The Impact of International Research Experiences on Undergraduate Learning

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1.0 Introduction

This paper compares the learning outcomes for students participating in domestic and international research experiences. This question is important given that science and engineering (S&E) research is increasingly collaborative and international in scope with research teams comprised of faculty and student researchers in multiple countries. The NSF reported in its 2014 Science Indicators that 24.9% of science and engineering papers published worldwide in 2012 were internationally coauthored; for science and engineering papers published in the U.S. for the same year, 34.7% were internationally coauthored. This is an increase from 1997 values of 15.6% and 19.3%, respectively.[1] In its 2011-2016 fiscal year strategic report, the National Science Foundation (NSF) identified as one of its key performance goals to "[k]eep the United States globally competitive at the frontiers of knowledge by increasing international partnerships and collaborations." The plan stated further that "[a]s S&E expertise and infrastructure advance across the globe, it is expected that the United States will increasingly benefit from international collaborations and a globally engaged workforce leading to transformational S&E breakthroughs".[2]

Given the increasingly global, collaborative nature of S&E research, this indicates that students interested in pursuing graduate education and academic positions within the field should become acclimated to communicating and working with researchers from different cultural backgrounds. This suggests the importance for students to gain international experiences that prepare them to effectively collaborate with international teams of researchers. In response, U.S. universities are experimenting with new curricular methods, including the development of international programs designed for S&E students, to foster the development of skill sets necessary for successful international research collaboration. However, limited research exists that comprehensively assesses globally focused outcomes associated with such efforts in order to answer the question of whether international programs for S&E students are effective in meeting these goals.

In this paper, the researchers compare the experiences of students participating in two Research Experiences for Undergraduates (REU) programs funded by the National Science Foundation; the NanoJapan International REU Program and the domestic Rice Quantum Institute REU at Rice University. The study assesses student- learning outcomes for two cohorts of both programs, summer 2013 and 2014, on the following key measures:

1. General knowledge, skills, and attitudes towards their research internship
2. Self-efficacy or confidence related to their research internship
3. Attitudes towards working as part of intercultural teams

Our research concludes that both the domestic and international REUs were effective at preparing students with research skills, but identifies some important ways in which the international experience affected students' self-efficacy and attitudes towards working as part of intercultural teams.

2.0 REUs in Context

2.1 The need for internationalization of S&E education

S&E majors have historically participated in study abroad programs at rates that lag behind other majors, particularly among students in the physical and life sciences and engineering. For the 2012-13 academic year, the most recent for which data is available, social science, business, and humanities majors comprised over half of all U.S. students studying abroad for academic credit, while physical and life sciences accounted for just 8.8%, and engineering for just 4.1%.[3] In comparison with earned bachelor's degrees in S&E, this means that just 6.7% of S&E students nationwide study abroad.[4] While the participation in study abroad among S&E students has been slowly rising over time, the low engagement of S&E students has persisted in spite of the Accreditation Board for Engineering and Technology (ABET) accreditation outcome 3(h) that requires engineering departments to show that they are providing students with "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context".[5]

In response, universities have developed a range of high-profile international education programs geared specifically to all Science, Technology, Engineering and Math (STEM) majors.[6, 7, 8, 9, 10] Parkinson classified these programs into nine categories of study abroad programs for engineering students, including dual degree, exchange, extended field trip, extension, internship or co-op, mentored travel, partner sub-contract, project-based learning/service learning, and research abroad..[11] Although the relative number of students in STEM fields studying abroad remains low in comparison to other disciplines, the data suggests that efforts to develop international programs for these students may be having an impact. The Institute for International Education reported that for 2012-13, STEM fields overall showed the greatest growth in students abroad, from 59,921 students in 2011-12 to 65,223 in 2012-13, an 8.8% increase in only one year. Looking at the fields of study most applicable to the student cohort studied in this research, among engineering students this represents an increase of 7.4% among engineering students 4.5% among students in the physical & life sciences.[12] One possible area for growth in international engagement among S&E students is through the development of international research experiences for undergraduates students that mirror the REUs that have traditionally been offered at domestic universities.

