

Board 245: Description, Assessment, and Outcomes of Several Interventions within a National Science Foundation Research Traineeship (NRT): Graduate Certificate, Field Trips, Internships and International Experiences

Dr. Eduardo Santillan-Jimenez, University of Kentucky

Dr. Eduardo Santillan-Jimenez is PI and project coordinator of a National Science Foundation Research Traineeship (NRT) program designed to enhance graduate education by fully integrating research and professional skill development within a diverse, inclusive and supportive academy. Originally from Mexico, Dr. Santillan-Jimenez joined the University of Kentucky (UK) first as an undergraduate research intern and then as a graduate student performing his doctoral research at the UK Center for Applied Energy Research (CAER) and at the University of Alicante (Spain). After obtaining his Ph.D. in 2008, he worked as a postdoctoral fellow at Utrecht University (The Netherlands) prior to returning to UK, where he now holds the positions of Program Manager at CAER and Adjunct Assistant Professor at the Department of Chemistry. His current research focuses on the application of heterogeneous catalysis to the production of renewable fuels and chemicals, with emphasis on the upgrading of algae and waste oils to drop-in hydrocarbon fuels. His synergistic activities include participating in a number of K-20 educational initiatives designed to increase and broaden participation in STEM fields.

Carissa B. Schutzman, Ph.D., University of Cincinnati

Dr. Carissa Schutzman is a Senior Research Associate for the University of Cincinnati Evaluation Services Center. In 2020 she joined the Center where she leads evaluation and research projects and actively represents the ESC within the university and the

Keren Mabisi

Keren Mabisi is a Junior Research Associate at the University of Cincinnati, Evaluation Services Center. As an external evaluator, she utilizes quantitative and qualitative methods on various NIH, ESF, NIEHS and SEPA funded projects. She obtained a Master

Apala Biswas, University of Cincinnati

Description, assessment, and outcomes of several interventions within a National Science Foundation Research Traineeship (NRT): graduate certificate, field trips, internships and international experiences.

1. Introduction

The University of Kentucky (UK) NRT envisions enhancing graduate education by integrating research and professional skill development within a diverse, inclusive, and supportive academy. To this end, this NRT is striving to generate an innovative model for STEM graduate student training by identifying and implementing the most effective tools for the preparation of STEM professionals. The general structure of this NRT has been described in a previous contribution [1]. A follow-up manuscript has described the first three interventions within the NRT, namely, an onboarding and orientation event, a career exploration symposium, and a multidisciplinary introductory course, along with the assessment and outcomes of each of these interventions [2]. A third manuscript has presented three additional NRT components, i.e., a transferable skills course, an interdisciplinary research proposal and project, and a multidisciplinary research symposium, as well as their assessment and outcomes [3]. In a similar vein, this contribution describes several additional interventions within this NRT – a graduate certificate, field trips, as well as internships and international experiences – and discusses the assessment and outcomes of each of these interventions.

2. Description of three interventions within UK's NRT

2.1. Graduate certificate

Under the auspices of its NRT, a graduate certificate on Innovations at the Nexus of Food, Energy & Water Systems (INFEWS) – which is the research topic of the traineeship – has been established at UK. This graduate certificate aims to 1) impart both conceptual and technical knowledge related to INFEWS to students; 2) provide them with training on key transferable skills; and 3) equip them to consider the societal, cultural, behavioral, and economic aspects of research on the food, energy, and water nexus. The starting point of the certificate is a multi-departmental and interdisciplinary course on INFEWS that has been described in a previous contribution [2]. In a subsequent semester, students receive training on key transferrable skills in a course designed to integrate these skills with content covered in the foregoing INFEWS course. This transferable skills course has also been described previously [3]. Completing these core courses gives students 6 of the 12 credit hours needed to attain the certificate. Students earn the other 6 credits by choosing from a list of elective courses, which includes multiple courses fulfilling both the certificate and their degree requirements. Notably, several of these courses equip students to consider the societal, cultural, behavioral, and economic aspects of research on the food, energy, and water nexus. Since the INFEWS and transferable skills core courses can also fulfill both certificate and degree requirements (e.g., they can satisfy out-of-department and seminar course requirements, respectively) the anticipated time-to-degree of trainees is not extended by their pursuit of the graduate certificate. The full list and short description of the core and elective courses comprising this graduate certificate can be found on the coursework page of the UK NRT website [4].

