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Assessing the impact of IRES on researchers, research outcomes, and students: A case study approach

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Assessing the Impact of IRES on Researchers, Research Outcomes, and Students: A Case Study Approach

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Executive Summary

IRES programs seek to develop globally connected future researchers while also facilitating broader long-term collaborations between U.S.-based and international research groups. Faculty and student exchanges are expected to result in international linkages between the researchers that bring new insights and methods to U.S.-based research projects, leading to transformative research. In this project, we conducted a comprehensive evaluation of IRES programs through a case study analysis. The nine selected cases focused specifically on engineering-focused IRES experiences for ease of comparison. Case studies included interviews with all U.S. PI's, a selection of additional international and U.S. faculty researchers, and select student alumni for a total of 59 interviews across the nine sites.

Our analysis highlights the variety of approaches different IRES programs have taken, which we hope will be helpful for institutions proposing new IRES programs as well as for NSF program officers who work with IRES PI teams. We highlight best practices in developing research exchanges, the return on investment of such programs, as well as ideas from program leaders and participants in how to structure such experiences for students as well as faculty and institutions both on the U.S. and international sides to achieve a range of outcomes.

Findings from Interviews with Program Leaders
We identified five different structures among our sample and demonstrated that the structure of the program appears to influence the magnitude, scope, and the kinds of impacts of the program on faculty members and the institution. Faculty PIs leading the endeavor on their own tended to realize greater individual and research benefits. Although there is a greater logistical demand on an individual faculty member, this model could support their career trajectory. Programs that bring together multiple departments in a network might be a better approach for colleges that are seeking to achieve broader internationalization goals. Network-wide programs taking advantage of consortia of institutions collaborating around a common research area could be a better model for graduate students because it becomes easier for students to find a suitable international project that aligns with their program of study. There were tradeoffs with respect to the student population that was involved in the collaboration. Involving undergraduates helped advance their specific skill level and offered a recruitment source for graduate programs, but their involvement tended to result in fewer research products relative to graduate students. Graduate students, in contrast, had a bit less flexibility in terms of their topic areas if they were to remain on track with their own thesis or dissertation work.

Findings from Interviews with Past Student Participants
IRES participants cited different program elements that were meaningful and pointed to a variety of learning outcomes, but every student participant said they would recommend similar experiences to others. Several indicated to "make sure the NSF keeps funding programs like this" because they would not have had an opportunity to go abroad without such an experience that offered financial support. Across the case studies we identify a variety of program elements that students described affecting their experience. Although we do not recommend a single model, we highlight considerations ranging from student selection to orientations and schedules to the ways in which students' research experiences may be structured. Students also pointed to a variety of different learning outcomes achieved during IRES, including technical and research skill development and cross-cultural and global engineering skills and awareness. By far the most common type of outcomes that were discussed across all of the programs related to students' careers or future lives, which included graduate school, industry, further international work and travel, preparation for academia, and building professional networks.

Project Overview

IRES programs seek to develop globally connected future researchers while also facilitating broader long-term collaborations between U.S.-based and international research groups. Faculty and student exchanges are expected to result in international linkages between the researchers that bring new insights and methods to U.S.-based research projects, leading to transformative research. In this project, we conducted a comprehensive evaluation of IRES programs through a case study analysis. Our work joins a recent report by Mitchell et al. (2019)[1] that collected ideas from expert attendees of a workshop focused on graduate students' experiences in IRES. Our study took a different approach by considering experiences of IRES participants and designers broadly.

We selected cases focused specifically on engineering-focused IRES experiences for ease of comparison. Our analysis highlights the variety of approaches different IRES programs have taken, which we hope will be helpful for institutions proposing new IRES programs as well as for NSF program officers who work with IRES PI teams. We point to some best practices in developing research exchanges, the return on investment of such programs, as well as ideas from program leaders in how to best structure such experiences for students and faculty both on the U.S. and international sides. Data collection focused on the following topic areas:

1) *Impact on Student Researchers*
   - How has IRES influenced students' career plans and motivation to participate in global research collaborations during their careers?
2) *Impact on Faculty Collaborators*
   - How has IRES and resulting linkages influenced their research and teaching?
   - What factors facilitated and hindered achievement of IRES research goals?
3) *Impact on Participating Institutions*
   - How has IRES influenced ongoing and future research collaborations between institutions?
   - How has IRES influenced the educational environment at participating institutions, including educational exchange/future study abroad opportunities?
4) *Impact on Quality of Research Outcomes (e.g., on Knowledge Environments)*
   - In what ways has the research process been transformed as a result of IRES?
   - How has IRES led to the identification of methods/approaches outside US that could facilitate better research?

This summary report focuses on the most salient findings from our data collection. We split our findings into two sections:

1) **Findings related to program structures**, in particular highlighting variable features that appeared to make a difference for students' and faculty members' experiences in the IRES program—and subsequent outcomes;

2) **Summary of interviews with students**, which describes how and why context matters, program elements, and learning outcomes from participants' perspectives.

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[1] Mitchell, B.S., et al., Final Report: Best Practices in International Research Experiences for Graduate Student, 2019. Retrieved from http://nsfworkshop.wp.tulane.edu/wp-content/uploads/sites/378/2019/04/NSF-2019-Workshop-on-International-Research-Experiences-Final-Report.pdf

In selecting cases, we sought to diversify the selection along the following dimensions: global region, U.S. institutional type, and length of time that the IRES program had been operational. The nine case study IRES programs include the following:
1. US-China: Bats as Model Organisms for Bioinspired Engineering (OISE-1658620)
2. U.S. - U.K.: Future Electric Transportation Systems (FETS) (OISE-1261162)
3. IRES: Multidisciplinary Water Engineering Research and Education to Protect and Enhance Ecosystems in Complex Environments (OISE-1658604)
4. The University of Michigan and South African National Space Agency (SANSA) Space Weather International Research Experiences for Students Program (OISE-1459911)
5. Practical Physical-Layer Security in Coimbra, Portugal (OISE-1460084, 1761280)
6. US-Germany collaboration to advance research and education in materials for extreme environments (OISE-1460045)
7. International Research Experience in Nanotechnology in Japan 2015 (OISE-1559368)
8. Avatar-based Adaptive Context System (OISE-1458272)
9. U.S.-Ghana Collaboration Providing Opportunities for Global Research Activities on Sustainable Water Purification (GRA-SWP) (OISE-1358204)

Case studies included interviews with all U.S. PI's, a selection of additional international and U.S. faculty researchers, and select student alumni. We used a combination of site visits and web-based video interviews. Inspiration for this kind of comparison across IRES program contexts stemmed from our prior work comparing students' IRES experiences in Australia and China (see Davis et al., 2018).[2] All interviews were transcribed and analyzed to understand variation across programs (see Table 1).

Table 1. Interview data collected across IRES case study sites.

Case	US University	International Institution	Country	PIs	US Faculty/Grad	Intl. Faculty/Grad	Student Alums	Total
1	Virginia Tech	Shandong University	China	1	0	1	3	5
2	Virginia Tech	University of Nottingham	UK	1	2	0	2	5
3	Virginia Tech	University of Queensland	Australia	1	1	5	10	17
4	Michigan	South African Nat'l Space Agency	South Africa	1	0	0	4	5
5	BYU/ U-Col-ColSprings	University of Coimbra	Portugal	1	0	2	5	8
6	UCF	German Aerospace Center (DLR)	Germany	1	0	0	3	4
7	Cornell	National Institute of Materials Science	Japan	1	0	0	6	7
8	UCF	Technical University Ilmenau	Germany	1	0	0	4	5
9	Southern	Kwame Nkrumah University of Science and Technology	Ghana	1	0	0	2	3
Total				9	3	8	39	59

[2] Davis, K.A., Jalali, Y., Knight, D.B., Lohani, V., & Mueller, R. (2018, June). Student learning in international research programs: A comparison across cultural contexts. Proceedings of the 125th Annual Conference of the American Society for Engineering Education, Salt Lake City, UT.

Findings Related to Program Structure

A series of tables summarizing findings across cases and snapshots of each case can be found in the Appendix. In comparing different IRES programs, we noticed very different structures in terms of how the collaboration was organized. From our nine case study sites, we identified five different program structures, each with different apparent impacts on the faculty member, their institution, and research outputs (see Table 2).

Table 2. Different program structures from the cases

Program Model	Faculty-to-faculty	Single faculty	Department-level broker	College-level broker	Network
Description	Faculty (PI) leads research in collaboration with international partners	A single PI runs research laboratories domestically and internationally	Faculty PI serves as a "broker" between different domestic departments and international partners	College-level PI serves as a "broker" between multiple domestic departments and international partners	Existing professional network structures the collaboration
Cases	4,5,6,8,9	1	3	2	7

The *faculty-to-faculty model* was the most common among our cases, where a faculty PI leads both the research undertaken by students and coordinates the logistics of the IRES program, with student research activities co-supervised by an international partner. Impacts on the faculty member included expansion of the PI's research areas, scholarly publications, access to the recruitment of new graduate students, and the securing of new grants to support their research. The impacts on the broader institution for some of these programs included the recruitment of postdocs and new graduate students from the international partner institution to the host institution. The quality of research was improved via interdisciplinary connections, and new cohort models for undergraduate research were also developed from this kind of structure.

The *single faculty model* involved a PI who ran laboratories both at their home institution and at the overseas institution. This single faculty structure was unique to Case 1, which took place in China, in that the faculty member held a staff position at the partner university in addition to the full-time appointment at their home institution. For the faculty member, this model held a valuable benefit in that they were able to create a larger research team which directly worked with their research projects at the partner institution. This model also strengthened the strategic partnership between the domestic institution and the Chinese institution. A disadvantage, however, was that because students worked with the PI both domestically and abroad, this model cultivated very few new collaborations at the host institution.

The *department-level "broker"* model included the faculty PI serving as a liaison to a different department; students' research projects focused on a different engineering discipline than the faculty PI's discipline, and the partnership stemmed from prior relationships. In this case, the faculty PI's responsibilities were primarily in the administration of the program and negotiation of the relationship with the partner institution abroad. This model has several advantages,

including strengthening the research collaborations at the home institution via the relationship between the PI's home department and the department overseeing students' research. In addition, it strengthened the partnership by broadening research collaborations across disciplines. Positive impact on the PI's home institution included more faculty becoming involved over the life of the grant, which led to more affiliations with the overseas partner. This partnership led to clear research benefits, including the development of new projects between faculty at the home institution and the overseas partner.

In the *College-level broker* **model**, the faculty PI served an administrative role in the college and served as the liaison to a number of different departments (handling the administration of the IRES program so they could focus on the research). This model, similar to the prior "broker" model, was successful in jump-starting new research collaborations and strengthening existing collaborations, leading to increased publications and jointly supervised graduate students. Because of broad participation across five departments and involvement at the administrative level, this approach also strengthened the college's strategic partnership with the overseas institution. Direct communication at the dean level with the partner institution led the partner to create a reciprocal research program to send its students to the United States, as well as to lobby the NSF-equivalent in their country to create a reciprocal funding opportunity.

Lastly, the *network model* was unique in that it involved students being recruited from institutions across the country through an existing professional network; it placed students in multiple research labs at the partner organization overseas. Rather than building on relationships between individual faculty members, this model capitalized on a professional global network. Benefits included that the overseas organization is now sending graduate students to the United States for research in the summer. New proposals are also being submitted for other collaborations between the networks. This model had unique benefits for U.S. students in that it broadened access to international research opportunities for students at smaller institutions. It also provided greater opportunities for placing students in experiences that matched their research interests. Although this program targeted undergraduate students, this model could provide a clear advantage for graduate students because selecting from a range of different research topics would increase the likelihood of finding alignment with their dissertations.

