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US-Sweden Bioinformatics IRES: Investigating Engineering Students' Attitudes and Perspectives Throughout a 10-week International Research Program

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Abstract

The US-Sweden Clinical Bioinformatics Research Training Program is an NSF-funded International Research Experience for Students (IRES) program that aims to develop a diverse cohort of globally competent and engaged scientists/engineers that seek career opportunities and collaborators throughout the world. The program consists of a six-week preparatory virtual training series, a 4-day pre-departure symposium at the University of San Diego and a ten-week research program on site at the Science for Life Laboratory in Stockholm, Sweden. The focus of this paper is to examine student attitudes and perspectives during their time abroad through an analysis of blog entries.

In Summer 2021, six engineering undergraduates—three women and three men—participated in the inaugural program session. Over the course of the ten-week program, the students completed blog posts in response to four prompts related to their experiences, observations, and challenges. In this paper, we present a qualitative analysis of the student blogs using a hybrid deductive and inductive thematic analysis approach. Our findings span two primary categories: professional and personal.

Introduction

A recent consensus report published by the National Academies of Sciences, Engineering and Medicine shows that research experiences for undergraduate students advance students' technical and research skills as well as broaden participation in science technology engineering and math (STEM) fields [1]. As such, there is a need for the development of structured research programs that train students outside of traditional learning environments, such as in the classroom. The US-Sweden Clinical Bioinformatics Research Training Program is one such program that is aimed at broadening the participation of women and underrepresented minorities in bioinformatics research. This 10-week summer program gives students an exciting opportunity to work with research group leaders in Sweden on projects related to bioinformatics. Given that research programs have such an important role in student development, all research programs should strive for continual improvement from year to year. Part of this continual improvement should be the documentation and dissemination of best practices to help to continually improve not only individual programs but to create a resource that other program directors can learn from to improve their own programs. As such, a main goal of this paper is to synthesize and present research student's perspectives throughout a summer program through the qualitative analysis of blog posts written at numerous points during the program.

This paper builds off of previous work aimed at preparing students for this research experience and for their time abroad [2]. Specifically, a large focus for preparing students for success in their research project was to make sure they were prepared for the technical challenges they would face throughout the summer. Bioinformatics is inherently interdisciplinary, making it difficult to adequately prepare students with diverse academic backgrounds (computer scientists, biomedical engineers, molecular biologists…etc.). Given this, the program director designed pre-departure activities to prepare students with the technical expertise to succeed in their projects. In order to

assess student preparedness going into the program, a full external evaluation was conducted and is presented in this year's ASEE NSF Grantees Poster Session with the title, *US-Sweden Bioinformatics IRES Year 1: Program Development and Initial Lessons Learned*. The program's external evaluation was primarily a quantitative assessment using a Likert-scale questionnaire to assess various portions of the program. While our assessment provided valuable information, we felt that it was difficult to assess how students' perceptions shifted during the summer. As such, a qualitative analysis of student blog posts was warranted. Additionally, since the program assessment took place at the end of the program, we only obtained a 'snapshot' of student's perceptions – the analysis of student blogs over the course of the summer allows us to gather data on student perceptions in real time as they are working on their research projects.

Given that Faber et al [3] demonstrated that the assessment of student perceptions is critical for gaining an understanding of how the students are experiencing their growth, we decided to assess student perceptions of the research program through an analysis of 4 blog posts that students wrote throughout the summer. This paper presents a qualitative analysis of the student blogs using a hybrid deductive and inductive thematic analysis approach. Another goal with the analysis of these blog posts is to improve this program for future students and to share 'best practices' with directors of other domestic and international research programs.

Methods

Student Participants & Program Description

In the summer of 2021, 6 undergraduate students from primarily undergraduate institutions in southern California participated in the inaugural program. Students were selected through an open application process where eligible students applied through an online portal. In order to be eligible for participation, students were required to: 1) be a full-time undergraduate student at a primarily undergraduate institution in Southern California, 2) be a U.S. citizen or permanent resident, 3) have taken a bioinformatics (or related) course, and 4) be at least 18 years of age at the beginning of the program. The program director screened all applications and selected finalists, who were then presented to the host labs. The host labs then made the final selection of which student they would train over the summer. During the 2021 program, 3 women (2 industrial and systems engineering majors and 1 molecular biology major) and 3 men (2 computer science majors and 1 molecular biology/data analytics major) participated.