2.2 Domestic and international REUs

The National Council on Undergraduate Research defines undergraduate research as "An inquiry or investigation conducted by an undergraduate student that makes an original intellectual or creative contribution to the discipline" and identifies six key benefits of these experiences: a) enhancing student learning through mentoring relationships with faculty, b) increasing retention, c) increasing enrollment in graduate education and providing effective career preparation, d) developing critical thinking creativity, problem solving, and intellectual independence, e) developing an understanding of research methodology, and f) promoting an innovation-oriented culture.[13]

The NSF has funded REU programs for many years in science and engineering fields at universities that are designed to "… support active research participation by undergraduate students …" and "… involve students in meaningful ways in ongoing research programs."[14] While the majority of REU programs' research is performed at domestic universities, some funding for international research is provided through specialized grant programs such as the

International Research Experience for Students (IRES) or Partnerships for International Research and Education (PIRE) programs of the NSF. [15, 16] The goal of these international research programs is to support the "development of globally-engaged U.S. science and engineering students capable of performing in an international research environment at the forefront of science and engineering." Some examples of international REUs include NSF-funded programs, such as the Optics in the City of Light IREU hosted by the University of Michigan and the Pacific Rim Experiences for Undergraduates (PRIME) project sponsored by UC San Diego.[17],[18] IREUs supported by sources other than the NSF include the DAAD RISE Program[19], the American Chemical Society's IREU Program[20], and the University of Tokyo's Research Internship Program (UTRIP)[21] among others.[22]

A report on international research programs found that, in addition to the technical and professional impacts, the global or transcultural aspects of these experiences include: a) fueling the emergence of 'best practices' effective in sustaining transcultural collaborations, b) encouraging the innovative development of a 'shared work space' to accommodate cultural differences, c) developing and extending research communities beyond the U.S., d) increasing non-English language proficiencies, e) affirming the centrality and power of language, and f) contributing to solutions of the 'Global Grand Challenges'.[23]

Despite these benefits, there remains a need for more assessment of specific outcomes. A workshop report issued by Sigma Xi regarding how to assess international research experiences specifically identified as a necessary research agenda the need for studies that examined the motives for a scientist's or engineer's desire for international collaboration, including the relationship to education and career development. The report also called for studies to assess the impact of international collaboration on the careers of scientists and engineers at all stages.[24]

3.0 The Framework of Global Competency for S&E graduates

Global competence, as it is most commonly used in the engineering literature, is alternatively referred to as cultural competency, multicultural competency, intercultural maturity, cross-cultural adaptation, cross-cultural awareness, or intercultural sensitivity. It assumes that particular knowledge, skills, and attitudes can be developed or learned and is evidenced by individuals' "effective and appropriate behavior and communication in intercultural situations."[25] This section examines general models for cultural competency and literature specific to students in STEM fields.

3.1 Cultural Competency

There are several models that describe cultural competency in general, and we have described two that are most relevant to this research. Deardorff's ground-theory-based model defines cultural competency as the ability to interact with those from different backgrounds, regardless location. Her "Pyramid Model of Intercultural Competency" characterizes intercultural competence as a process that begins with attitudes, leading to knowledge, comprehension, and skills. The desired internal and external outcomes are to demonstrate an ethnorelative viewpoint and an ability to communicate and behave in appropriate with those from other cultures. Deardorff identifies traits essential for an individual to move through her model: attitudes of respect, openness, and curiosity; critical-thinking skills; and an ability to assess global. Her model recognizes intercultural competence development as an ongoing process.[26]

King and Baxter Magolda proposed a model of intercultural maturity with three interrelated domains: cognitive, intrapersonal, and interpersonal.[27] The cognitive dimension touches upon the epistemological issue of the nature of knowledge; specifically the transition from dualistic thinking to a nuanced recognition of alternative perspectives. The intrapersonal dimension concerns to the extent that one is knowledgeable about oneself, while the interpersonal dimension relates to the ability to communicate with others. The model is developmental, with the authors conceptualizing three levels of development on the dimensions. This model provides an overview of broad categories of skills that should be taken into account when developing or assessing international programs. The model of intercultural maturity is one of the frameworks that has guided the assessment plan for the NanoJapan program.