Conclusions and Implications

We identified five different structures among our sample and demonstrated that the structure of the program appears to influence the magnitude, scope, and the kinds of impacts of the program on faculty members and the institution. Take-home conclusions as well as consistent themes identified across sites are as follows:

- Faculty PIs leading the endeavor on their own tended to realize greater individual and research benefits. Although there is a greater logistical demand on an individual faculty member, this model could support their career trajectory.

- The "broker" and network structures might be better approaches for colleges that are seeking to achieve broader internationalization goals. For the "broker" approach, a faculty or administrator PI can think more strategically and recruit faculty members on both sides of the partnership to participate in the program, which can have magnification effects that can expand internal relationships (e.g., the faculty broker) or institutional collaborations (e.g., the college broker).

- A network-wide program takes advantage of an existing consortia of institutions that collaborate around a common research area. This approach could be a better model for graduate students because it becomes easier for students to find a suitable international project that aligns with their program of study. Such alignment may help graduate students gain the support of their advisors to participate in an international program.

- PIs noted that the biggest challenge with IRES concerned NSF's restriction that international partners could not receive direct funding. Since this is the case, the domestic PIs felt like they were in a situation where they were asking international hosts to volunteer their time to mentor students, and so it became especially important for the project to generate a research output so that the host could justify their time spent on the project.

- There were tradeoffs with respect to the student population that was involved in the collaboration. Involving undergraduates helped advance their specific skill level and offered a recruitment source for graduate programs, but their involvement tended to result in fewer research products relative to graduate students. Graduate students, in contrast, had a bit less flexibility in terms of their topic areas if they were to remain on track with their own thesis or dissertation work.

This section of this report highlights some of the different tradeoffs that are involved in deciding the structure of an international research experience for students program. Although we are not recommending one model over another, we do want to flag that there should be a different set of expectations with respect to faculty and institutional impacts as a function of that structure decision. Additional details about these findings can be found in Sanderlin et al. (2020).[3]

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[3] Sanderlin, N., Davis, K., & Knight, D.B. (2020, June). Work in Progress: Design Considerations for an International Research Program for Students: Learning from Existing Programs. *Proceedings of the 127th Annual Conference of the American Society for Engineering Education*, Virtual conference

Summary of Findings from Student Interviews

All 39 students who were interviewed emphasized that they enjoyed their IRES program. They cited different program elements that were meaningful and different learning outcomes, but every student said they would do the program again and recommend similar experiences to others. Several indicated to "make sure the NSF keeps funding programs like this" because they would not have had an opportunity to go abroad without an experience like this that offered financial support. Of course, the fact that these students agreed to participate in interviews may bias the study towards students who had positive experiences. However, it seems important to note that whatever else may have been different across experiences, nearly every interview ended with the student saying they were glad they had the opportunity to participate in IRES.

Context Matters

When making decisions about program elements for an IRES program, it is important to consider the context of your program and how that may influence the student experience. Based on our interviews, it is especially important to consider the following aspects of your context:

Culture of the Host Country

Certain aspects of the host country culture can significantly influence the student experience. For example, students across programs discussed the following cultural factors:

- **Work Culture**
  - Even in countries where the overall culture may not seem too different from the United States, the work culture can be quite different. Differences include factors like how projects are coordinated, how much people are expected to work, and the amount of structure in the work environment.
  - Based on these differences, you may choose to provide structure or opportunities for collaboration for students where these aspects might be lacking, or build in some pre-travel training about work culture to prepare students for how things may work differently than they are used to.
- **Social Culture**
  - Some countries tend to be more social and welcoming by default, and others tend to be more private. These cultural factors can make a huge difference in students' ability to connect with local people during their time abroad and have meaningful interactions with the culture.
  - Based on the social culture, you may choose to build in planned opportunities for social and/or cultural interaction where these may not naturally occur.

Culture of the Host Research Group

In the programs we talked to, there was significant variation in the culture and personalities of the host researchers, research groups, and departments. Students in some cases felt very integrated into the local group, and others felt rather separate. These experiences varied even within single programs in cases where students were assigned to different research groups or mentors. Thus, it may be helpful to consider the following questions:

- Is the host research group collaborative?
- Does the host research group provide opportunities for mentoring?
- Does the host research group socialize together?
- Will your international colleagues go out of their way to make the students feel at home?

In cases where the research group does not provide a more social or collaborative atmosphere by default, it may be helpful to build in professional development and/or social activities in a more structured way to ensure that students have these experiences.

Student Characteristics

The characteristics of the students participating in an IRES program can also influence their experiences. Some students will require more support than others in different areas. For example, if you tend to have students with no prior international experience, you will want to provide more cross-cultural preparation beforehand and perhaps more structured cultural activities in-country. Similarly, if you are seeking to give students their first research experience, they may need more of an introduction to research than if you were recruiting experienced researchers. If you have a mix, you may consider structuring projects so that more experienced students can mentor or lead the others, or you could assign less experienced students to more supportive mentors/research groups and/or more structured projects with clearly defined goals.

Program Elements

Each interview was coded to see which elements of IRES programs were mentioned by students over the course of the conversation. In total, 13 program elements were identified, as summarized in Table 3. If students mentioned a program element without much detail, they were often asked a follow-up question to get more detail about their experience (e.g., "you mentioned you were working on your project on a team, who was part of that team?") We also asked each student at the end of the interview for any parts of their program that were particularly helpful and anything that they would change or improve. This question elicited many of the details about significant program elements, but students did talk about them throughout the earlier questions as well. Table 3 summarizes the extent to which students from different IRES sites discussed different program elements.

Table 3. Program elements that students discussed in their interviews

Key: Mentioned (orange), Notable (yellow), Significant (green), blank = not discussed

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Student Selection	Mentioned				Mentioned		Notable	Mentioned	
Pre-Travel Prep	Notable		Notable	Mentioned	Notable	Significant	Significant	Mentioned	Notable
Program Schedule		Mentioned	Mentioned	Mentioned	Mentioned			Notable	Mentioned
Deliverables				Notable	Notable		Mentioned	Mentioned	Mentioned
Post-Travel Activities	Mentioned	Notable	Notable	Notable	Notable	Mentioned		Notable	Significant
PI Travel	Mentioned	Mentioned		Notable		Mentioned	Notable		
Student Housing		Notable	Notable	Notable	Significant	Notable	Mentioned	Notable	
Planned Activities	Mentioned		Mentioned	Significant	Notable	Significant	Significant		Significant
Social Activities	Significant	Significant	Notable	Significant	Significant	Notable	Significant	Significant	Mentioned
Project Structure		Significant	Significant	Notable	Significant	Notable	Significant	Significant	Significant
Research Tasks	Notable	Mentioned	Significant	Notable	Mentioned	Notable	Notable	Notable	Notable
Mentoring & Support	Mentioned	Notable	Significant	Significant	Significant	Significant	Significant	Significant	Notable
Collaboration	Significant	Significant	Mentioned	Mentioned	Significant	Notable	Notable	Notable	Notable

Student Selection

There were several variables that the IRES programs in this study considered when selecting students for their programs. The ones most often mentioned by the student participants were:

- Graduate students vs. undergraduates
  - Programs sending both graduate and undergraduate students tended to set up the graduate student as a leader or mentor for the undergraduate students.
  - Undergraduate students who worked closely with graduate students highlighted this arrangement as being helpful for their growth both personally and professionally.
  - Graduate students found such leadership roles to be professionally useful for them as they prepared for careers in academia to learn about advising and leadership of research projects, although they noted that research progressed more slowly than if the whole team had been graduate students.

- Students who had participated in the same IRES program previously
  - In programs that only recruited undergraduate students, sending a student who had previously engaged in the IRES program before in a new leadership capacity allowed for a similar structure and also provided continuity between summers (especially important where there was a single group project that continued across summers).

- Disciplines of study
  - Students who worked on teams that crossed disciplines (either within the IRES cohort or at the host institution) frequently highlighted this arrangement as a major opportunity for learning about different research approaches, new methods, and how to communicate across disciplinary boundaries.

- Gender
  - Students identifying as women who worked closely on projects with other women (either other women IRES students or women at the host institution) often mentioned this arrangement as a particularly meaningful part of the experience.
  - A few women mentioned experiencing gender-bias during their IRES program in cases where there were few women present.

- Students who had participated in a specific REU program previously
  - A professional network within a specific discipline hosted a nation-wide REU program, and participants in this program were invited to apply for the IRES. This arrangement ensured that every applicant already had one summer of research experience within the same field.
  - Because these students went into IRES with this prior research experience, they were able to hit the ground running in their research projects, focus on learning about cultural differences, and compare research approaches across countries.

Overall, students seemed to appreciate and benefit from being part of an IRES cohort and/or host research group with more diversity, including a range of school years (grad & UG), disciplines, gender, race/ethnicities, and nationalities (the latter in the host research group).

Pre-Travel Preparation

The IRES programs we reviewed took a variety of approaches to pre-travel preparation for students, and this was a program element mentioned frequently by students across programs (for both pros and cons). As suggested by prior literature, preparation can have a big influence on student experiences in both research and study abroad. We found that the content of pre-travel preparation covered three main topics:

- **Logistics**
  - <u>Most programs included a series of meetings</u> with the students in the semester before they left to work through logistics related to flights, visas, housing, and other paperwork.
  - <u>Most students felt prepared logistically</u>, but a few commented that they could have used more information on navigating the city where they would live (especially if they had not traveled before).
  - Two approaches students mentioned as helpful were:
    - Connect incoming IRES students with students from a previous year either through an in-person Q&A session or through documents with recommendations for food, socializing, travel, cell phones, managing money, etc.
    - Requiring students to create a budget at the start of the program to ensure they had a plan for food and other personal expenses.

- **Cultural Preparation**
  - Programs varied in how much cultural preparation they included, but this was consistently the area where students felt there could be more preparation.
  - Cultural preparation was felt to be most lacking in countries where there was a significant <u>difference in work culture</u> or where there was a <u>different language</u>.
    - *In cases of work culture*, students could use more introduction to how the work culture operates in the host country and suggestions for how to adapt their work and expectations.
    - *In cases where there was a foreign language*, almost all participants mentioned they wished they had more language practice beforehand.
  - Three approaches students mentioned as helpful were:
    - One program included a language class as part of the program while students were in-country.
    - Some students mentioned receiving training on cultural differences through campus study abroad offices, and found such programming helpful in understanding their colleagues abroad.
    - In cases where the PI travels to the country with the students, it is helpful if they use this opportunity to introduce them to important cultural practices or pitfalls to avoid.

- **Research Preparation**
  - Research preparation varied the most across programs. Some programs had no research preparation at all, but in these cases, students consistently suggested that more preparation would have been helpful.
  - Several students mentioned wishing they could have "hit the ground running" rather than feeling like two weeks were wasted getting up to speed.
    - Overall, students seemed open to having tasks <u>before the program</u> if it meant accomplishing more during the summer.

- o Research preparation included a variety of tasks: instruction in technical content, reading literature, writing a literature review, creating a research plan for the summer, completing lab or fieldwork training, or Skyping with the host mentor.