2.2. Field trips

Field trips to facilities related to INFEWS operated by organizations and personnel both inside and outside academia have not only exposed them to various work locations and career paths, but have also helped foster a sense of community among trainees. To date, sites visited include:

- Robinson Forest: a teaching, research, and extension forest administered by UK.
- E. W. Brown Station: a site owned and operated by Kentucky Utilities comprising a coal/natural gas power plant, a solar farm, a hydroelectric plant, Kentucky's largest battery, and a carbon capture demonstration.
- AppHarvest Farm in Morehead, KY: a 60-acres controlled-environment vertical farming facility dedicated to the hydroponic production of tomatoes.

Logistically, these field trips are organized at times that avoid conflicting with graduate student coursework and teaching duties, such as spring or fall breaks. Transportation to the field trip site and back is provided from a central location on UK's campus, with lunch being provided at the field trip location. The latter gives trainees the opportunity to interact with and get to know one another as well as personnel working at the site being visited.

2.3. Internships and international experiences

While internships at the types of organizations best aligned with their career interests further expose trainees to various work sites and career paths, international experiences help them gain a global perspective and appreciation for the international nature of STEM research. To date, 5 trainees have participated in domestic internships and 8 trainees have had an international experience. Domestic internships took place in government agencies, startups, and nonprofits. International experiences allowed trainees to visit, work, and attend summer school in universities, nonprofit research institutes, and international education facilities, as well as to present the results of their work at international conferences held abroad. Logistically, most of these opportunities took place over the summer to avoid conflicts with graduate student coursework and teaching duties. NRT funds were typically used to cover the cost of these trips, albeit in some instances the international hosts covered the costs. It is important to note that most trainees participating in these opportunities did so while being supported by fellowships awarded by the NRT, which made things easier for trainees from a financial standpoint.

3. Assessment and outcomes of three interventions within UK's NRT

The University of Cincinnati Evaluation Services Center (UCESC) serves as the external evaluator of the UK NRT. The evaluation of the UK NRT is a cohort-sequential design with retrospective and concurrent comparison groups that includes both formative and summative activities. Evaluation is designed to support continuous program improvement and to generate resources to improve graduate student training. Student pre-surveys, post-surveys, and follow-up surveys were created to assess the success of the training model, student competencies, and perceptions of inter/transdisciplinary skills, all of which are related to the graduate certificate. A series of demographic questions is included only in the pre-survey, and a series of questions related to trainee satisfaction with academy components, a self-assessment of skill levels, and general program satisfaction is included only in the post-survey. Reliability coefficients (internal consistency among items expected to measure the same content) were calculated using

Cronbach's alpha. Alphas of 0.70 or greater are considered acceptable, with higher values denoting greater reliability [5]. Most of the scales in the surveys had an acceptable level of reliability ($\alpha \geq 0.70$).

Quantitative data analysis and practices included data quality checks, assessment of survey scale and subscale reliability estimates, and descriptive statistics to reveal basic data patterns. Data distributions were described with descriptive statistics. Frequency counts and percentages or means and standard deviations were used depending on the measurement level of scales, subscales, and items. Univariate paired t-tests were also used to test statistically significant differences between mean values at pre- and post-survey and at pre- and follow-up survey. SPSS 27 was used to conduct these analyses.

3.1. Graduate certificate

Components of the graduate certificate have been assessed individually; however, the assessment of the graduate certificate altogether is comprised of several measures including a pre-survey, post-survey, follow-up survey, trainee focus group discussions, competency assessments, and student dossiers. The confluence of the graduate certificate components (e.g., required core courses, transdisciplinary electives, graduate research, etc.) aims to prepare graduate students for a workforce – in academia, industry, government, or nonprofits – that requires transdisciplinary problem solving both locally and globally.