3.2 Global competency and preparedness of STEM graduates

Many researchers have approached the question of what makes a globally competent STEM graduate by identifying lists of requisite knowledge, skills, and attitudes (KSAs).[28,29]. Parkinson's[30] survey of experts from industry and academia identified the attributes of a globally competent engineer, including an ability to appreciate other cultures and to communicate across cultures; familiarity with the history, government and economic systems of several target countries; an ability to speak a second language at a conversational level and at a professional (i.e. technical) level; proficiency working in or directing a team of ethnic and cultural diversity; ability to effectively deal with ethical issues arising from cultural or national differences; understanding cultural differences relating to product design, manufacture and use; understanding of the connectedness of the world and the workings of the global economy; understanding implications of cultural differences on how engineering tasks might be approached; having some exposure to international aspects of topics; having had a chance to practice engineering in a global context; and viewing themselves as "citizens of the world," as well as citizens of a particular country.

Jesiek et al[31] expressed concern that lists of KSAs were often based on an imprecise definition of global engineering competency and proposed a more robust model. They define global engineering competency as "those capabilities and job requirements that are uniquely or especially relevant for effective engineering practice in global context," and identify three dimensions: technical coordination, or working with or influencing people to complete a project in a multinational/multicultural setting; understanding and negotiating engineering cultures, which refers to the multinational/cultural differences in the actual practices and processes of technical problem solving; and navigating ethics, standards, and regulations, which occur when technical coordination or technical problem solving "happen in the midst of multiple – and often conflicting – normative and/or policy contexts".

Ragusa[32] expands the concept of global or intercultural competency to "global preparedness", which includes a readiness to engage and effectively operate in ambiguous situations and in different cultural contexts to address engineering problems. Global preparedness brings together the set of congruent behaviors, attitudes, and policies in a system, agency, or among professionals, enabling that system, agency, or those professionals to work effectively in cross-cultural situations. Streiner et al.[33] described a conceptual map of global engineering preparedness, developed as part of a Delphi study including engineering educators, international education professionals, and industry experts. The model extends global preparedness beyond technical competency to include cross-cultural communication abilities, international contextual knowledge and personal and professional qualities, suggesting that international experiences that focus on engineering as well as those that focus on the more general global context both contribute to student engineering global preparedness.

The concept of global preparedness frames this particular study because it examines not just the knowledge, skills, and attitudes required to work cross-culturally, but their specific application for technical professions. It is consistent with the theoretical model of intercultural maturity which grounds this study, assuming intercultural development occurs in cognitive, interpersonal, and intrapersonal domains.

4.0 Methods

4.1 Programs and Participants

We selected the NanoJapan: International Research Experiences for Undergraduates (NanoJapan IREU) and the RQI Research Experiences for Undergraduates (RQI REU) programs for comparison because both programs are funded by the NSF, headquartered at Rice University, recruit participants from universities nationwide via a competitive selection process, enable students to participate in cutting-edge research in fields related to nanoscale and atomic-scale systems, phenomena, and devices, and require participants to present topical research posters on their summer projects at a summer research colloquium as a capstone experience.

The NanoJapan: IREU Program, the key educational initiative of the NSF PIRE grant awarded to Rice University in 2006, is a twelve-week summer program through which twelve freshman and sophomore physics and engineering students from U.S. universities complete research internships in the multidisciplinary field of nanoscience and nanoengineering in leading Japanese laboratories.[34] The program first received five years of funding in 2006 and was selected for a five-year renewal in 2010 with funding confirmed through 2015. Within this PIRE grant, the research projects conducted by NanoJapan students are concerned with various aspects of nanoscience and nanoengineering, ranging from synthesis of nanomaterials through nanodevice fabrication to a variety of electrical, magnetic, and optical characterization measurements.[35]

NanoJapan recruits high-potential first and second year physics and engineering undergraduate. Women, students traditionally underrepresented in STEM fields, and those from institutions with limited research opportunities available are particularly encouraged to apply. Before beginning their research internships, students complete a three-week orientation program in Tokyo that combines 45 hours of Japanese language instruction, an orientation to Japanese life and culture, and a series of introductory seminars on solid state physics, quantum mechanics, and nanoscience. During the eight-week research internship period, each NanoJapan student is integrated into an existing PIRE international research project in a Japanese partner’s laboratory, under the mentorship of an English-speaking Japanese graduate student or post-doctoral researcher and under the co-advisement by their Japanese host professor and a U.S. PIRE professor. This structure gives NanoJapan students experience working as part of a true international research collaboration and, over the course of the summer, in learning to successfully navigate not only differences in approaches to research in the U.S. and Japan but also language and cultural barriers within their research laboratories in Japan.[36] In addition, they must develop skill sets necessary to overcome logistical barriers, such as time differences, to enable them to remain responsive and engaged with all members of the PIRE international research team. Throughout the summer, NanoJapan students complete weekly reports on topics related to their research and the cross-cultural experiences in their laboratories and receive feedback from their U.S. research advisors and education program staff.