The program was broken into three parts. First, the program director ran a virtual training series for 6 weeks (weekly 90-minute Zoom sessions) covering introductory materials related to bioinformatics, the research institute in Sweden, and the research they would be conducting. Following the virtual training series, the students traveled to the University of San Diego for a 4-day pre-departure symposium to prepare for their trip and get to know each other. At the end of the symposium, the director and the IRES students traveled to Sweden together where the students worked in research labs at the host institute for 10 weeks. This paper focuses only on the qualitative assessment of student blog entries – please see [2] for more details on program logistics.

Blog Posts

Each week, two of the six IRES students wrote a blog post, expect for the last week, during which all students posted. Prompt 1 was spread over weeks 1-3, prompt 2: weeks 4-6, prompt 3: weeks 7-9, and prompt 4 was given during the final week of the program (Table 1). Blog post prompts were spread out over a three-week period so followers of the blog could read entries every week throughout the summer. Prompts 1-3 were based off of blog prompts from a previous study examining the development of global competence among IRES students [4]. The final prompt was written by the program director.

Table 1: Blog post prompts for the IRES students.

Timing	Prompts
Weeks 1-3	1.1 Give a summary of what you've been up to during the first week(s) of the program - include an update on your lab work as well as what you've seen when exploring Stockholm. 1.2 Additionally, address these questions in your response: during the first week(s), what is one trait/practice/behavior/way of life that you have observed in Sweden that is most different from your native culture/background? What was your reaction when you noticed this difference?
Weeks 4-6	2.1 Give a summary of what you've been up to since your last post. Make sure to comment on your lab work as well as what you've been up to in the city. 2.2 Additionally, answer the following: Since starting your research work, what is one significant challenge that you have successfully overcome? In your response, make sure you: a. Describe the challenge. b. Discuss what you have learned from this experience. c. Reflect on how this experience might help you in the future. d. Include at least one picture and aim for about 1-2 paragraphs.
Week 7-9	3.1 Give a summary of what you've been up to since your last post. Make sure to comment on your lab work as well as what you've been up to in the city. 3.2 Please also answer the following: Since starting your research work, what is one significant challenge that you have NOT been able to resolve? In your response, make sure you: a. Describe the challenge. b. Discuss what you have learned, or not learned, from the challenge. c. Reflect on how you will deal with this type of challenge in the future. d. Include at least one picture and aim for about 1-2 paragraphs.
Week 10	4.1 Reflect on your past 10 weeks in Stockholm (both professionally and personally): a. Professionally: describe what you have learned during your time in the research lab. b. Personally: describe your favorite thing about living in Stockholm as well as what you thought was the most challenging part of living abroad for the summer. c. Include a picture if you'd like.

Analysis

We used a hybrid deductive and inductive thematic analysis approach to analyzing the student blog posts [5]. Because the blog prompts were highly structured and specific, we used themes of interest from the prompts as a starting point for organizing the student responses. We then went through an iterative process of reading through the blog posts and seeing if they mapped well to the themes. We divided the blog prompts into two primary categories: professional and personal.

Within those categories, we grouped related blog prompts into themes. We analyzed the data and present it in this paper in the identified categories (professional and personal) and corresponding themes (Table 2). Pseudonyms are used for student participants.

Table 2: Categories and Themes Mapped to Blog Post Prompts.