- o Three approaches that seemed to work well:
    - Requiring students to register for undergraduate research credits the semester before traveling abroad to spend time getting up to speed on the research, working with the U.S.-based PI.
    - Connecting students with the host mentor and requiring them to develop a contract with research plan, timeline, and anticipated deliverables.
    - Requiring students to write an annotated bibliography or literature review.

Program Schedule

The IRES programs we reviewed varied in their schedules in the following ways:
- Some programs included a week at the home campus before and/or after the time abroad for orientation and/or wrap-up.
- Some programs built an extra week into the time abroad and encouraged students to take a week to travel at the beginning or end of the program.
- Programs ranged in the time spent abroad from 4-12 weeks, but most were 8-10 weeks.

Student feedback suggested that:
- They really appreciated being explicitly given time and encouragement to travel, especially if they had never traveled before and might not have considered doing this if they were not given permission.
- Spending a week on the home campus can help with some orientation but may not be sufficient to get up to speed on a research project (e.g., write a lit review).
- Some students mentioned wishing they had more time on their project, and that the summer was too short to make the progress they wanted. This could be addressed by:
    - o Increasing time abroad
    - o Requiring pre-travel research preparation (section above)
    - o Building in opportunities to continue with the project upon return (section later)

Deliverables

Most of the IRES programs in this study required specific deliverables from students, but the participants did not discuss deliverables much in the interviews. The deliverables that were most frequently mentioned by students were:

- Conference or journal articles
    - o Students generally seemed interested in being part of a publication, even if it required continuing to contribute to the project after the IRES program was officially over (see "Post-travel Activities" below).
    - o Some students who did not end up with a publication commented that they would have liked to set this goal as a specific target up front and get started earlier to achieve this goal.
    - o Others felt this could be intimidating, but perhaps giving students the option would allow them to decide if it makes sense based on their career goals.

- Presenting at a professional conference
  - Several of the programs required or encouraged students to submit their work to be presented at a conference (during or after the IRES program).
  - Some programs also built in funding to pay for the students to attend the conference.
  - Students who were able to present their work described this experience as a highlight of the program, which helped them build their network, make connections for graduate school, see the international nature of their field more broadly, and improve their ability to communicate their research.

Post-Travel Activities

Although most of the IRES programs in this study did not build in required post-program activities, participants across almost every program gave examples of how they continued to work on their IRES project after the program was officially over. These activities included:
- Continuing the IRES project as a senior capstone project
- Continuing the IRES project as undergraduate research for credit
- Continuing the IRES project as a master's thesis or doctoral dissertation project
  - These students also frequently had their international colleagues as committee members.
  - One student received a Fulbright to return abroad and continue the project.
  - Some of these students continued collaborating with their colleagues abroad after finishing PhDs and starting jobs in academia.
- Continuing to work on finishing up a paper for publication (even if not paid or for credit)

The programs that did require post-travel activities tended to require:
- Presenting the IRES project at a conference (funding for travel included in program)
- Providing training for the next set of IRES students (usually the following spring). This arrangement was for programs where a single project continued across summers.

Suggestions based on student comments:
- Because so many students ended up doing post-travel activities and seemed to appreciate having these opportunities, PI's could consider building these experiences in as required or optional parts of the program.
- For example, if a student is particularly interested in moving their work toward a publication, they could have the option to build out a research plan that includes activities to be completed after they return (either as part of an independent study or capstone project).
- Offering an option like this arrangement up front could: 1) help students set clear goals; 2) help students build reasonable timelines and thus reduce stress; 3) challenge students to think a little bigger and go a little deeper with their project if desired.

PI Travel

For about half of the IRES programs in this study, the U.S.-based PI traveled to the host country while the students were there (either at the beginning or mid-way through the program). For the programs where this happened, students mentioned it as being particularly helpful, for the following reasons:
- Maintaining a sense of continuity as they transitioned into a new cultural and work environment.
- Learning about the culture, how to behave professionally in a new environment, and how to navigate the city where they would be living.

- Being introduced to a variety of people in the new work environment, including the mentors they would work with for the summer.
- Having cultural and social activities planned and coordinated for them early in the program to help them get connected to their colleagues and/or the culture.

Having the PI travel with them was especially helpful for students who had not traveled abroad much before and helped them feel supported until they adjusted and learned (by watching) how to navigate in the new environment.

Student Housing

Student housing can play a large role in the types of experiences a student has outside of work during their time abroad. The housing options can be limited depending on how an IRES program lines up with the local university schedule, but if choices are available, here are considerations in choosing housing:

- Housing IRES students together versus separately
  - Some students enjoyed sharing housing with their IRES cohort, saying it was nice to have a team with which to approach the new country and feel "at home" when they got to their apartment.
  - On the other hand, students who lived with local roommates or in their own apartment appreciated that this arrangement gave them opportunities to connect with local people and forced them outside the "IRES bubble."
  - It may be helpful to consider whether your IRES students have traveled before.

- Type of Housing
  - IRES students who lived in either university dorms (with local students) or in national lab housing (with other researchers) were more likely to make friends outside of the IRES program naturally through shared spaces (e.g., kitchens) or events (e.g., campus clubs).
  - IRES students who lived in non-campus apartments or Air BnBs tended to find it harder to connect with local people, unless planned social activities were included in the program or their research group was particularly social.

- Location of Housing
  - Housing students close to their work site is generally preferred; students with long commutes mentioned this arrangement as a challenge.
  - However, housing location should be balanced with awareness of what else is around - if the university or lab is outside the city and there is little to do, students may benefit from being located closer to the city to encourage social and cultural engagement beyond the "IRES bubble."

Choice of housing is important to student experiences and also context dependent. The context factors listed earlier (student characteristics, local culture, research group culture) should inform choice of housing. If the available housing may limit students' engagement with the local community, it may be wise to build in planned opportunities to facilitate this engagement.

Planned Activities

A few of the IRES programs in this study (notably, programs traveling to some of the more culturally distant countries) had some social and/or professional activities built into the program. These activities were coordinated either by the U.S.-based PI, the international collaborators, or both. Activities that were highlighted as helpful by the students included:

- Welcome dinners to meet everyone in the research group and/or local college students
- Visits to local cultural sites
- Visit to a research lab at another university, national lab, or an industry tour
- Dinners with prominent people at the university or in the city
- Dinners at the home of a host researcher
- Cultural exchange and research presentations with local college students
    - This experience was especially helpful since the IRES students were working and living at a national lab where there were few undergraduate students.
    - This experience can range from an afternoon to a whole weekend (where the IRES students stayed with the college students and explored a new city).
- Weekend trip to another city, including cultural sites and/or professional interactions
- Participation in a science/research-based camp at the host institution
- Presenting at a research symposium at the host institution
- Participation in a two-week short-term study abroad trip that was run out of the same university as the IRES program (to the same country)

It is helpful to note that for at least the last three items on this list, the IRES programs did not have to do any additional planning but just took advantage of activities already happening at the location where students were traveling. It is also important to consider the context factors described earlier when considering what planned activities would be helpful for a specific IRES program.

Social Activities

Although all of the participants in this study said they enjoyed their IRES program, one of the bigger points of variation among them was the level of social interaction they had with people in the host country. For students who were able to make strong social connections, this experience was a significant aspect of the program for them, and many continued to be in contact with their friends abroad long after the program. For students who struggled to find social connections, they mentioned this aspect as something as an area for improvement.

Students made successful social connections in different ways on different programs, and it depended a lot on the context factors mentioned earlier. It is important to acknowledge that there is notable individual variation in terms of how outgoing a student is and their comfort with seeking social activities in a foreign context. Nevertheless, here are several ways that students can be supported in finding these opportunities:

- Housing students with local students on a university campus or researchers at a national lab housing location (especially if there are shared spaces, such as kitchens).
- Placing students in a research group that has a social culture of eating together and spending time together outside of work.
- Putting students in a project where they will work closely with a local graduate student or undergraduate student who is also encouraged to be their "local guide."
- Assign students to local mentors who are interested in connecting with the students, inviting them to their homes, and/or showing them around the area.
- Incorporating planned activities into the IRES program that connect students with local students (see previous section).

- Inform students of local cultural, social, and professional events that would help them connect with the local community.
  - Students mentioned meeting people while hanging out at parks, going to concerts, attending events at the university, attending religious services, and joining local gyms.
- Enroll students at the local university as study abroad students, which gives them access to residence halls, cafeterias, and local student groups (in addition to other benefits discussed below under "Mentoring and Support").

Although none of the programs documented this activity, it may help to talk to students specifically about the benefits of trying to connect socially, what challenges they may face in the local culture, and suggestions for how to get started.

Project Structure

Project structure is a program element that significantly influences students' IRES experiences, especially the research-related learning outcomes that are most prominent. Decisions about project structure can be closely connected with the later program elements of "Mentoring and Support" and "Collaboration." A few structural options to consider based on the programs in this study were:

- Teams: IRES students all on one project versus being paired on projects versus being assigned to individual projects
  - If on one project together: assign a leader versus no leader (e.g., graduate student or returning IRES undergraduate student could be a leader)
- Responsibility: IRES student owns their project versus an IRES student that assists someone else in their tasks
- Structure: Give IRES student defined tasks versus open ended problem to solve
- Timeline: IRES projects continue across years versus new project line up each year based on mentor interest and project status
  - *If new projects:* how to pick good projects for students?
    - Status of project: Study design versus data collection versus data analysis
    - Mentorship availability: Will the PI be available throughout the summer? Is there a graduate student or postdoc on this project?
- Familiarity: Start a new project(s) for IRES grant versus add students into existing projects
  - *If new project:* do the U.S. PI and international mentor have enough experience on the topic to guide students? Can the project get to a status where students can meaningfully contribute in time for the summer?
  - *If existing projects:* are there suitable tasks for students to contribute?

Project structures that worked well varied based on the context factors discussed earlier, the type of research that was being conducted and the level of support and mentoring that was available. For example, here are some differences noted from students' experiences:
- Students with prior research experiences appreciated having more responsibility for their projects and were more comfortable with open-ended projects.
- Students working in small teams (2-3 people) seemed to be able to handle more open-ended projects, but individual students could be overwhelmed, and larger groups could get harder to organize and keep on track.

- Students working on an early-stage project could feel bogged down in literature, especially if their mentor did not know the literature well and was relying on them to become the expert (this is OK for grad students, but can overwhelm undergraduates).
- Students working on existing projects were able to connect with other people in their research group and develop long-lasting social and professional connections, whereas students on new projects just for IRES tended to end up in an "IRES bubble."
- Students working on interdisciplinary projects tended to connect with a variety of people at the host institution and develop new perspectives and research skills.
- Students working in the same research group but on different projects (or sub-projects of the same larger project) could support each other in learning background material while also each having personal responsibility for specific research outcomes.

Research Tasks

The specific research tasks required of students varied significantly across the IRES programs included in this study, including programming, software development, lab work (from biological to metallurgical to clean rooms), fieldwork, computer simulations, and mathematical modeling. The IRES programs seemed successful regardless of specific research tasks, and what was more important was:
- Building in sufficient pre-travel preparation so that the student was prepared to complete the tasks assigned while abroad.
- Having sufficient support and mentoring for students to feel confident on their project.
- Having clear project structure so the student understood where they fit in the larger project and what tasks they should be pursuing.

With that said, in programs where there was lab work or fieldwork projects available, students who did not get to participate in these activities sometimes felt left out or like they did not get the "full" research experience. It may be helpful to try to build in some access to these types of activities for all participants where possible, as they are unique experiences and can contribute to a students' overall understanding of research opportunities in a field.
- For example, in one of the programs we studied, students could help out each other with their fieldwork even if it was unrelated to their own project, thus giving everyone a chance to work in the field a bit.