The learning objectives for the NanoJapan IREU are: a) to cultivate an interest in nanoscience as a field of study among college students, b) to cultivate the next generation of graduate students in nanoscience, c) to add to the skill set of active nanoscience researchers, d) to create students who are internationally savvy and have a specific interest in and knowledge of Japan, and e) to educate students in culture, language, and technology, in order that they will be more effective when addressing global scientific problems. The program has been nationally recognized by both the National Academy of Engineering and the Institute of International Education as a best practice in the expansion of international opportunities for STEM students.[37,38]

The RQI REU was the first REU program at Rice University and has been in continual operation since 1996 with funding confirmed through 2014.[39] The program provides highly promising juniors and seniors with an opportunity to train during the summer in an intense, interdisciplinary, and collaborative research environment and involves them in a variety of discussions and interactions with faculty, post-doctoral researchers, and graduate students. Students from schools nationwide spend 10 weeks at Rice, working on cutting-edge, fundamental research projects on quantum phenomena in physical, chemical, and biological systems under the advisement of RQI faculty fellows. In addition, each student is expected to attend special seminars and group discussions for REU participants, make a report of the project, and participate in the RQI Annual Summer Research Colloquium at the end of the summer. As with NanoJapan, participating students are frequently recruited from populations traditionally underrepresented in STEM fields and from schools with limited research experiences and resources. The objectives of the program are for students to: a) acquire the capability of reading and understanding advanced scientific publications, b) understand and experience how to bring a research project to a successful completion, c) be able to successfully present their work to an audience, and d) understand principles for ethical and responsible research.

Table 1 contains socio-demographic information of students for the past two years.

Table 1: Socio-demographic Characteristics of NanoJapan and RQI Students: 2013 and 2014

	NanoJapan (n=24)	RQI (n=24)
Gender		
Female	8	10
Male	16	14
Race/Ethnicity		
African-American	2	0
Asian/Pacific Islander	4	7
Caucasian/White	13	13
Hispanic	2	1
Multi	0	2
American Indian/Alaska Native	1	0
Pacific Islander	0	1
No Response Given	2	0
Institutions Represented		
	Brown Univ. – 1 Carnegie Mellon – 1 Harvard Univ. – 1 Morehouse Coll. – 1 N. Arizona Univ. – 1 NW Vista Comm. Coll. – 2 Penn State Univ. – 1 Rice University - 7 S. IL Univ., Carbondale – 2 Tulane University – 1 Univ. of Dallas - 1 Univ. of FL – 2 UNC, Chapel Hill – 1 Univ. of Tulsa – 2	Univ. of Florida-1 Texas A&M-1 Florida Atlantic-1 Cal State-1 Univ. of South Carolina-1 University at Buffalo-1 Univ. of Houston-1 Duke-1 MIT-1 Centenary College of Lousiana-1 Wellesley College-1 Scripps College-1 Stevens Institute of Tech.-1 St. John's-1 Univ. of Texas (Austin)-2 Rice Univ.-2 Maryville-1 Harvard-1 John Brown-1 UNLV-1 Cooper Union-1 Univ. of Virginia-1
Fields of Study (Note: some students report multiple fields of study)		
	Electrical/Computer Eng.-2 Physics-10 Physics (Biomedical)-1 Nanotechnology-2 Mechanical Eng.-1 Engineering-2 Chemical/Biomolecular Eng.-3 Mathematics-2 Biochemistry/Cell Biology Materials Science-1 Japanese-1 Chemistry-4	Physics-15 Chemistry-4 Biology-1 Biochemistry-2 Mathematics-2 Electrical Eng.-1 Engineering-1 Natural Science-1

4.2 Methods

The students were assessed using the Georgia Institute of Technology International Internship Survey (GITIIS) to evaluate i) general knowledge, skills, and attitudes towards their research internship; ii) self-efficacy or confidence for general skills related to their research internship; and iii) attitudes towards working as part of intercultural research teams. The GITIIS was given to NanoJapan and RQI students as a pre- and post-program assessment to measure students' general knowledge, skills, and attitudes towards their research internship and self-efficacy. Results are reported for both Summers 2013 and 2014 for participants in the NanoJapan program (n=24), and the RQI program (n=25).

