you have only weeks [to do a project], you have to figure it out."

Participants described independence as the ability to initiate work, seek support strategically, and take responsibility for outcomes—skills they continued to apply in both academic and industry contexts. Participant 2, an undergraduate during the program and now a master's student, reflected, "I had to be proactive about things, and those skills are one of the biggest things I learned: how to be more independent and manage my time better."

These accounts suggest that IRES cultivates professional independence by fostering self-direction, proactive problem-solving, and effective time management, which participants continue to apply in both academic and early-career contexts.

Summary of Performance Domains

Across all four categories, participants consistently described IRES as a formative experience that contributed to lasting performance domains evident in their early careers. Rather than viewing these outcomes as temporary gains, participants framed them as integrated components of their professional competence and identity. These findings underscore the role of international research experiences as long-term educational interventions that support the development of globally competent engineers.

Discussion and Implications

The findings from this study offer actionable insights for educators, program designers, employers, and policymakers involved in international research experiences and study abroad programs for engineering students. These insights are based on the experiences of U.S. students participating in an IRES program in the United Kingdom and should be interpreted within this specific context. While the results highlight important patterns in student development, additional research including participants from programs in a wider range of host countries is needed to extend the applicability of these findings across diverse international settings.

Educational and Program Design Implications

IRES participation helped students clarify career goals, often shifting them from broad interests to specific paths, while fostering technical expertise, self-awareness, and intentional career planning. Mentorship, peer support, and structured reflection were critical in this process, suggesting that programs should prioritize collaborative learning environments and strong mentoring relationships. This finding is consistent with other engineering education research, which highlights how mentorship allows students to form support groups, improve retention rates, and assist in student learning outcomes that are important to accreditation [29].

Participants also highlighted the challenges posed by cultural differences in work norms and communication styles, underscoring the value of predeparture cross-cultural training to prepare students for international research environments. In addition, incorporating social activities into the program provides opportunities to broaden networks and cultural understanding, creating a more holistic experience and helping to develop a global mindset. These social and predeparture cross-cultural training activities connect to Learning Experiences from SCCT [24]. When learning experiences properly prepare students, they can more intentionally plan their careers.

Industry Implications

Early-career engineers credited IRES with developing competencies highly relevant to global engineering work, including flexibility, communication skills, self-efficacy [24], and the ability

to collaborate across cultures. As shown in SCCT, self-efficacy leads individuals to align their interests and make career choices and actions. These outcomes are consistent with the mid-term impacts of study abroad, which were collected through reflections of senior engineers with their first-year study abroad experiences [30]. Employers seeking talent capable of thriving in international and multicultural contexts can benefit from recognizing the value of such programs during recruitment and professional development. Structural barriers – such as visa restrictions or limited global operations – may limit the full application of these skills, so organizations should consider strategies to better leverage globally trained engineers. These barriers connect to the contextual influences of SCCT [24]. Both barriers and support external to the individual can have an impact on the individuals' career choices and performance.

Importantly, participants are distributed across industry, academia, and government roles, with industry representing the most common employment sector (7), followed by academia (5) and government (4). This distribution highlights that IRES programs may have particular relevance for preparing students for private-sector engineering careers. This suggests that industry employers can benefit directly from recruiting participants with international research experience, as they bring both technical skills and global competencies to their roles.

Policy Implications

The long-term professional benefits described by participants suggest that IRES programs deliver value beyond immediate educational outcomes, supporting the case for sustained institutional and federal funding. Policies that prioritize investment in programs integrating international research exposure and mentorship could help develop a more globally competent STEM workforce. At the institutional level, administrative leadership and cross-departmental coordination play a critical role in program implementation. Prior research highlights the importance of support from program directors, deans, and department heads in successfully establishing engineering study abroad programs [31]. These findings suggest that policies encouraging collaboration across administrative levels, along with dedicated resources and incentives for faculty participation, may strengthen program effectiveness. Consistent with our findings, multi-level investment from students, mentors, faculty, and administrators is essential to program success.

Future Research

This study focused on a single IRES program in a culturally similar host country (the United Kingdom), did not account for participants' prior international experiences, and did not include quantitative results, limiting the ability to measure the magnitude or statistical significance of observed outcomes. Future work should examine samples across multiple programs and include countries with greater cultural distance, while incorporating longitudinal tracking to better understand how international research experiences shape long-term career development. Additionally, research with larger, more diverse samples across multiple countries and program types would strengthen generalizability and allow for more robust comparisons. Future

quantitative studies could focus on measuring changes in participants' research self-efficacy, cultural awareness and career paths using surveys, or by tracking participants over time to assess the statistical significance and persistence of those changes.

Conclusion

Overall, IRES participation contributes to enduring professional competencies, including technical expertise, global collaboration, leadership, and adaptability. By linking participant reflections to Social Cognitive Career Theory, this study demonstrates how structured international research experiences function as long-term educational interventions that shape career trajectories, professional identity, and self-efficacy. These findings underscore the value of sustained investment in international STEM programs and provide guidance for educators, employers, and policymakers seeking to cultivate globally competent engineers.

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Appendix

Interview Protocol

Participants: Former IRES participants
Approx. 60 minute interview

Welcome:

- Overview of the interview process/IRB information:
  Thank you for agreeing to participate in this interview. This study aims to explore the career trajectories of former IRES participants. Before we begin, I'd like to remind you that your responses will be confidential, and you can choose not to answer any questions you are uncomfortable with. We are recording and transcribing our own notes, but these will not be shared with anyone else. Feel free to speak as openly and in as much detail as possible.
- Do you have any questions before we start?
- Start Record and transcript

Introduction:

1. Can you start by telling me a little about yourself, e.g., engineering background, where you're from, and your current position and field of work?

2. Please tell me about the timing of your IRES experience in the context of your time at the University. What degree program were you in when you did IRES, and when did you graduate from that degree?

Journey and Experiences:

3. Please walk us through a timeline of your career path since you graduated from the University and ending with your current position. How did you get to where you are now? Is this path different from what you imagined?

4. Please tell me more about your current role in either graduate school or employment.
   a. What are your primary job responsibilities, and do you have any positions that report to you?
   b. Are you currently involved in research?
   c. Does your current work or research have a global component or bring you into contact with people from other countries or cultures?

5. What are the top three skills you feel you developed through your IRES experience that have influenced your career?

6. What role do you feel IRES played in your career journey and career choices?

7. Have you had ongoing interactions with anyone from your IRES host country or institution?

Impact of IRES:

8. Thinking back to your career timeline, when was a time when you needed to draw on something you learned during your IRES program:
    a. What was the situation?
    b. What knowledge or skills did you need to draw on?
    c. What was the outcome?

9. How do you feel participation in your IRES program affected your preparation to work globally?

Reflection and Insights:

10. If you were to talk about your career journey with someone considering participating in an IRES program, what advice or insight would you share with them?

Future Vision:

11. What are your hopes or aspirations for your future career? How do you see your career unfolding in the next few years?

Closing Question:

12. Do you have any final thoughts you have not mentioned yet that you think would be helpful for the research team to know?