Mentoring and Support

Students' development of research skills and their interest in doing future research seemed to be influenced by the amount of mentoring and support they received in their IRES program. This primarily focused on support related to the research itself, but also support provided in helping the students navigate the new foreign environment. Mentoring and support was especially important for students who were new to research, new to foreign travel, and those students working on a newer and/or more open-ended project.

Best Practice #1: Place IRES students within a **strong research group** and encourage or require them to participate in research group activities.
- Students connected better socially and professionally when in a research group with a welcoming culture.
- Students discussed having a supportive research group experience as a highlight of their time abroad and also helped them know what to look for in grad school
  - o Students with negative or little research group support noted such experiences as a downside of their program

- Students who were required to report out to their research group regularly found this requirement as helpful practice in learning to talk about their work and develop communication skills.
- *Options:* IRES students all in one research group versus separate research groups
  - Being in one research group allowed students to support each other in learning about the research content.
  - Students in the same research group were more likely to form an "IRES bubble" if the research group was not particularly welcoming.

Best Practice #2: Be very intentional and careful in the assignment of **research mentors**. Having a good mentor could make a big difference in students' overall experiences and interests in continuing to do research in the future. When a research mentor went out of their way to spend time with students, show them local customs or sites, or have them over to dinner, this was often a highlight of the program for students.

A few options to consider here:
- IRES students all with one international mentor versus being assigned separate mentors
  - One mentor can find it overwhelming to oversee multiple students and may not be able to give sufficient time to support each of them.
  - This approach can be useful when the students are working on one project and can support each other to some extent (especially if one of the IRES students is a graduate student). However, this arrangement can result in an "IRES bubble."
- Assigning students to a faculty mentor versus graduate student mentors
  - Faculty mentors can work well if they are available all summer and have time to support the IRES student(s) regularly (short project timeline).
  - Graduate student mentors can work better if the faculty are not around and have the added benefit that they may connect well with the students socially and introduce them to other students (especially if asked to play this role).
  - Mentoring an IRES student can be a professional development opportunity for a graduate student who wants to pursue an academic career and advise students in the future.

- *Quality Assurance:* The U.S.-based PI checks in regularly on IRES students.
  - Several programs required students to send a weekly research update and/or reflection on their experiences to the PI.
  - This requirement helps the PI catch any issues early on and also can build a foundation to continue working together on the project after the student returns.

Best Practice #3: **Enroll the students** at the local university as exchange students
- This arrangement provides logistical support for students, including access to: residence halls, cafeterias, laundry facilities, gyms, medical facilities, and student organizations.
- Students earn research credits at their home university.
- This model does cost more money because either the students must pay summer tuition OR the PI must cover the summer tuition using the IRES grant.

Collaboration

Connecting back to the project structure a bit, it was clear that some IRES students worked primarily on their own in their projects, whereas others regularly worked with other people. As discussed earlier, some students collaborated with other IRES students on the same project, but others collaborated closely with people at the host institution. In the latter case, students were more likely to see the importance and benefits of international collaboration in research.

There are a variety of other benefits to having students work on more collaborative projects:

- If collaborating with 1-2 other IRES students...
  - Student were able to support each other before seeking out their mentors for help (larger teams seemed varied in their success).
  - Students would often mention teamwork and project management as primary learning outcomes.

- If collaborating closely with their research mentor…
  - Students talked about getting to know their mentor more personally and appreciating this opportunity.
  - This arrangement often gave students new perspectives on research, academia, differences across national contexts, or insights about faculty members in general.

- If collaborating with multiple members of the host research group…
  - Students who felt they could go to several people for help felt they were well-supported and the relationship with the primary mentor was less important.
  - Students became embedded on the research team and could see their contribution to the overall project better.
  - Students were more likely to connect socially with people in the research group.
  - Students in this situation often commented that they enjoyed the research group environment and looked for similar arrangements when considering graduate schools.

- If collaborating with researchers from multiple disciplines…
  - Students emphasized this arrangement as a great opportunity to learn new methods and research approaches.
  - Students discussed learning to communicate their work more clearly for someone outside their discipline.

- If collaborating with graduate students (local or part of IRES)...
  - Students discussed learning more about the graduate school process and what can be expected when working on a dissertation.

During the interviews, we asked students several questions related to learning outcomes. First, we asked about their biggest takeaways from the program, and then we would follow up with specific questions about research learning and cultural learning. We also asked students to tell us two stories of significant events from their IRES program and what they learned from these experiences. The following categories shown in Table 5 capture the many different types of learning that students described. For each category, we describe the different ways that this outcome manifested, as each program and student were unique.

Table 5. Learning outcomes that students discussed in their interviews

Key: Mentioned = orange, Notable = yellow (pale), Significant = green, blank = white

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Technical Skills	Notable	Mentioned	Notable		Mentioned	Mentioned	Mentioned	Notable	Mentioned
Research Skills	Notable		Significant	Mentioned	Notable	Notable	Mentioned	Mentioned	Notable
Nature of Research	Significant		Notable	Notable	Significant	Mentioned	Mentioned	Notable	Notable
Professional Skills	Notable	Notable	Mentioned		Mentioned	Notable	Notable	Mentioned	Mentioned
Cross-Cultural Skills	Significant		Notable	Notable	Significant	Mentioned	Significant	Mentioned	Mentioned
Cultural Differences	Significant	Notable	Significant	Significant	Notable	Significant	Significant	Significant	Notable
Perspective Change	Mentioned	Mentioned	Significant	Significant	Significant	Significant	Notable	Significant	Significant
Global Engineering	Notable	Notable	Notable	Mentioned	Mentioned	Significant	Significant	Notable	Significant
Personal Growth	Significant	Notable	Significant	Notable	Significant	Notable	Notable	Significant	Mentioned
Career/Future Outcomes	Mentioned	Significant	Significant	Significant	Significant	Significant	Significant	Significant	Significant

Technical Skills

Less frequently than other outcomes, students mentioned specific technical skills as key learning outcomes from their IRES experiences. These included elements like: learning to use MATLAB, learning to use specific pieces of equipment, learning a specific software, learning a specific technical concept, or learning a new programming language. Students earlier in their programs of study were more likely to discuss technical skills.

Research Skills

In some of the IRES programs, students emphasized specific research skills that they developed through the program, ranging from: reading literature, writing a literature review, asking good research questions, designing a study, planning project implementation, carrying out field work or lab work, data analysis, writing up results, or presenting research findings.

- Students with less prior research experience were more likely to talk about developing research skills.
- Students in programs with significant fieldwork or (in some cases) lab work were more likely to talk about developing research skills related to these activities - often some version of needing to make decisions on the fly or deal with unexpected situations.
- Students who wrote a paper for publication or gave a conference presentation tended to mention this as an important part of developing research skills.
- Students working on interdisciplinary projects talked about developing new research approaches and the ability to communicate across disciplinary boundaries.

Nature of Research

A significant learning outcome for some students was a deeper understanding of how research works, which frequently informed their perspective on whether they wanted a career doing research or not. In describing the nature of research, students often talked about: the process followed in a research project, how research is funded, the open-ended and unstructured nature of research problems, the need to understand the big picture purpose and motivation behind a research project, or the iterative process of experiencing failure and trying new approaches. This learning outcome varied across programs in the following ways:

- Students with less prior research were more likely to talk about the nature of research.
- Students who were designing and conducting experiments or developing mathematical models were more likely to talk about the iterative process of failing and trying again.

Professional Skills

Less frequently than some of the other learning outcomes, students mentioned developing professional skills like teamwork, general communication skills, mentoring, leadership, project management, time management, and initiative. There were fewer patterns in terms of who talked about these skills, except:

- Students working on collaborative projects were more likely to mention teamwork and communication skills.
- Graduate students or other team leaders were most likely to talk about mentoring and leadership skill development.

Cross-Cultural Skills

In contrast to the Cultural Differences outcome, the IRES programs in this study varied in terms of how much students talked about developing cross-cultural skills. This outcome focuses on students talking about learning to interact across differences, such as: increased awareness of how to behave in a cross-cultural situation, adjusting their behaviors to align with local practices, developing skills to communicate effectively across cultures (including language skills), and increased interest and motivation to engage in cross-cultural activities.

Development of cross-cultural skills is often connected to students' prior cross-cultural experiences (or lack thereof), but some trends worth noting are:

- For the most part, students in countries that have a high cultural distance from the United States were more likely to discuss learning cross-cultural skills.
- Students in countries with a different language were more likely to talk about learning cross-cultural communication skills.

Cross-Cultural Differences

A common topic across all of the programs in this study was learning more about cross-cultural differences. This outcome focuses on awareness of differences as opposed to learning how to interact across differences. Students in most contexts identified some kind of cross-cultural differences, although the types of cross-cultural differences students noticed varied a bit across contexts:

- Students in countries that have a low cultural distance from the United States tended to notice differences in work-life balance approaches most strongly.
- Students in countries that have a high cultural distance from the United States were more likely to discuss differences in cultural values and practices.
- Students working in close collaboration with researchers abroad were more likely to notice differences in communication styles or workplace behaviors.

Perspective Change

Students across all of the programs in this study described having perspective changes, such as: increased awareness of other cultures, discovering the world to be a bigger place than they thought, increased empathy for international students coming to the United States, recognizing different approaches to aspects of life (e.g., work-life balance), seeing people in other countries as "not that different," increased awareness of international news and political events, and seeing faculty as approachable people. These types of outcomes were most common in the following cases:

- Students who had never traveled abroad before were likely to talk about having a different view of the world and having "escaped their bubble."
- Students who developed friendships while abroad were most likely to talk about how similar people were in other countries.
- Students with strong mentoring relationships and opportunities to spend time with their mentors talked about learning to see faculty as approachable.

Global Engineering

Some participants talked specifically about learning about the global nature of engineering research, different approaches or methods for engineering research around the world, or the global scope of the research community in their field. Students on some programs talked about this outcome more than others, and it also varied by student, potentially for these reasons:

- Students with more prior research experience (especially graduate students) were more likely to notice differences in research approaches or applications.
- Students who worked in close-knit cross-cultural research groups were more likely to discuss the global scope of the research community in their field.
- Students who interacted with local college students were likely to discuss differences in the educational systems across countries and how that could influence collaboration.
- Students in developing countries were more likely to notice the influence of government policies or cultural context factors on engineering work and research.

Personal Growth

Students across all of the programs in this study discussed personal growth in a variety of areas including: self-confidence, independence, openness to new experiences, self-awareness, getting outside their comfort zone, self-improvement, and setting personal priorities (e.g., work-life balance). These types of outcomes were especially common in the following cases:

- Programs where students were encouraged to travel on their own helped students develop self-confidence in their ability to navigate foreign environments.
- More open-ended research projects led students to develop independence or ability to work through feeling overwhelmed (although this could also be a negative experience - should be balanced with students' prior research experiences).
- Experiences where students needed to use a foreign language tended to challenge their willingness to get out of their comfort zones. This experience also often caused students to want to continue learning languages upon their return.
- Having personal responsibility for a project, sub-project, or research team helped some students develop self-confidence, independence, or self-identify as a "researcher."