The instrument contains three sections. In the first section, students are asked to rate knowledge, skills, and abilities in terms of their **importance** (1 = *not at all important*, 5 = *very important*) and the students' perceived level of **preparation** (1 = *not at all prepared*, 5 = *very well prepared*). The second section asks students about their confidence in workplace skills and abilities as a measure of **self-efficacy** (1 = *not at all true*, 4 = *exactly true*). The final section asks students about their career plans and uses the same scale as the second section. The instrument was developed by the Georgia Tech Office of Assessment and uses an externally validated General Self-Efficacy Scale to assess an individual's ability to cope with stressful life events.[40]

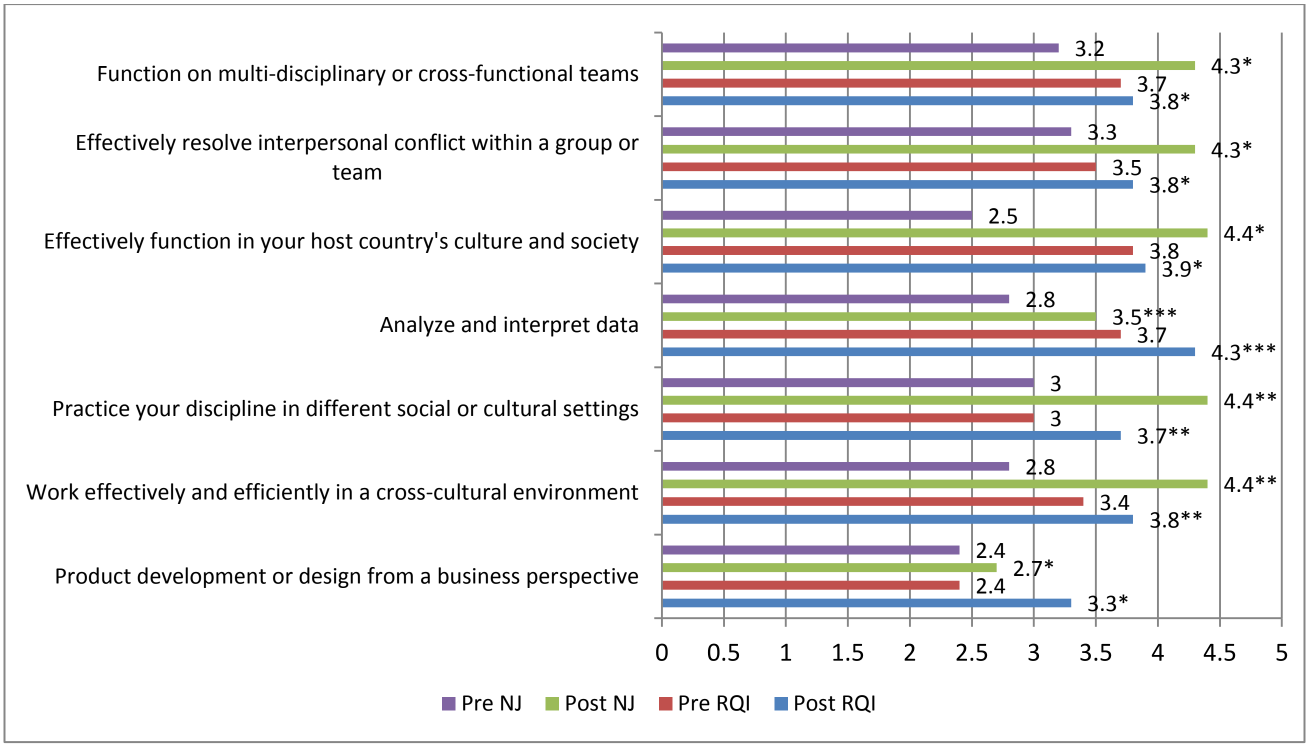
5.0 Results

Mean scores from the GITIIS were computed for both programs, and independent and dependent samples t-tests were conducted in order to assess between and within group mean differences, respectively. The complete results are reported in the appendix, but this paper will focus on the student responses to items measuring **perceived level of preparation** at the end of their summer experience, post-program.