Results of Cohort 1 are reported here since the data set includes all three time points, specifically pre-survey to follow-up survey. When comparing Cohort 1 trainee baseline and follow-up results, all four subscales within the Research Self-efficacy scale showed statistically significant increases. Cohort 1 trainees reported statistically significant positive changes in Conceptualization (mean change=15.6; $p<0.001$), Implementation (mean change=14.2; $p<0.01$), Early Task (mean change=9.8; $p<0.05$), and Presenting the Results (mean change=15.5; $p<0.001$). This change suggests that as Cohort 1 entered their second year in the program, there was an increase in their confidence to complete several research tasks. In addition, statistically significant increases were observed for the subscale Showing concern/interacting with the team (mean change=0.6; $p<0.05$) within the Leadership skills scale. While not significant, 3 out of 4 of the other subscales, Participative Decision-Making, Coaching, and Informing all showed increases from baseline to follow-up (mean change=0.4, 0.2 and 0.1 respectively).

A focus group protocol was created for NRT participants and was designed to include discussion topics related to experiences with the INFEWS graduate certificate and suggestions for program improvement. The student focus group protocol consisted of eight questions that covered topics such as program activities, student satisfaction, program contribution to student learning, development of interdisciplinary skills (e.g., teamwork, leadership), research proposal development, and program strengths and opportunities for improvement. The focus group with Cohort 1 was conducted in person and was video and audio recorded. A team of two evaluators from UCESC conducted the focus group with one facilitating the focus group discussion in person while the other evaluator attended virtually through Zoom and took notes. The Cohort 1 trainee focus group lasted approximately 30 minutes. The recorded sessions were transcribed and coded using MAXQDA 2020. Qualitative data from the focus group were thematically coded

and analyzed to identify emerging patterns. The coding process was guided by the evaluation questions.

During the focus group, Cohort 1 students reiterated the importance of interdisciplinary research to their development as researchers and problem solvers. They felt that their connections with people in other disciplines had contributed positively to their graduate experience both professionally and personally. Students also valued interaction with trainees and faculty. While not directly citing the graduate certificate, students spoke about how the components of the certificate were contributing to their successes. One student shared that they were currently applying for jobs, and they had included the transferrable skills course in their resume and provided examples of how they had demonstrated skill attainment: *“I’m looking for a job right now, and I was able to list that as I was trained. It’s been extremely helpful.”* Another Cohort 1 student commented that the transferable skills and the interdisciplinary aspect of the NRT had prompted a conversation in which a potential employer emphasized the need for such skills: *“He’s just like ‘that’s really major right now that you already understand trying to connect with other people from different backgrounds and different perspectives to work together to try to get something done’.”* When Cohort 1 students were prompted to reflect on what additional supports to promote development in inter/transdisciplinary research they needed, training on computational and IT skills was mentioned.

3.2. Field trips

Field trips were evaluated through both the quantitative and qualitative data collection and analyses as described above. Students in Cohorts 1 and 2 reported being Satisfied to Very Satisfied on a four-point scale with the field trips organized through the program: Cohort 1 (mean=3.1, SD=0.69) and 2 (mean=3.5, SD=0.52). Faculty completed a pre-survey and post-survey for which the questions were similar to the student questions regarding program satisfaction. The field trips were valued by program faculty who reported on the survey being Satisfied to Very Satisfied on a four-point scale (mean=3.7, SD=0.49). In separate focus groups, faculty and students remarked on the *“unique learning experience”* that was offered and the chance for students to create a sense of belonging among their peers. One trainee further remarked that it was, *“an opportunity to both learn how and participate in making a positive impact.”* Students’ only recommendation for improving the field trip component of the traineeship was for the latter to offer more field trips.

3.3. Internships and international experiences

Internships were primarily evaluated through surveys and focus groups as described above. Cohort 1 trainees in the follow-up survey of NRT component satisfaction were Satisfied to Very Satisfied on a four-point scale with Inter-departmental Internships (mean=3.0, SD=0.71) and with External Institution Internships (mean=3.3, SD=0.96). Cohort 2 trainees in the post-survey of academy component satisfaction were Dissatisfied to Satisfied on a four-point scale with Inter-departmental Internships (mean=2.8, SD=0.50) and with External Institution Internships (mean=2.3, SD=0.58). Since Cohort 2 completed the post-survey at the end of their first academic year in the program, it is reasonable to assume that Cohort 2 students had limited or no experience with internships related to the NRT. The scale did not provide a “not applicable” response choice. Faculty who responded to the post-survey of academy component satisfaction

were Satisfied to Very Satisfied on a four-point scale with Trans-departmental Internships (mean=3.5, SD=0.58) and with External Internships (mean=3.0, SD=1.22).