Career/Future Outcomes

By far the most common type of outcomes that were discussed across all of the programs in this study were outcomes related to students' careers or future lives. Some of the most common topics were:

- Graduate School: For many students, IRES provided either new inspiration to apply to graduate school or confirmation that their plan to go to graduate school was what they wanted. In some cases, the research conducted during IRES inspired students to focus on a specific topic in graduate school or informed the types of advisors, research groups, or programs they sought out in graduate school. For other students, IRES helped them decide against graduate school as a pathway once they understood more clearly what research entailed.

- Industry: Several students who chose a career in industry mentioned that skills developed during their IRES program were influential in their work (including both technical and professional skills). In particular, some mentioned that doing research helped them become more comfortable with open-ended problems and creative thinking in ways they had not experienced in traditional engineering coursework.

- International Work: Many students also discussed being more open to working internationally as a result of IRES. Some students talked about moving abroad for graduate school or a postdoc, and others discussed finding an industry job that would allow them to travel abroad. In many cases students said that even if they had traveled abroad before, they had not realized that working abroad was an option in their field, and IRES provided both confidence that they could do it and information about where to look for people in their field.

- International Travel: Although not every student was interested in working abroad, nearly every participant talked about how IRES inspired them to do more international travel (or plan to do more in the future). Developing confidence and skills to navigate international settings made the idea of taking an international vacation more feasible for most students.

- Preparation for Academia: Students who planned on a future in academia (mostly graduate students) talked about gaining understanding of how grant funding works, the benefits of international collaboration for research, project management skills, confidence in running a research project, and mentoring skills (if paired with undergraduates). A few students also mentioned interest in running an IRES (or similar) program of their own one day because they found the experience so important.

- Professional Network: Some students looking at graduate school and academic careers talked about how IRES helped them expand their professional network internationally. These students talked about wanting to be more aware of what was happening in their field around the world, learning different research approaches, and developing research collaborations abroad once they started their careers.

Appendix. Detailed information for each case study site

Appendix. Summary of findings across cases

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
US University	Virginia Tech	Virginia Tech	Virginia Tech	Michigan	BYU/U-Col at Col Springs	UCF	Cornell	UCF	Southern
International Institution	Shandong University	University of Nottingham	University of Queensland	South African National Space Agency	University of Coimbra	German Aerospace Center (DLR) -- Cologne & Stuttgart	National Institute of Materials Science	Technical University Ilmenau	Kwame Nkrumah University
Country	China	UK	Australia	South Africa	Portugal	Germany	Japan	Germany	Ghana
Collaborators	None - PI runs labs on both sides	Partnership at college level, some already collaboration, started new collaboration for IRES	Existing UQ partnership w/ENGE dept., connected w/VT Civil to write IRES grant.	Existing collaboration between PI & 3 colleagues at SANSA	PI studied abroad in Portugal during PhD, started 1 collab, but IRES accelerated # of projects	Collab started from earlier NSF small grant, successful decided to try for IRES	US Nano Network has collaborated with Japan Nano Network, this IRES is built on that	PI longstanding relationship with two researchers in Germany had done projects together	PI had ongoing collaboration, one of the Ghana faculty was a classmate
Research Impact	Access to new bats, bigger team makes more research possible	Jumpstarted collaboration, strengthen existing collaborations, publications, joint researcher position in mining	Grant between VT Civil faculty and UQ faculty since IRES started.	Help SANSA publish in intl. journals (fees), expand PI research area and # SANSA collaborators.	PI got multiple grad students, several publications, collab expanded to new projects & 2nd prof. Developed strategy for successful UG research -- "pods" of UG working together.	New collab within UCF. ID new instruments, methods, data. ID new interdisciplinary connections with Physics & Nano. Learn from German approach to research - more risk averse.	N/A no researcher collaborations	Was not actively collaborating, used IRES grant to start the collaboration up again	IRES led PI to start new area of collab w/ Ghana. They were working on this topic, he was not. Now applying for new IRES grant on new topic. Shifted his research area to more env. focus.

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
US University	Virginia Tech	Virginia Tech	Virginia Tech	Michigan	BYU/U-Col at Col Springs	UCF	Cornell	UCF	Southern
Country	China	UK	Australia	South Africa	Portugal	Germany	Japan	Germany	Ghana
Institutional Impact	3+2 program, Chinese students adjust to US better if they have worked with IRES students; IRES helps to expand Shandong connection	Stronger connection w/ UN Expanded # and quality of research group connections. UN students coming to VT. Research England created IRES program. Setting up exchange.	Connection w/UQ expanded - more faculty involved since start of grant, on both sides. ENGE faculty are affiliated w/UQ now.	Financial incentive to SANSA mentors, supports their work. PI serves as external evaluator for South African PhDs. Postdocs come to Mich from South Africa.	Students in Portugal benefited by having intercultural RG, improved English.	Expanded from 1 prof with DLR collab to 4-5 profs at UCF with connections. Also built into 3-way collab with Argonne NL in Chicago.	Japan Nano Network now sending grad students to the US for summer (Nano REUs). Proposal out for other collab (workshops, early career, etc.).	University already had an exchange connection with Ilmenau and other research collabs. IRES just built further connection.	Students from uni in Ghana are now coming to Southern for grad school to work with PI.

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
US University	Virginia Tech	Virginia Tech	Virginia Tech	Michigan	BYU/U-Col at ColSprings	UCF	Cornell	UCF	Southern
Country	China	UK	Australia	South Africa	Portugal	Germany	Japan	Germany	Ghana
Student Selection	Advertised at VT, interdisciplinary backgrounds	VT Faculty mentors do recruitment, find students aligned w/topic	Advertised in VT civil dept, app reviewed by ENGE and Civil at VT	Try for diversity in SES, gender, etc. and research & travel experience	Advertised at U-Col and local CC, did info sessions, looked for math background	Advertised to UG, grad, faculty at UCF. Former IRES helped interview	Past participants in Nano REU programs can apply, from across US	Advertised to CS, ECE, ISE students at UCF	Bio/chem/env majors across multiple universities in southern US
Year of Student Participants	Mostly Juniors and Seniors	UG, masters, PhD, sent some twice	Mostly Juniors and Seniors in 4+1	Juniors & Seniors in 4+1	Juniors & Seniors, 2 grad students	2 UG, 2 Grad each year (mentors)	Going into senior year, mostly	One grad student + 3 UG each year	Mostly sophomores & juniors
Pre-Travel Activities	Regular meetings to do paperwork, logistics, learn about China. 1 week project prep.	3 meetings + 3 week seminar. Logistics, travel, lit review, research plan, mentor contract	1-2 meetings in semester for paperwork and logistics	2 meetings - one is global orientation, also pre-reading + research plan, logistics, email w/SANSA mentor	Weekly lectures on research topic (1st year outside class, 2nd - in class, 3rd - videos + disc), some language	Spring 10-hr/week research credits, lit review, summer plan, meet regularly w/ German mentor. Global Ed Orient.	Logistics emails with PI pre-travel, then 1-week orientation in country with PI	Regular training sessions starting in January, focus on lit review & formal logic. Intl orientation just before travel, mostly logistics.	IRES is offered as a 3-cr class "Intro to Sustainability" -- pre-departure intro to Ghana, research project, logistics, and course content
Program Schedule	1 week at VT, 8 weeks in China, 1 week at VT	3 weeks at VT, 7 weeks in the UK	8 weeks at UQ	8 weeks at SANSA	10 weeks at Coimbra	Spring research, 10-12 weeks in Germany	10 weeks in Japan	8 weeks in Germany	1 week in US, 4 weeks in Ghana, 3 weeks in US

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
US University	Virginia Tech	Virginia Tech	Virginia Tech	Michigan	BYU/U-Col at Col Springs	UCF	Cornell	UCF	Southern
Country	China	UK	Australia	South Africa	Portugal	Germany	Japan	Germany	Ghana
Student Deliverables	Final Report & Poster	Grad students thesis/diss, some joint publications	Final Report, ENGE joint publications	All do poster presentation, some joint publications	Around 80% of IRES students are on publications	Final Presentations, Conference papers, Grad thesis/diss	Final Report & Poster. Some joint publications	Conference papers each year	Final Presentation in Ghana, Final Report & Poster in US, Submit to NSF Imagine Research conference & others
Post-Travel Activities	UG Research Symposium	None official, some students continue research at VT	None official, some students continue research at VT	2 meetings during fall semester, some students continue project as capstone or ind. research	None official, some students continue UG research after or as grad students	None official, some students continue UG research after or as grad students	Poster at Nano REU Convocation (National network for Nano REUs)	Finish testing, write conference paper, train next year's students on their system in the spring.	Last three weeks are writing the final report in the US (but part of program)

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
US University	Virginia Tech	Virginia Tech	Virginia Tech	Michigan	BYU/U-Col at Col Springs	UCF	Cornell	UCF	Southern
Country	China	UK	Australia	South Africa	Portugal	Germany	Japan	Germany	Ghana
PI Travel with Students	First week and last week	No	ENGE Grad Student in country all summer	Visits either at start or mid-program	No	No	First week to help settle in	First week to help settle in	First week to settle & cultural activities
Student Housing	International dorm on campus	Apartments Coordinated by Nottingham	Air BnB	SANSA dormitory on their campus	Started in campus housing, later rented apartment instead (all together).	Students get apartments	National Lab dormitory on their campus	Students register as exchange students at Ilmenau, stay in university housing, access to dining and all support resources	TBD, unclear
Student Mentoring/Support	Students put on small teams (3-4) led by a Chinese grad student	Mentors both sides for each student. Mentor contract agreed to by both. Part of RG at Nottingham	Originally just faculty mentor at UQ, year 3 added grad student mentor. Access to 2 RG at UQ	PI on Mich side, each student different mentor at SANSA. No RG, create contract before arrival.	US PI called into meeting 1x per week. 5 IRES mentored by 2 profs, collaborative RG w/grad and UG students	Each student has mentor in US and in Germany. UG paired with Grad on similar or related project.	Each student has mentor in Japan and is part of their RG. US PI checks in weekly for progress, but not research.	1 German mentor for all students during summer, US PI takes over once they get back. Grad student is the group leader.	Work with local research mentors in Ghana and their grad students, join the RG there.

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
US University	Virginia Tech	Virginia Tech	Virginia Tech	Michigan	BYU/U-Col at Col Springs	UCF	Cornell	UCF	Southern
Country	China	UK	Australia	South Africa	Portugal	Germany	Japan	Germany	Ghana
Student Projects	On different teams, work closely with Chinese UG & grad students	Students selected based on projects by VT mentors	Students rank options from list, each assigned individual project but opportunities for other fieldwork	Students rank projects then assigned in spring, usually their own project, not part of larger one.	Some ind. projects, some teams. Complementary topics, can help each other and work with students in RG.		Researchers at National Lab submit project ideas, students rank and then are assigned	Students work together on same project. Open-ended, they self-organized. Build on project from prior summer.	In pairs work on same project from diff angles. Build on work from prior summer. Coursework + language weekly.
Extracurricular Activities		Students encouraged to explore UK/Europe, take long weekends. No planned activities.	All students are invited to join fieldwork opportunities across multiple projects within the RG.	Opportunities to participate in K-12 outreach in South Africa	Students encouraged to explore Europe, take long weekends. No planned activities.	K-12 outreach during spring before IRES	Visit to a Japanese university w/presentations & cultural exchange.	Students encouraged to explore Europe, take long weekends. No planned activities.	Cultural activities: Visit king's palace, drumming & dancing performances, slave trading sites. Site visit: village where research is focused.