Category	Theme	Prompts
Professional	Challenges Overcome	2.2 Since starting your research work, what is one significant challenge that you have successfully overcome?
	Challenges Not Overcome	3.2 Since starting your research work, what is one significant challenge that you have successfully overcome?
	Professional Reflection	4.1 Reflect on your past 10 weeks in Stockholm: a. Professionally: describe what you have learned during your time in the research lab.
Personal	Fun and Exploration	1.1, 2.1, 3.1 Give a summary of what you've been up to - include an update on what you've seen when exploring Stockholm.
	Cultural Observations	1.2 During the first week(s), what is one trait/practice/behavior/way of life that you have observed in Sweden that is most different from your native culture/background? What was your reaction when you noticed this difference?
	Personal Reflection	4.1 Reflect on your past 10 weeks in Stockholm: b. Personally: describe your favorite thing about living in Stockholm as well as what you thought was the most challenging part of living abroad for the summer.

Results

Findings Related to the 'Professional' Category

Theme: Challenges Overcome

The students described encountering and overcoming a wide range of challenges during their research experiences. For example, Dan described a challenge with applying his computer science experience to an area that is newer to him, and found working with a multidisciplinary and multicultural team helpful for solving problems and working effectively:

> *My degree is in Computer Science and while I have familiarity with bioinformatics concepts, actually putting this knowledge into practice is a new experience. However, working together in a team, I am able to accomplish more than I could alone. In my lab, I am working with another student from Portugal whose background is in genomics. It's a great experience to work as a part of a multidisciplinary and multicultural team. Our differences complement each other as we need both my lab partner's strength in biology/genomics and my strength in programming/computer science.* (Dan)

Later, Dan described this multicultural experience translating outside of the lab and going indoor rock climbing with the Portuguese student he met from the lab.

Jessica felt challenged by being "assigned the responsibility to ask hard, detailed specific questions to [a] group presenting an update on their research to ensure they're prepared for similar questions in the future." She described her feelings and success in meeting the challenge: "I was pretty nervous about it, but I was able to ask a few questions that led to a large discussion."

Kevin felt challenged by the task of "creating efficient and reproducible code that can be applied in multiple scenarios." He described this challenge with going beyond "simple data cleaning and data analysis" to "understanding how to simplify that code, make it more efficient and use it for other situations is challenging." His valued the opportunity to practice and stated that "there is no better way to become a better programmer than to keep working on projects like these."

Sarah described a challenge with creating cluster plots, which she overcame through collaboration and asking for help:

> *I overcame this challenge by speaking with Wu, another bioinformatician in my lab. He gave me some good pointers and advice on how to overcome this problem because he too had this issue when analyzing the data…This challenge will help me in the future because it helped me get comfortable with not knowing the answer and asking for help. It also helped increase my understanding of how to tackle larger problems that may come up. If it is too complicated in the beginning, stepping back and simplifying it will probably help. (Sarah)*

Jack's experience with working through coding errors also helped him develop perseverance and become more comfortable with failure:

> *This experience might help me on a personal level and not feel like a failure when something does not go my way. There will always be a roadblock when working with new software but by constantly thinking and setting time aside, a solution will arise."*

Kate felt that she went into the program without a strong background in coding, and said she was prepared for "a lot of me learning as I go. It was going to be a lot of trying and failing, then trying again... and failing again and that's been really challenging at times." She was relieved to discover that "often times there is someone else out there who has struggled with the same thing or [a] very similar thing before you," and found that "nobody expects everyone to know everything." In persevering through the not-knowing, Kate said, "I see moments of struggle and challenge that have (almost always) lead to feelings of accomplishment and satisfaction." This culminated in a valuable life-lesson for Kate:

> *"I think what I've taken away from that experience is that we shouldn't be afraid or ashamed of using the resources that are available to us whether it's a professor, mentor, co-worker, or google. It's important to remember that there are things that even people at the top of their craft are still learning and might need to ask for help on. In addition, I think this experience has reminded me that we shouldn't judge or criticize people that ask for help, especially if they are less experienced than you."* (Kate)

The underlying themes of challenges that the students described encountering and overcoming (participating in a group discussion, interdisciplinary application, not knowing the answer and asking for help, perseverance, and failure) have broad professional and personal value,

and it would be difficult to replicate the experience for students to meet these challenges in a classroom setting or in a research setting that is already familiar to them.