In addition to internships, students had a varied range of international experiences including opportunities for taking courses, attending conferences, presenting research proposals, and getting exposure to new research ideas. Several students participated in a focus group where they were asked to describe their experience, discuss how it related to the traineeship, describe how it impacted their inter/transdisciplinary skills (e.g., collaboration, leadership, teamwork, etc.), as well as to describe what additional support and resources might be needed. Some participants enrolled in courses, mostly interdisciplinary, that broadened their perspectives and contributed to their existing research interests. In addition, several other participants informed that they had the chance to present their own research at international conferences, seminars, and universities. From the data gathered in the focus group interview, it was apparent that students appreciated the opportunities of encountering new ideas and different cultures outside of the U.S., experiencing inter/transdisciplinary education, and making connections with people in international settings.

3.4. Main themes emerging from the data

- Making connections with people assisted in future learning and research endeavors. One of the recurrent themes emerging from the focus group interview was the benefits obtained through networking and making connections. The participants were vocal about how their own research was enhanced after connecting with people in and outside of their respective fields, as one participant commented: *“So, I met a lot of people that are, you know, still in the field of ecology. But they're doing vastly different things than I am.”* Not only did the networking opportunities help trainees discuss research, but also gave participants the chance to work on their research with faculty members from other universities. As one participant stated: *“I ... was able to make a ton of contacts with other faculty from both in the States and internationally. They're actually helping me with some dissertation work now.”* A couple of students mentioned the importance of collaboration, especially in scientific studies, and how the NRT provided them with opportunities for international collaborations. Furthermore, the students also acknowledged that the international experiences prepared them to better understand and deal with other peoples' views.
- Interdisciplinary experience facilitated further learning and research. The participants in the focus group recognized interdisciplinary experience as a significantly valuable tool for promoting further learning and research. The interdisciplinary experience helped the students to learn a lot about other external topics. It also fulfilled several participants' purpose to be involved with the program. This interdisciplinary experience also exposed students to research topics outside of their fields and opened new avenues for future research, as one participant commented: *“So, I would say that the [international] class that I took kind of gave me a larger overarching picture of the water sector, and how my research can eventually be used to ultimately help people.”* Additionally, the participants admitted that engaging in interdisciplinary discussions with people from different fields aided them to create meaningful and useful connections.

- Opportunities for attending and presenting at conferences encouraged new learning and discussion around research. The participants were vocal about the benefits of attending and presenting at international conferences. To begin with, they said this experience taught them how to attend and build a network at a conference setting with like-minded people. One participant commented: *“How to figure out really what you want to learn and take away from the conference and find the people that you want to talk to, was my big, big takeaway.”* Through this new learning, the networking skills of participants increased because they had opportunities to talk about their research with many people outside of their field and build a strong connection. Also, according to the participants, this experience enlightened them about the techniques and styles of presenting at a conference and communicating their research with a broader audience, which could be useful to them in the future. One participant shared: *“To figure out what works and what doesn't work was incredibly beneficial, as I'm going to another conference in November.”* In addition, these opportunities inspired the students to attend future international conferences and actively look for relevant opportunities.
- Exposure to new ideas and cultures outside of the U.S. proved to be a valuable resource for the students. A frequent topic among the participants was the experience of encountering new ideas and cultures outside of the U.S. The participants were appreciative for the opportunity to work with people coming from diverse cultural and academic backgrounds and shared that it was a meaningful experience that broadened their perspectives. They admitted that working and learning experiences in the U.S. could be very self-centered, but the international experience made them realize there are a lot of interesting phenomena to consider around the world. One participant addressed this experience as “*a wake- up call*” and a “*humbling experience*.” The participants were also very enthusiastic about the new cultures they encountered in the international surroundings, as one participant commented: *“It is really nice to learn about other cultures and see kind of what's out there in the different ways that people think, and the different ways that people go about their scientific research and endeavors.”* While sharing their international experiences, several participants talked about the differences between the U.S. and other countries. They compared several aspects including the public-private partnerships, public involvement in environmental issues, and Ph.D. programs abroad. One participant was really interested in public-private partnerships in the water sector. Another participant, while sharing their major learning from the experience, talked about how they were encouraged to ensure the public in other countries becomes involved in environmental assessments. One participant commented on how the Ph.D. programs outside the U.S. were different and how that encouraged them to apply for a Post Doc outside of the U.S.
- The participants mentioned some challenges associated with payment, reimbursement, and advertising. When asked about how these traineeship components could be improved, the participants mentioned advertising and shared several issues associated with payment and reimbursement associated with travel. Indeed, students provided suggestions about promoting some of these NRT components to more students. According to the participants in the focus group, there should be more resources and media outreach to encourage more students to seize these opportunities. A few trainees who traveled abroad shared their experience of facing problems with payments, such as a bank transfer required by an institution in Europe, which UK could not pay. They suggested that the payment system should be made easier. Moreover,