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
US University	Virginia Tech	Virginia Tech	Virginia Tech	Michigan	BYU/U-Col at Col Springs	UCF	Cornell	UCF	Southern
Country	China	UK	Australia	South Africa	Portugal	Germany	Japan	Germany	Ghana
Other Key Factors	Non-IRES students also go, so it's a bigger group (8-10)	Logistics managed at college level on both sides - PIs focus on research	Logistics managed by ENGE dept at VT, Grad student evaluator in country	Students participate in Space-Weather camp for 1 week during time at SANSA	PI switched schools after year 2, so year 3 was at BYU instead of Colorado.	Required spring research to ensure students feel comfortable at DLR (no other UG there). Did not want to require prior research for IRES.	All students completed nano REU before this IRES. All from diff schools, unique in giving students from small non-research schools the chance.	PI had IRES in France first, learned from that to create this one. Focused on publishable project this time. Students pay UCF summer tuition as exchange students.	Grant covers conference travel for any presentations based on IRES research AND grant covers summer tuition since they are all registered for the course.

Case 1: Virginia Tech and Shandong University (China)

Title: US-China Collaboration: Bats as Model Organisms for Bioinspired Engineering

Program Structure

- **Year of Participants:** Mostly Juniors and Seniors
- **Student Selection:** Advertised at Virginia Tech, interdisciplinary backgrounds
- **Program Schedule:** 1 week at VT, 8 weeks in China, 1 week at VT
- **Pre-Travel Activities:** Several meetings in the spring to complete paperwork, communicate logistics, and learn about China. One week project prep in summer.
- **Post-Travel Activities:** Finish report and present at undergraduate research symposium
- **Student Deliverables:** Final report and poster for symposium

In-Country Logistics

The PI travels with students to China for the first week and then joins them again at the end of the program to bring them back to the United States. Students live in the international residence hall on campus, which is near the building where they work. Students are placed on teams of 3-4 undergraduate researchers, each led by a Chinese graduate student. Each team works together to complete a different project during the summer. The Chinese graduate students are the primary mentors for the IRES students because the PI runs labs both at Virginia Tech and at Shandong University, so the PI is the only faculty mentor for students in the program. He remains connected with students remotely during the summer. There are no formally planned extracurricular activities during the summer, but students are encouraged to travel and the Chinese students have historically helped them coordinate trips, often traveling with them or inviting them to participate in different local activities.

Other Program Features

- Non-IRES students also travel with the IRES group, so it is a larger group (8-10 students)

Research & Institutional Impacts

Because the PI runs the labs on both campuses, there is not a collaboration with another faculty member. The primary benefit of having the second lab in China is that there is access to different bats in China, resulting in unique data that cannot be collected in the United States. The IRES grant helps provide undergraduate students the opportunity to participate in that aspect of the research and push forward the projects in the China lab.

The IRES grant has strengthened the ongoing connection between Virginia Tech and Shandong University by adding another point of collaboration. Chinese students participating in a 3+2 program have also been better able to adjust to US if have worked with IRES students.

Student Interviews

The students in Case 1 talked a lot about working with Chinese students and other IRES students in the lab, and they described their projects as collaborative. The IRES students were typically working with 2-3 other people on their project, usually a Chinese grad student who provided guidance and then a few other undergrad students from the U.S.

The collaborative nature of this set up provided several benefits that the students highlighted:
- Support in the research process -- they learned a lot from the Chinese grad students about setting up experiments, using equipment, and working with the bats

- Cross-cultural experience -- they ran into some challenges working with the Chinese students and had the opportunity to work through these and learn both how to work across difference and different cultural perspectives on certain topics
- Social activities -- the Chinese students did a great job of creating a social atmosphere with the U.S. students, including having lunch with them, showing them around the city, and even helping them plan longer trips to other cities

The students in Case 1 discussed both technical and research skills that they developed through their program, especially gaining MATLAB skills and a better understanding of what research is and how the process works. Earlier students focused more on technical skills and more advanced students on learning about the research process.

The support from the Chinese students helped a lot with the language barrier and learning about the culture, but students did mention it would be nice to have a little more information about the language and culture before they left. Language differences came up as a critical incident for learning across interviews.

Some students in this case were able to continue working on their IRES project after they got back as UG researchers during the semester and/or as part of their senior capstone project. However, they mentioned that having more information about the project before they left would have been helpful, including both high-level information about the goals of the project and their own personal tasks/role in the project.

Case 2: Virginia Tech and the University of Nottingham (UK)

Title: Future Electric Transportation Systems (FETS)

Program Structure
- **Year of Participants:** Have sent undergraduates, master's students, and PhD students
- **Student Selection:** Faculty mentors at VT recruit students to ensure alignment and interest in a specific project
- **Program Schedule:** 3 weeks at Virginia Tech, 7 weeks in the UK
- **Pre-Travel Activities:** 3 meetings during the semester to sort out logistics, then 3 weeks at VT in the summer to work on a literature review, research plan, and mentor contract.
- **Post-Travel Activities:** None officially, some students have continued working on their summer projects at VT after completing IRES.
- **Student Deliverables:** Several joint publications, some graduate students have used their IRES work as part of a master's thesis or PhD dissertation.

In-Country Logistics
The PI for this program is a college-level administrator at Virginia Tech, who coordinates primarily with the administration at Nottingham to handle the logistics of the program. The students travel to the UK on their own and live together in apartments near the campus. Student projects are proposed jointly by faculty members across multiple engineering departments at VT and Nottingham who have ongoing collaborations. Each student then has a mentor on each campus and starts the summer working with their mentor at VT (3 weeks) followed by working with their mentor at Nottingham (7 weeks). The student-mentor contracts are developed to ensure that expectations are clear across both mentors. No extracurricular activities are planned for students, but they are encouraged to travel during their time abroad.

Other Program Features
- Because the PIs on both sides of this program are at the College level, the faculty mentors are able to focus entirely on the research projects and not logistics.

Research & Institutional Impacts
This program has strengthened the ongoing relationship between these two universities. It supported existing research collaborations and jump-started a new collaboration in one department. Researchers at VT have been able to pursue new research areas due to access to equipment at Nottingham. A joint faculty position between the two universities was introduced and the first person hired into this position was one of the early IRES participants. This program encouraged Nottingham to send student researchers to VT in return, ultimately causing them to ask their funding agency to create a similar grant program which is now in place.

Student Interviews
LIMITATION: Only interviewed Graduate Students in Case 2, even though many participants were undergrads.

In Case 2, the IRES grant was held at the college level rather than with a specific faculty member. This design meant that participants were sometimes from different departments and worked on entirely different projects while they were abroad. The grant was used to encourage faculty to develop new collaborations at the partner university, and the students interviewed viewed themselves as part of helping to build these new connections. As graduate students, they were included in the project conceptualization phase and continued to work on the projects after IRES, as part of their dissertation projects. The students described how their traveling abroad helped cement the relationship that was being developed between their faculty advisor in the U.S. and the collaborator abroad.

As graduate students, the Case 2 participants brought a unique perspective to their IRES experience. Both have gone on to become faculty members, so they emphasized professional learning outcomes such as:
- Learning to mentor younger students
- Learning about different advising styles
- Building their network and collaborations abroad
- Learning about higher education systems in another country

Perhaps as a result of being in the UK (low cultural distance), these participants rarely mentioned cultural differences or the development of cross-cultural skills. In fact, they emphasized how similar the people were that they were working with (except for some differences in work-life balance preferences).

Both participants emphasized that a key aspect for success in an IRES program was that the collaboration between the faculty must be strong. They discussed the need for funding on both sides, that the research must be mutually beneficial for both faculty careers, and how both sides must be able to contribute something useful and unique to the project. They emphasized good "matching" between collaborators as essential to the success of an IRES program.

Some logistics were discussed, especially comparing different housing options and different set ups of students (grad + UG vs grad only). Both participants benefited a lot from being part of a research group that invited them to lunch/tea breaks. Some discussion here about needing to open up to making those connections (personal growth) rather than sticking with the other IRES students.

The Case 2 participants also highlighted the publications and ongoing collaborations as important benefits of the program. They also appreciated the different approaches and perspectives that collaborating with a lab abroad brought to the research, ultimately leading to better quality research.

Case 3: Virginia Tech and the University of Queensland (Australia)

Title: Multidisciplinary Water Engineering Research and Education to Protect and Enhance Ecosystems in Complex Environments

Program Structure
- **Year of Participants:** Juniors, Seniors, Graduate Students (especially those in the 4+1 master's program)
- **Student Selection:** Advertised in the Civil Engineering department, applications are reviewed by VT faculty in Civil and Engineering Education departments
- **Program Schedule:** 8 weeks in Australia
- **Pre-Travel Activities:** Two meetings during the spring to handle logistics
- **Post-Travel Activities:** None
- **Student Deliverables:** Final Report, joint publications in Engineering Education

In-Country Logistics
An Engineering Education graduate student travels with the students to Australia and remains there all summer as a program evaluator and to conduct engineering education research. This person and the Civil Engineering students stay in AirBnB apartments near the campus. Student projects are proposed by Civil faculty members at UQ, and students are matched based on interest. Each student has a faculty mentor at UQ, and in year 3 of the program a graduate student mentor was also assigned to improve access. Students also have access to two active research groups at UQ related to their projects. Extracurricular activities are not planned for students, but they are often invited to participate in fieldwork opportunities outside of their own projects.

Other Program Features
- Logistics for this program are managed by the PI in the Department of Engineering Education who is not involved in the student research projects.

Research & Institutional Impacts
This project stemmed from an existing collaboration between the Department of Engineering Education at Virginia Tech and the School of Civil Engineering at UQ. This grant helped build an initial connection between Civil at UQ and Civil at VT, resulting in visits back and forth between these departments and eventually a shared grant between them. The UQ Civil department has excellent research facilities and access to unique coastal environments which give new opportunities for research than is available in Virginia.

The project has expanded collaborations between these two universities and more faculty members have become involved on both sides. Two of the Engineering Education faculty members have become an affiliate faculty at UQ during this project.

Student Interviews
NOTE: We had more interviews for Case 3 than any other case. This meant that all of the learning codes showed up more frequently within this case - more opportunities to be mentioned. The students here also knew their interviewers better than the other cases, and so may have felt more comfortable expressing challenges they had with the program.

A central experience for many participants in Case 3 was participating in a fieldwork experience. Activities related to fieldwork and support/mentoring provided for doing fieldwork significantly influenced many students' impression of the overall IRES experience. For the graduate student participant, fieldwork provided an opportunity to manage a project and mentor undergraduate

students. For the undergraduate participants, participating in fieldwork helped them learn a variety of outcomes, including:

- The nature of research and need to adapt as stuff happens in the field
- What type of research they might want to do in graduate school
- Confidence in feeling like they are a "real" researcher or engineer
- Opportunities to connect with faculty members in a casual setting and experience mentoring

Students who did not get to complete fieldwork in this program felt that they did not have as good of an experience or were disappointed. One even suggested that not having done fieldwork made them feel like they didn't have a full understanding of what research is and therefore was not sure about going to graduate school. The experience of doing fieldwork (and how it was structured) in this IRES program was central to students' learning and attitude toward research.

Students in Case 3 also had significantly different experiences with mentoring and support during their time abroad. Some students found strong mentorship through working closely with a PhD student in the lab abroad on their project, which often led to friendship and social connections. Others highlighted time spent with faculty members during fieldwork as key experiences during their IRES program. Not only did these relationships help develop students as researchers, but several students said they began to see faculty members as "real people" too.