Theme: Challenges Not Overcome

The students also described challenges that they could not or did not overcome and the personal growth they experienced as a result of experiencing those challenges. For example, Dan described a difficulty in completing a study due to a "gap in knowledge," however he became comfortable with the unknown that he encountered and reflected that there isn't always a "right" answer:

> *While this may be a challenge with no apparent answer, missing this analysis does not necessarily mean the project is a failure. What we do have now is a groundwork for exploring…Coming from a purely academic background, there is always a "right" answer to a project/test/etc. When in the lab, this isn't necessarily the case. There isn't always going to be a 'right' answer. While this is neither good nor bad, it has been a good insight into the realities of lab work.* (Dan)

Jessica described a challenge with her coding skills, that while broad, she felt lacked depth in a specific language. Instead of asking for help with coding errors/issues, Jessica worked on *not* asking for help, and developing a comfort with trying to puzzle through things more on her own before asking for help, which found helpful to her development of critical skills applicable to any situation:

> *There are plenty of times when I receive an error and instead of immediately asking for help, I've practiced working through it myself and trying to exhaust all of my options before resorting to help. When I am given help, I try to ask questions to fully understand where I went wrong and the functions of the correct code. This research has helped strengthen my tenacity, patience, and problem solving skills that can be applied to any situation.* (Jessica)

Jack also encountered challenges and failures related to software and coding challenges, and found that though frustrating, they were valuable learning experiences:

> *After a week of just trying to get this running, I ran out of ideas since I kept getting error after error. It made my experience frustrating but made me realize that in research, not everything may go your way. There will be roadblocks and this is where you are tested. You can either give up or keep trying. This is a learning experience and the more I learn now, the better I can handle these types of situations in the future. If I ever create documentation for a program, I will make it possible for a 5 year old to understand how to install it.* (Jack)

Sarah struggled with focus and engagement, and ultimately discovered that a future in research is not for her. She specifically referenced the repetitive and slow-moving nature of some research, as well as sitting at a desk for most of the day:

> *One challenge that I have not been able to overcome is staying focused on my task or even just keeping interest in the topic at hand. Research can move slowly. A lot of things become repetitive, and sometimes I just don't have anything new to work on. I often have trouble staying focused when I just sit at a desk all day. It honestly makes me nervous because this aspect of the job can be common across all fields unfortunately. From this challenge, I*

have learned that I value a fast-paced environment that will present multiple challenges to me often. I will keep this in mind when conducting my job search in the near future. (Sarah)

Kate similarly struggled with focus and the desk-nature of her work: "One challenge that I find myself facing week after week is my patience and ability to stay focused while sitting behind a computer for most of the day." Kate also confronted the nonlinear nature of research work:

> *There have been periods of time where I've got a lot of stuff that I can do to help me move forward in my project and then all of a sudden I hit a roadblock or need to wait before continuing and everything seems to slow, even time. It's at these moments that I struggle. When things are moving at a slower pace than I'd like them to, it makes hard for me to focus, especially when I'm sitting at the computer. This has been educational and helped me realize that in the future I would ideally like to find a job that has a balance between the sedentary tasks at the computer, analyzing the data, as well as doing part of the job that is a little bit more active and physical (like being a part of the earlier processes such as the wet lab).* (Kate)

Both Sarah and Kate found things they did not like about the research experience, which were helpful in realizing what characteristics are important to them in their future work.

Theme: Professional Reflection

In their professional reflections, we noticed themes of collaboration and interdisciplinarity in the student writings. For example, Dan shared about this by writing:

> *I have learned alot about not only biology, but also how research is done, how to formulate a question that can be answered by data, and how to determine which results to include in a final report. What was most impactful professionally was the opportunity to see how my expertise in computer science could partner with science experts and together we could collaborate on a project, with each of us contributing our unique skills.* (Dan)

Jessica and Kate both expressed the importance of the welcoming lab environment, and for Jessica, having lunch as a lab contributed to that impression:

> *I think I had the best lab and they were all so welcoming. Our lunches were priceless because I could learn from their life experiences, while strengthening my bond with them. I like how collaborative research is and I look forward to incorporating that into more aspects of my life.* (Jessica)

Kate expressed appreciation for her coworkers and mentors as she confronted challenges during the program:

> *The past 2.5 months have really tested my patience and problem-solving skills at times because of [research not being linear and not moving at a constant pace]. During those times of struggle I was glad that I had coworkers and mentors surrounding me that were there to support and help me. I especially appreciate everything that my mentor has done to help guide me through my research project. I really couldn't have done anything this summer without him.* (Kate)

The students also reflected on failure and perseverance, and expressed that they experienced failures and had the opportunity to develop perseverance. For example, Jack wrote:

During my time in the research lab, I learned that failure is more common than usual. We always see the end results of the research but we never get to see the process. In our lab meetings, I realized I wasn't the only one who had setbacks. I saw firsthand how they reacted to the unexpected results but they kept trying. Being part of this lab, made me more perseverant. There were times where I wanted to give up because I could not get anything done due to technical issues, but I kept pushing and trying new methods. (Jack)

Jessica also described encountering challenges and obstacles, and reflected on her development of patience and tenacity:

Because of this experience, I think I've gained more patience and tenacity when faced with an obstacle. I also gained more security in doing things by myself and taking myself on adventures everyday. (Jessica)

For Jack, and other students, part of encountering challenges was learning to ask for help:

I also learned how to ask for help. Throughout my entire academic life, I have always kept to myself and tried to find a solution. After this experience, I realized asking for help is more beneficial, especially when I am surrounded by experts. By interacting with others, ideas are thrown around which I might have never thought of. (Jack)

Sarah also reflected on learning to ask for help, and finding support in return. Sarah was insecure about her coding skills, but realized that she could just ask for help if she got stuck. She felt the benefit of a positive and supportive learning community:

I wanted to impress my new lab, but I was not sure if I could meet their expectations. Well I had nothing to worry about because I think I had the most supportive lab in the world!

The students also reflected on gaining insights about the role they want research to play in their career. For some, the program strengthened an interest in research, while for others, they realized that they do not want to pursue research in their careers. Jessica expressed her interest in research: "This experience has been such a life changing experience! This research experience has confirmed my desire to go to graduate school." Conversely, Sarah expressed, "Overall, this program has taught me that while research is not for me, it is still good to get outside your comfort zone and try new things. There's nothing to lose!" Kate did not express whether she wants to do research in the future, but stated, "This opportunity was my first real research experience and one of my personal goals for the program was to learn more about what doing research full-time could be like and use it to help me make a decision about what I wanted to pursue after graduation."

Findings Related to the 'Personal' Category

Theme: Fun and Exploration

The students described a wealth of rich cultural experiences and exploring that they did outside of the lab, from visiting museums and parks, to venturing outside of Stockholm. They sometimes mentioned doing so with other students from the IRES cohort or the lab. We include several student quotes here that capture the sentiments of fun and exploration that were pervasive across their blog posts:

On Tuesday evening, the other IRES students and myself went out to dinner in Gamla Stan, which is Stockholm's "old town" where the city was founded in 1252. As a California native, it is an amazing experience to walk the streets and see buildings that were built in the 17th and 18th centuries. (Dan)

Outside of the lab, a group of us went to this food place called Bun Meat Bun after work on Friday and had burgers and milkshakes. We then went to the Ice Bar in the Stockholm Hotel and got to have fun and dance in very cold temperatures. I've really enjoyed wandering the city and taking pictures of the interesting architecture and places that we've visited. (Jessica)

Since my last post, I have sunbathed by the water, eaten more delicious Swedish pizza, shivered at an ice bar in central Stockholm, danced my way through the ABBA museum, and went back in time to see the viking way of life. My lab manager, Alex, hosted a small dinner party at her home. Her family treated our lab to a three course meal. It was a nice blend of traditional Swedish cuisine and classic American BBQ. Most significantly, I went on a weekend trip to Göteborg, Sweden. Göteborg is the second largest city in Sweden with lots of charm and things to do. The main difference I noticed is that since the city is not as big as Stockholm, everything seems to be within walking distance and life moves at a slower pace. (Sarah)