some participants also expressed concerns about reimbursements. Though the participants were satisfied with the reimbursement they received after their return, they also commented on how many students might be discouraged by the need to pay upfront.

- The participants appreciated the support from the PI and the UK NRT. The participants acknowledged the overall support they received from the traineeship and the PI. Several participants admired the dedication and effort of the PI and appreciated how they helped the participants to organize and prepare for the conferences. The participants also received support from the traineeship while travelling abroad; they expressed that they expected it to be a lot of trouble and paperwork as a student, but they received adequate support from the NRT itself to make their travel arrangements easier. The students contrasted the support provided by the UK NRT with the challenges of navigating their own department's policies and processes.

4. Conclusions

By sharing a description of several interventions within the UK NRT – namely, a graduate certificate, field trips, as well as internships and international experiences – as well as details about their evaluation and their outcomes, this contribution intends to inform practitioners interested in similar training programs and experiences of the challenges and opportunities associated with this kind of initiatives. Thus, the overall objective of this report is to inform and assist the higher education community in its pursuit to identify and implement the best and most effective practices of graduate student training.

Through surveys designed to evaluate the Graduate Certificate established by this NRT, trainees showed statistically significant positive changes in all four subscales within the Research Self-efficacy scale – i.e., Conceptualization, Implementation, Early Task, and Presenting the Results – as well as in the subscale Showing Concern/Interacting with Team within the Leadership skills scale. In a focus group, students remarked on the importance of inter/transdisciplinary research to their development as researchers and problem solvers and opined that their connections with people in other disciplines contribute positively to their graduate experience both professionally and personally. When asked about what additional support they needed to promote development in inter/transdisciplinary research, students mentioned training on computational and IT skills.

In surveys designed to assess the field trips organized through the NRT, both students and faculty reported being Satisfied to Very Satisfied. In separate focus groups, faculty and students remarked on how these trips offered not only a “*unique learning experience*” but also the chance for trainees to create a sense of belonging among their peers. The only recommendation students offered for improving the field trip component of the NRT was for the latter to offer more field trips.

Through surveys designed to evaluate the trans-departmental and the external institution internships, both trainees and faculty reported being Satisfied to Very Satisfied with these components of the NRT. From the focus group held to assess international experiences, it was

apparent that students appreciated the opportunity of encountering new ideas and different cultures, experiencing interdisciplinary education, and making connections with people in international settings. Several themes emerged from the data acquired, including how making connections with people assisted in future learning and research endeavors, how interdisciplinary experiences facilitated further learning and research, how attending and presenting at conferences encouraged new learning and discussion around research, and how exposure to new ideas and cultures outside of the U.S. proved to be a valuable resource. Finally, trainees mentioned challenges associated with payments and reimbursements for those participating in international experiences and suggested the latter to be better advertised. Finally, the trainees expressed their appreciation for the support they received from the PI and the UK NRT.

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