However, significant variations in project structure meant that some students did not have clear mentors or failed to find their place in the research groups. These students felt confused about what they were meant to do and also struggled to connect socially during the time abroad. Students in these positions highlighted learning independence, figuring out how to get information on their own, but expressed some doubt about doing research in the future.

Interestingly, although Australia is not culturally distant from the U.S., the students in Case 3 identified far more cultural differences than those in Case 2. This may be related to the fact that Australian work culture is one of the big differences and the students were embedded in the work environment daily. Several students struggled with working in the "laid back" Australian work environment, which may be connected to the lack of project structure that caused challenges for several students. Some students commented that more preparation up front for the differences in the work environment would have been helpful.

Case 4: University of Michigan and the South African National Space Agency (SANSA)

Title: Space Weather International Research Experiences for Students Program

Program Structure
- **Year of Participants:** Juniors and Seniors in the 4+1 master's program
- **Student Selection:** Opened to University of Michigan students, tried to recruit for diversity in gender, race/ethnicity, SES, research experience, travel experience
- **Program Schedule:** 8 weeks in South Africa
- **Pre-Travel Activities:** 2 meetings in the spring, one for logistics and one for global orientation with global office. Students also create a research contract and email with their SANSA mentor before arriving in South Africa.
- **Post-Travel Activities:** Two meetings in the fall to wrap up projects, some students continue their projects as a capstone or for independent research credit
- **Student Deliverables:** All students present a poster at a conference in South Africa before the end of the program, some joint publications

In-Country Logistics
The PI either travels to South Africa with the students for the first week or will visit for a week mid-program. Students are housed in the SANSA dormitory on their research campus with other international researchers working at SANSA. This gives a unique opportunity for interacting with local students and researchers within the housing complex and dining facilities. Students projects are proposed by mentors at SANSA and then students rank these choices and are assigned based on their preferences. Students are mentored by the PI at Michigan and each has a separate mentor at SANSA based on their project. They create a mentor contract before the start of the summer to ensure they are all on the same page. Students have the opportunity to participate in K-12 outreach activities through SANSA during their time in South Africa.

Other Program Features
- Students participate in Space-Weather camp for 1 week during their time at SANSA.

Research & Institutional Impacts
The PI had an existing collaboration with three researchers at SANSA. This project expanded his connections to other researchers at SANSA which has expanded his research topics. He has also become more connected to the research community in South Africa by serving as an evaluator for PhDs there and receiving South African graduates as Post Docs in his lab. The SANSA researchers also benefited because their work was able to be published in international journals as the grant was able to help cover the publication fees.

Student Interviews
Case 4 had a rather **more structured IRES program** that many of the other cases, and students seemed to benefit a lot from this approach. This structure started even before the program began, where the PI provided a lot of pre-travel activities ranging from a panel of students from prior years, skype conversations with their South African mentors, and coming to the PI's house for dinner so they could all connect before the trip.

The PI also traveled to South Africa during the students' time there (mid-program) so that he could check in on their progress and connect with his collaborators. He also checked in regularly with them throughout the summer, providing a lot mentoring and support if issues arose. The students also described their mentors at SANSA positively, saying they were accessible and also went out of their way to make the students feel welcome. Some folks at

SANSA even went out of their way to introduce the students to South Africa and took them on various outings.

In addition to the connections made at SANSA, this IRES program included some planned activities. First, there was a space research "camp" held for two weeks at SANSA while they were there, where students from other countries came and there were lots of opportunities to interact. Second, all the students got to present their work at an international conference at a university near the end of the summer. Both of these activities were highlighted as impactful for students, but especially the conference, which led to a range of learning outcomes, including:
- Awareness of global research connections
- Ability to communicate their research
- Understanding of how a research community works
- Validation of the work they were doing

Most of the students in Case 4 highlighted their housing situation as beneficial to their ability to connect with South Africans during their program. They stayed in a dormitory on the SANSA campus, which included communal living areas. Several students discussed the friends they developed there as a key experience in the program. All of the participants seemed to have made good connections with locals, although one student felt that the others in her cohort did not do a good job engaging (by choice, rather than by not having opportunities).

As a result of these connections and their explorations of the region, students in this program experienced perspective changes and awareness of cultural differences as key learning outcomes. Many noted the wealth disparity in South Africa and reflected on this in different ways. Several students also commented positively on the welcoming, happy, or peaceful aspects of South African culture, which caused them to reflect on US culture.

Case 5: Brigham Young University/University of Colorado at Colorado Springs and University of Coimbra (Portugal)

Title: Practical Physical-Layer Security in Coimbra, Portugal

Program Structure
- **Year of Participants:** Mostly juniors and seniors, occasional graduate students
- **Student Selection:** Held information sessions at UC-CS (later BYU) and a local community college. Looked for participants with strong math background.
- **Program Schedule:** Spring semester at UC-CS/BYU, 10 weeks in Portugal
- **Pre-Travel Activities:** Weekly lectures from PI to get up to speed on research topics. Some foreign language practice included.
- **Post-Travel Activities:** None official, some students have continued on the project as undergraduate researchers or graduate students.
- **Student Deliverables:** Around 80% of participants are on joint publications.

In-Country Logistics
The students travel to Portugal on their own and stay in apartments together (tried campus housing one year, but felt apartments worked better). Two professors at the University of Coimbra mentor all students as they all work on complementary projects in a similar research area. The U.S. PI calls into meetings once a week to keep up-to-date on the projects and provide additional mentorship. Students work on projects individually or in small groups, depending on the complexity of the project. Because the projects are highly related, they are able to help each other and work closely with the undergraduate and graduate students in the research group.

Other Program Features
- The PI switched schools between years two and three, so year three was at BYU.

Research & Institutional Impacts
The PI studied abroad in Portugal as a PhD student making the initial connection. This program has expanded that existing collaboration to a second collaborator and accelerated the number of ongoing projects and publications. The program also led several students to work with the PI for graduate school and has encouraged him to incorporate undergraduate researchers in his lab based on the success of the IRES projects. He has developed a format where they can support each other by working in small groups, as done on IRES.

The researchers at the University of Coimbra have found the program helpful in expanding the amount of research that their research group can complete. They also felt that their students benefited by having a cross-cultural research group and improved their English skills.

Student Interviews
The participants from Case 5 all spoke positively about the work environment during their IRES program, although they seemed to experience different types of project structures. Some students worked on more solo projects while others were on a small team together. In some cases, a graduate student was part of the team mentoring undergrads, in other cases, students worked closely with researchers in Portugal. One student talked about having an interdisciplinary project that involved both math and engineering researchers.

Career/future outcomes for students in Case 5 were not only related to deciding whether or not graduate school was for them, but also in learning what type of work environment they preferred. Most of the participants mentioned enjoying some aspect of the work environment in

the program, whether it was working on a small team, getting to wear multiple hats, having open-ended problems, or working on interdisciplinary problems. This seems to suggest that regardless of their different project types, the overall environment was positive and supportive.

The students on teams emphasized that they learned about and came to value collaboration highly. Several of them emphasized that they could not have done their project alone. All of the students seemed to feel well-supported and able to get help with their project when needed. For some students, this mentoring and support came from the Portuguese researchers, for others it was from the students in their IRES program.

Despite feeling supported, some of the students mentioned that it might have been nice to connect more with Portuguese students during the program (probably varying based on student initiative). One suggested that all the IRES students living together may have hindered their initiative to branch out more. However, several of the students appreciated having an additional week built into the project schedule and being encouraged to travel. This may have contributed to the students talking a lot about the cross-cultural skills they developed during the program.

Perhaps because of the more theoretical nature of the research in this IRES program, all of the students talked about learning about the Nature of Research as a key learning outcome. In this case, they mostly discussed research as open-ended, ill-structured, "banging your head against a wall," and required you to be willing to fail and keep trying again. Most students seemed to have the opportunity to continue on projects after return, either as undergraduate research or part of a master's thesis. Several also were able to publish papers as a result and seemed to appreciate being able to see the project to the end (even if they weren't paid for that part of the experience).

Case 6: University of Central Florida and the German Aerospace Center (DLR)

Title: US-Germany collaboration to advance research and education in materials for extreme environments

Program Structure
- **Year of Participants:** 2 graduate students and 2 undergrads each year
- **Student Selection:** Advertise to students and faculty across engineering departments
- **Program Schedule:** Spring semester research then 10-12 weeks in Germany
- **Pre-Travel Activities:** 10 hr/week research during the spring semester where students work on their literature review, summer research plan, and global orientation
- **Post-Travel Activities:** None official, some students have continued on the project as undergraduate researchers or graduate students.
- **Student Deliverables:** All students do final presentations, some have worked on joint publications or used their IRES work in their graduate thesis or dissertation.

In-Country Logistics
The students travel to Germany on their own and live in apartments (sometimes together, other times with local students). Each student is assigned a mentor in the US (PI or other UCF faculty members) and a mentor in Germany. They communicate with their German mentor during the spring semester to create a plan for the summer. Each undergraduate student also is assigned one of the graduate students as a mentor and these pairs are assigned similar or related projects. Initially, all students were located at the DLR site in Cologne, but later the students were split between there and Stuttgart. In these later years, students had the chance to travel to the opposite site and present to researchers there. Students also participated in K-12 outreach related to the IRES projects during the spring semester to local schools in Florida.

Other Program Features
- Spring research was required to ensure students felt comfortable at DLR, and the PI did not want to require prior research experience to participate in IRES.

Research & Institutional Impacts
This collaboration started between the PI and DLR through a one-year international NSF grant. Through the IRES grant, the collaboration expanded to include new researchers on both sides, (including interdisciplinary partners) and Argonne National Lab in the US. As a result, the projects now have access to different methods, instruments, and disciplinary perspectives on what data to collect. Further, the PI discussed learning from the different more risk-averse approach to research held by German colleagues as compared to US-based researchers.

Student Interviews
Case 6 included a combination of graduate students and advanced undergraduates. The participants interviewed from this program had prior research experiences, but even if they had not, a defining feature of this IRES program was that students were required to do a semester of research on the IRES project before leaving for the summer. All of the participants highlighted that this was helpful in hitting the ground running when they arrived in Germany. During the spring research, participants conducted lit reviews, got to know their German collaborators remotely, and became familiar with their part in the project. The only suggestion students had was that some language preparation could be added too.

All of the participants described feeling welcome and supported during their time in Germany. Because the German collaborators would come visit the lab in the US also, the students

seemed very comfortable with them and able to ask for help when they needed it (possibly also helped by starting the project in the spring). Some students were working on individual projects while others were more collaborative, but in either case they seemed to feel adequately supported.

The students from Case 6 lived in student housing for a local university, but had varying success connecting with local students. Some students described mostly spending time with other IRES students, while others were able to make local friends (probably varying by initiative). In some cases, the housing provided an opportunity for connection (via roommates), but in other cases students were housed alone.

Perhaps because they were already working on the research before leaving for Germany, the participants for Case 6 emphasized non-research related learning outcomes from their time abroad. In particular, the students were most likely to talk about personal growth (in areas like confidence and perseverance) or having a perspective change (about the world or culture). The participants from Case 6 in general had less prior travel experience than in some of the other cases, so learning to navigate in a foreign country on their own was a big step. However, they emphasized that the German culture wasn't too different and in some cases discussed how similar people were.

The students in Case 6 were working at a national lab, and this seems to have informed or affirmed career goals for several of them, who wanted to work at a national lab in the future. One student obtained a Fulbright to continue working on the same project with the researchers in Germany. Uniquely, multiple participants discussed wishing to continue international research collaborations going forward in their careers, with one student specifically looking for this opportunity when choosing their PhD program and advisor.