This past weekend I visited Gröna Lund, Stockholm's amusement park, took pictures at a garden near Vasastan, and also got some great views of Stockholm from Mariaberget. I also traveled to Gröndal with some friends that I met at KI for a cheese tasting night. On Wednesday I had the opportunity to visit the Huddinge Hospital once again to see how our lab group collects and performs biopsies on our research volunteers. I ended the week with a lab dinner at Minh Mat, where I was able to try frog legs for the first time! (Kevin)

Outside of work, I've enjoyed what Stockholm has to offer. I visited the Royal Palace that was built in the 1600's and saw the amazing art inside the palace. I also went to the Tekniska Museet which is the technology museum. It was fascinating to see the amazing exhibitions, especially "Moving to Mars" and "Hyper Human". They really make you think about the potential humanity has to offer in the future. One fun activity that I wanted to do in Stockholm was go kayaking and I finally did it. We went kayaking around Vaxholm and it was an experience I won't forget. (Jack)

Theme: Cultural Observations

Dan observed a cultural difference between the U.S./Sweden in the attitude towards workday lunchtime. While the notion of a 'working lunch' (i.e. lunch at the desk) is commonplace in the U.S., Dan noted that "this does not happen in Sweden." Dan reflected on the lunchtime practice of stepping away from work and enjoying some social time:

This was a pleasant surprise, especially as a new person in the lab. This lunch hour allowed me to meet and interact with some of the other people in the lab, in a social setting and to start to feel like one of the group even if just a temporary member. (Dan)

For Sarah, a similar sentiment stood out to her that was also captured by the Swedish word 'lagom' which she translated as "just the right amount." In her words:

> *I like this phrase because it reminds me to make sure there is a balance in my life. To do everything in moderation and to not stress over small things that won't matter by tomorrow. To make sure I have a productive day at work but be sure to sit back and take a break when wanted.* (Sarah)

Jessica noted "the balance between large city vibes and nature, scenic environment" in Stockholm, and observed a cultural difference in spending time in and caring for parks:

> *There were a bunch of people having picnics and hanging out with their friends and families in the many parks in the city. In San Diego, I feel like we neglect our local parks and don't normalize having lunch or picnics with our friends and coworkers as much as they do out here.* (Jessica)

Sarah also noted the nature and her enjoyment of the flowers and trees on her walk to work, as well as the 'mix of modern and classic architecture.' She noted a cultural difference in terms of transportation, with an emphasis on "bikers, walkers, people who ride scooters and subway riders [in Sweden]. Basically everything except a car." She reflected that, "Sweden has a lot more pedestrian-friendly infrastructure than we do in the States. For that, I am jealous. I enjoy walking, biking, and riding the subway so this city is right up my alley." Kate similarly reflected on Stockholm's "very pedestrian friendly layout" and said, "you can see how the city was really built around public transportation like metro stations. However, I have been surprised to see mopeds and other motorized vehicles, other than electric bikes and scooters, take up space on the sidewalks."

Jack was struck by a cultural difference in the approach to going to college. He felt that "in the US, that is considered the top priority in high school and usually, it is a must for everyone. Everything is built to prepare you for college and they expect you to start college as soon as you finish high school." However, in Sweden, he noted that:

> *It is not as common to go to college once you are done with high school. Many take a gap year or a few, depending on their situation. During this break, they work to save money or explore their interest before they make a final decision in applying to their desired program. I was surprised when I found out about this because I thought college had the same priority around the world. I hope to continue to learn more about Sweden throughout my stay here. (Jack)*

The students also made smaller observations about cultural differences, like how Americans wear bike helmets, while many Swedes instead wear a Hövding around their necks (Kate), or an observed lack of toilet seat covers in Sweden (Kevin). Each of these reflections captures the nonstop learning and observing that takes place when one visits a new culture, where everything from the scenery to the bathroom supplies are new and different.

Theme: Personal Reflection

For most students, this program was their first experience being this far away from home and for this long. And, the program took place in the midst of a global pandemic. The students struggled with homesickness and cultural challenges. In Dan's words:

> *Personally, Stockholm is the farthest I have ever been away from home and even though I am not here alone, it was still mentally challenging to pack a suitcase, fly across an ocean, and live and work in a completely new place in the midst of the global pandemic. I came over prepared for some homesickness about the "big" things (missing friends, family, etc.), but I didn't realize how much home sickness there can be about small cultural differences. For instance, some grocery items may be in different packaging than in the US (i.e. box vs. can). Since the accommodations came with a kitchen I did a lot of cooking and finding spices the first time around also proved to be challenging. In those moments, these minor differences seemed more difficult than they were, contributing the most to any homesickness I felt.* (Dan)

In some cases, the homesickness got better over time, like for Kevin, who reflected, "Being away from friends and family is difficult, but it is something that you can get used too after settling in." Others found coping strategies to deal with waves of homesickness, like Sarah who wrote, "I am starting to feel a little homesick, so to help with that, I went to a cafe that served traditional American pancakes. They were pretty tasty and it felt good to get some time to relax a bit."

The students also felt challenged by cultural differences experienced during a long stay away from home. For Jack, one way this manifested was through not having the same food he is accustomed to at home:

> *The most challenging part about living abroad is the food. From eating fresh meals everyday to meal prepping to save money and time is very difficult. Part of the challenge was learning how to cook and what to cook. Also since all the food was labeled in Swedish, it was difficult to navigate the grocery store and look for items. Without google translate, it would be almost impossible to get the right item.* (Jack)

For other students the disruption to their 'normal', familiar routine was most challenging. In Sarah's words:

> *The most challenging part about living abroad is changing your routine and having to adapt to the local way of life. There were times when I wished I could just stop at a Target or go to Trader Joe's for my favorite snack. Those stores do not exist over here obviously so I had to find new favorites.* (Sarah)

Kate similarly expressed this sentiment by saying things were always 'a little uncomfortable:'

> *I think the most challenging part about being abroad for so long has been missing some of the little things back home and always being a little uncomfortable. Being in Sweden I've had to change some of my normal habits and kind of create a new routine, which is always hard to get into. I'm looking forward to being able to get back on track when I get back home and surround myself with the comfort of friends and family and my favorite things that I haven't been able to find/do here in Sweden.* (Kate)

Contrasting homesickness and discomfort was student expressions of cultural appreciation and gratitude for the opportunity to live and work abroad for the summer. Visiting a foreign place in this context allowed the students to reflect on the new place and consider their home place and culture. The students reflected on the beauty of Stockholm, the architecture, the public parks, and often contrasted their descriptions with reflections about San Diego:

Stockholm is a beautiful city with a deep history that blends both municipality and nature beautifully. I am very thankful to have had the opportunity to experience the beauty of Skogskyrkogården and marvel at the age of the Vasa. The public transit system is much more robust than it is in San Diego, which makes travel around, and even out of, the city easy and extremely affordable, especially when compared to the cost of services like Uber. (Dan)

My favorite thing about living in Stockholm is seeing the beautiful architecture mix with the surrounding water. Everywhere I would go, there would be a different style of architecture which made the experience new every time. Attached to these, there was always a story behind every building. Stockholm also has a diverse culture so we were able to meet different people from all around the world. (Jack)

My favorite part about living in Stockholm has definitely been the modes of transportation. I really enjoyed walking to work pretty much every day with Kate and taking the metro. I don't get to do this when I am in San Diego so I am glad I took advantage of it. The only thing that could have made it better is if I had a bike. (Sarah)

Discussion

The students were impacted by the program both personally and professionally, and encountered challenges both personally and professionally. The students overcame some of the challenges, cultivating perseverance and failing forward, while they could not or did not overcome others (cultivating familiarity with the unknown, unsolvable and nonlinearity). The analysis of blog entries revealed attitudes and perspectives that were not identified in the formal external evaluation process. This suggests that personal narratives posted on a publicly available domain allows program directors to gain insights into student experiences that are difficult to gather in a more formal setting. The identification of these attitudes and perspective in the blog could have resulted for a variety of reasons, but the authors hypothesize that it could stem from one of two reasons. Firstly, when students are given a creative and public outlet, such as blog writing, to document their experience, they are potentially more honest. Since this blog was public, students were writing to their friends and family back home, which could lead them to writing about topics they would not write about otherwise. Secondly, the blog posts were written throughout the summer, so we were able to examine student perspectives while they were actively working on the project. Gathering student perspectives in 'real-time', as opposed to at the end of the program through the external evaluation, allows one to gather insights at numerous times throughout the summer. Additionally, responding to prompts during the summer does not rely on students reflecting back on the experience as a whole, which could distort their perspectives.