Case 7: Cornell University and the National Institute of Material Science (Japan)

Title: International Research Experience in Nanotechnology in Japan

Program Structure
- **Year of Participants:** Going into Senior year
- **Student Selection:** Past participants in Nano REU programs can apply, from across US
- **Program Schedule:** 10 weeks in Japan
- **Pre-Travel Activities:** Logistics emails plus 1-week orientation in-country with PI
- **Post-Travel Activities:** Attend and present a poster at Nano REU Convocation
- **Student Deliverables:** Final report and poster, some joint publications

In-Country Logistics
The PI travels with the students to Japan and stays for the first week to show them around and help them get settled. Students are housed in a dormitory on the research campus with other international researchers working at the national lab. This gives a unique opportunity for interacting with local students and researchers within the housing complex and dining facilities. Researchers at the national lab submit project ideas which the students rank and then are assigned based on their preferences. The students are mentored by researchers at the national lab since the PI is not involved in the research projects, although he does check in regularly to make sure that the students are doing well. The students are a part of research groups which are often quite international as researchers from around the world work at the national lab. The PI coordinates a trip to a Japanese university in another city where students present their research and spend several days getting to know local university students.

Other Program Features
- All students completed a Nano REU programs the summer before this IRES.
- The program recruits from across the US, so the students are from different schools and students from small, non-research schools have the opportunity to participate as well.

Research & Institutional Impacts
This program is unique because the PI does not have a research collaboration with the partner organization. Instead, the partnership is between the U.S. Nanotechnology Network and the Japanese Nanotechnology Network. Since this IRES program started, the Japanese Network has started sending Japanese graduate students each summer to participate in U.S.-based REU programs, making this an exchange. The two networks have also submitted proposals for other collaborations (e.g., workshops, early career programs) but these are still under review. Nevertheless, IRES has helped develop the connection between these two networks.

Student Interviews
Case 7 is particularly unique in its student selection process, where applications are only accepted from the pool of students who participated in a nationwide REU program the summer before. This serves as a unique pre-travel preparation in the sense that every incoming IRES student has already done at least one summer of research in the general field of study. It also means that participants tended to be either rising seniors or in the year between undergrad and grad school at the time of the IRES program. Several students also highlighted the fact that the U.S.-based PI for this grant traveled with them to Japan and helped them settle in for the first week, citing this as extremely helpful in their adjustment to Japan.

Having prior research experience meant that participants focused much more heavily on the cultural aspects of their experience when discussing learning outcomes. Cultural differences were a common topic of discussion, but even more, students on this program described how they developed cross-cultural skills and/or had a significant perspective change about how things can be done differently across cultures. Several of the participants in Case 7 had very little prior travel experience, so they described large changes in their worldview and also personal growth in developing confidence in their ability to navigate foreign locations.

The students in Case 7 were placed in different research groups within a national institute in Japan. All the participants described feeling welcomed into their research groups and experienced mentoring and support through this structure. In most cases, the research groups were a very diverse group of students, post docs, and PI's from around the world. This provided students with an increasing understanding of the international scope of their field, which in turn influenced the types of career outcomes that they discussed. Most of the participants were continuing to grad school and many suggested that they looked for advisors with international collaborations or diverse lab groups. Several also said they were interested in pursuing international post doc or faculty positions in the future.

The positive research group environment also provided social activities for students during their time in Japan. Most participants described having daily lunch with lab mates, becoming good friends, and some also traveled with colleagues on weekends to explore the country. In addition, the Case 7 program included an event planned in advance for students, where they traveled to a Japanese university, presented their work to local students, and then spent time touring the area with the students. All of the participants mentioned this activity in their interviews and most described it as a significant memory from the IRES program. Because the program took place at a national institute, this trip provided a unique opportunity for the U.S. students to connect with Japanese students, which they found particularly meaningful.

Case 8: University of Central Florida and the Technical University of Ilmenau (Germany)

Title: Avatar-based Adaptive Context System

Program Structure
- **Year of Participants:** One graduate student + 3 undergraduates each year
- **Student Selection:** Advertised to CS, ECE, and ISE students at UCF
- **Program Schedule:** 8 weeks in Germany
- **Pre-Travel Activities:** Regular training sessions starting in January, focus on doing a literature review and formal logic. Global orientation just before travel, mostly logistics.
- **Post-Travel Activities:** Finish testing the system developed over the summer, write conference paper, train next year's students on the system the following spring.
- **Student Deliverables:** Conference papers

In-Country Logistics
The PI travels with the students to Japan and stays for the first week to show them around and help them get settled. The students in this program are enrolled as exchange students at the Germany university, which allows them to stay in the dorms on campus, eat in the dining halls, and use other campus resources. This gives them several opportunities to interact with local German students. All of the students in this program work on one project together, building on the work of prior years of IRES students. The project is an open-ended problem, and the students must self-organize and manage the project to completion. They are mentored by one professor in Germany during their time abroad, and the UCF PI takes over once they return at the end of the summer. The graduate student provides additional guidance and experience within the group. There are no planned extracurricular activities, but students are encouraged to travel within Europe (and their German student ID gives them free use of local trains).

Other Program Features
- PI had a separate IRES in France first, learned from that to create this one. Focused on finding a publishable project this time so students can write a paper each year.
- Students are enrolled as exchange students (therefore must pay UCF summer tuition).

Research & Institutional Impacts
The PI had a longstanding connection with the researcher in Germany, but had stopped collaborating prior to gaining the IRES grant. This project helped restart the collaboration. UCF already has multiple research collaborations and a study abroad exchange agreement with the Technical University of Ilmenau, so the IRES program added another component to this existing university partnership.

Student Interviews
Case 8 was notably different from the other IRES programs in terms of the project structure. Rather than assigning each student an individual project, the 4-5 IRES students worked together on the same project all summer. Further, this project was continued across the years of the IRES program, so that each year built upon the work of the previous year. Part of the pre-travel preparation then, was to meet with the prior year's students to get up to date on the project status and receive training on the relevant software before traveling abroad. Additional support was provided by selecting one student from a previous year to join the team again as the team leader, giving some continuity to the project. Although the students in some years enjoyed working together, apparently the close-knit collaboration structure sometimes led to issues if there was team conflict.

It is also notable that the project was new to the PI and collaborating researchers in Germany, meaning that the IRES students had a lot of responsibility for reading relevant literature and making decisions about how to move the project forward. This resulted in the students developing insights into the nature of research related to open-ended problems and the need to ground their work in existing literature. One student did note that since the project was so new, and not necessarily within the existing expertise of the mentors (on both sides), the students sometimes felt that they had more responsibility than they wanted for determining project direction. Nevertheless, the participants for Case 8 reported strong support and mentoring from the collaborating researchers in Germany, describing a welcoming and encouraging atmosphere where they received regular feedback. These researchers also invited the students over for dinner and connected them with colleagues for networking opportunities.

Case 8 was also unique because the students were registered as exchange students at the local German university and received credit for their IRES program at their home university. This forced students to pay for summer tuition as part of their program, but it also provided additional support for them while they were abroad. They were able to use campus housing, cafeteria, laundry, and gym facilities and also get involved with student groups on campus. This led to some participants to form strong social connections with local students, although this did vary based on student initiative.

Several of the case 8 participants mentioned that the program schedule seemed too short to accomplish what they were trying to do in their project. This could be related to the new and exploratory nature of the project and/or the fact that the students needed to spend significant time reviewing literature to move forward. Several of the students did appreciate that the schedule left time for personal travel at the end of the program, which most participants chose to do. This resulted in personal growth for most students in terms of developing confidence in planning and navigating international travel on their own. The participants' career/future outcomes also tended to focus on a desire to work abroad or pursue more personal travel in the future.

Case 9: Southern University and Kwame Nkrumah University of Science and Technology (Ghana)

Title: U.S.-Ghana Collaboration Providing Opportunities for Global Research Activities on Sustainable Water Purification

Program Structure
- **Year of Participants:** Mostly sophomores and juniors
- **Student Selection:** Advertised in departments of biology, chemistry, and other environmental-related fields at several universities in the southern United States
- **Program Schedule:** 1 week in US, 6 weeks in Ghana, 3 weeks in U.S.
- **Pre-Travel Activities:** IRES is a 3-credit "Intro to Sustainability" course. Pre-travel, the course covers intro to Ghana, intro to the research project, and travel logistics.
- **Post-Travel Activities:** Last 3 weeks are spent in the U.S. writing the report for the course.
- **Student Deliverables:** Final Presentation in Ghana, Final Report & Poster in U.S., Submit to NSF Imagine Research conference and/or other conferences

In-Country Logistics
The PI travels with the students to Ghana for the first week they are there to help them get settled. The local university helps coordinate cultural activities for students, including visiting a palace, slave trading sites, and local musical performances. The students also visit the village in the northern part of the country that will benefit from the research project so that they can engage with the community. The students work in pairs to approach the same problem (water purification) from different angles and they are building on the work completed in prior summers. All of the students are part of the research group in Ghana that is focused on this project and are mentored by the faculty and graduate students in that group. At the same time, the students are taking the "Intro to Sustainability" course, taught by the PI, which includes weekly course activities and language practice.

Other Program Features
- The grant covers conference travel for any presentations based on IRES research and summer tuition since all students must register for the course during summer session.

Research & Institutional Impacts
The PI had previously collaborated with the researchers in Ghana, but not on this project (which they had already started). IRES helped expand his collaboration to this new area and has in general shifted his research focus to more environmental topics. He is now planning to apply for another IRES grant with these researchers on a different project and has also had several students from this university come to Southern to work with him as graduate students.

Student Interviews
LIMITATION: Only interviewed two participants and they talked about some different parts of the experience.

Case 9 followed a unique project structure where the students in the IRES program were all working on the same overarching project, but they were divided into pairs to work on specific portions of the project during the summer. The participants found this structure effective as they were able to feel ownership of their part of the project while also having support and collaboration. The project was housed within a lab group with faculty and graduate students at the host university which provided further support and mentoring for the IRES students and

continuity between years. The IRES students were from a variety of disciplinary backgrounds, which provided an interdisciplinary aspect to the program.

Case 9 was also notable in that the research tasks involved significant lab work as well as a field experience visiting the community the project aimed to support. Although both participants discussed the benefits of the lab work, the community visit was a highlight of the program. Being involved in a community-based project led both participants to discuss many complex issues involved in global engineering projects, especially the need for cultural awareness and community engagement in such projects. Both participants described learning in the form of perspective changes on topics such as international development, broader impacts of research, and the way Africa is often portrayed in Western contexts.

More than any other IRES program in this study, Case 9 included several planned activities to help orient students to the international environment. The students participated in cultural tours of sites in the local area, dinners with prominent people, and a language course, in addition to the fieldwork trip mentioned earlier. These activities along with the program schedule, where the students had one week together in the US before traveling, helped the students feel prepared for the international portion of the trip. One participant did suggest that more pre-travel preparation would have been helpful for the research, but that they felt prepared for the culture.

The Case 9 students had the opportunity to present the results of their research at a conference after they returned from the IRES program (paid for by the IRES grant). This post-travel activity was highlighted as significant by both participants as an opportunity to improve their professional communication skills and build their networks by making important connections that led to grad school opportunities. Both participants felt that participating in IRES was significant for their career outcomes in terms of gaining access to specific grad programs and developing skills necessary to succeed in grad school.