The analysis of these blog posts revealed the value and importance of international research experiences in the development of 21st century engineers prepared to practice in diverse and global contexts. Throughout their blog posts, many of the students mention how exciting it was to be working in an international lab where they were able to interact with researchers from all over the world. Learning how to communicate with people from outside of one's home country is a vital skill that is critical for success in today's globalized world. Understanding how to communicate with people who do not share your native language and knowing how to navigate different cultural norms helps an individual work effectively with and manage a muti-national/cultural team. Learning how to do this can be difficult, but these skills are easily developed while living abroad

and it has been previously shown that students studying abroad improve their cultural sensitivity [6]. Most everyone in the laboratory and on the street were not from the U.S., so the students were able to develop their intercultural skills both in and out of the lab, which is a prominent theme in the blog posts.

The analysis of these blog posts is part of the continual improvement that we strive for in the IRES program and can also be used as a model for other programs. Using blog posts to learn about student experiences is helpful for the program director to prepare future cohorts of IRES students. Learning from past IRES student experiences, the program director can tailor the pre-departure activities to highlight common issues students had during the summer. For instance, a few students mention that the work can be hard to focus on at times, which can be common in any line of work, but this could be a new feeling for students. With this new insight from the blog posts, the program director is now able to coach the next cohort of students on how to remain productive when concentrating is difficult. Additionally, since the posts are public, new IRES cohorts can read the blog posts prior to departure to get the 'student perspective' of working and living abroad for 10 weeks, which could ease any anxieties the students may have. For instance, if the students are worried about being homesick, there are various ways in which the IRES students wrote about in their blog to help them cope with being far from home for so long. Additionally, reading the blogs from previous IRES students could better prepare future cohorts for the research program if they read about the strategies that other students employed to get their work done – i.e. asking for help is ok! Finally, the blogs can be used by future students as a source for fun activities to do outside of lab while living in Sweden. Prior to departure for the host site, there is only so much knowledge the program director can impart on the students, so blog posts can be an effective resource for students to see the perspectives of their peers. Given this, other directors of comparable programs, and even directors of domestic undergraduate programs, are encouraged to have their students document their research/personal experiences during the program.

Although it is important to prepare students with an adequate technical training, they must also be emotionally prepared for scientific research. In particular, students must be prepared for encountering challenges and know that they may fail to overcome difficult roadblocks. Having worked in academia for over a decade, the program director has become accustomed to the fact that setbacks in research are commonplace. As a result, emotionally preparing students for failure was not a main focus of the pre-departure activities. In the process of examining the blog posts, however, the program director recognizes that preparing students to face obstacles in their projects is necessary. As previously mentioned, these types of observations were not present in the more formal external evaluation of the program – this demonstrates that to ensure continual improvement to research experiences, research program directors should have a variety of avenues through which to document student perspectives *during* the program and not just at the program's conclusion.

On a final note, the blog entries underscore the importance of pairing students with supportive and welcoming mentors and labs. A solid support network of professors, postdoctoral scholars and graduate students is necessary for a student to have a positive research experience. All students mention the supportive and nurturing environment of their labs in their blog posts as well as in our external evaluation data. In order to ensure that students would have a welcoming research environment, the program director vetted potential principal investigators (PIs) primarily by

assessing the PI's willingness to mentor a student and the PI's previous mentorship experience with undergraduate students. Once PIs were identified, the program director made sure that PIs had a concrete project description, a clear role for the undergraduate researcher and a mentor in the lab that the student would work directly with (in cases where the PI would not be involved in day-to-day mentorship responsibilities). This type of oversight by a program director is necessary for students to have a positive experience.

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