5.1 General Knowledge, Abilities, and Skills Required for an Internship

Between group differences: The NanoJapan students reported significant post-program gains as compared with the RQI students in perceived preparedness on the following items: function on multi-disciplinary or cross-functional teams; effectively resolve interpersonal conflict within a group or team; effectively function in your host country's culture and society; practice your discipline in different social or cultural settings; and work effectively and efficiently in a cross-cultural environment. The RQI students reported greater gains than the NanoJapan students on items measuring an ability to analyze and interpret data and ability to develop a product from a business perspective. Figure 1 reports all between group post-program differences in perceived preparedness.

Figure 1: Between Group Post-Program Differences in Perceived Preparedness



Note: **p*<.05, ***p*<.01, ****p*<.001; all significant differences indicated are between-groups

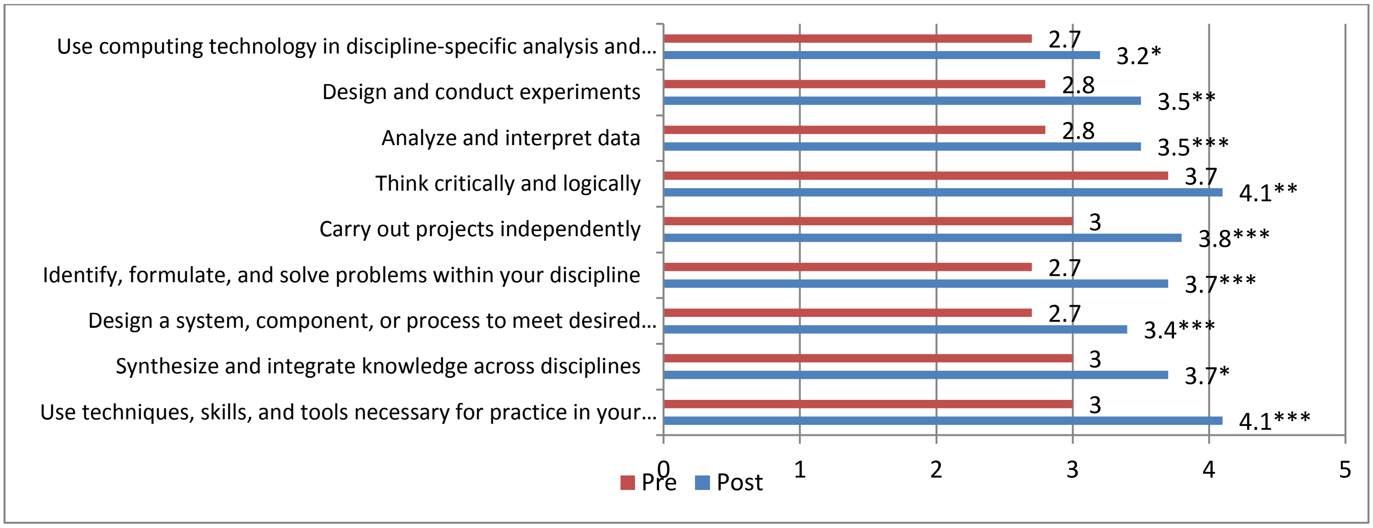
Within-group differences for NanoJapan students: NanoJapan students reported significant gains for perceived preparation on the following GITIIS items post-program:

- *Technical and research skills*: Ability to use computing technology in discipline-specific analysis and design; design and conduct experiments; analyze and interpret data; think critically and logically; carry out projects independently; identify, formulate and solve problems within your discipline; design a system, component, or process to meet desired needs and quality; synthesize and integrate knowledge across disciplines; and use techniques, skills and tools necessary for practice in your discipline. (Figure 2)

- *Communication and teamwork skills*: Ability to communicate orally, informally, and in prepared presentations; communicate in writing (e.g., business letters, technical reports); exercise leadership skills; function on multi-disciplinary or cross-functional teams; and effectively resolve interpersonal conflict within a group or team. (Figure 3)

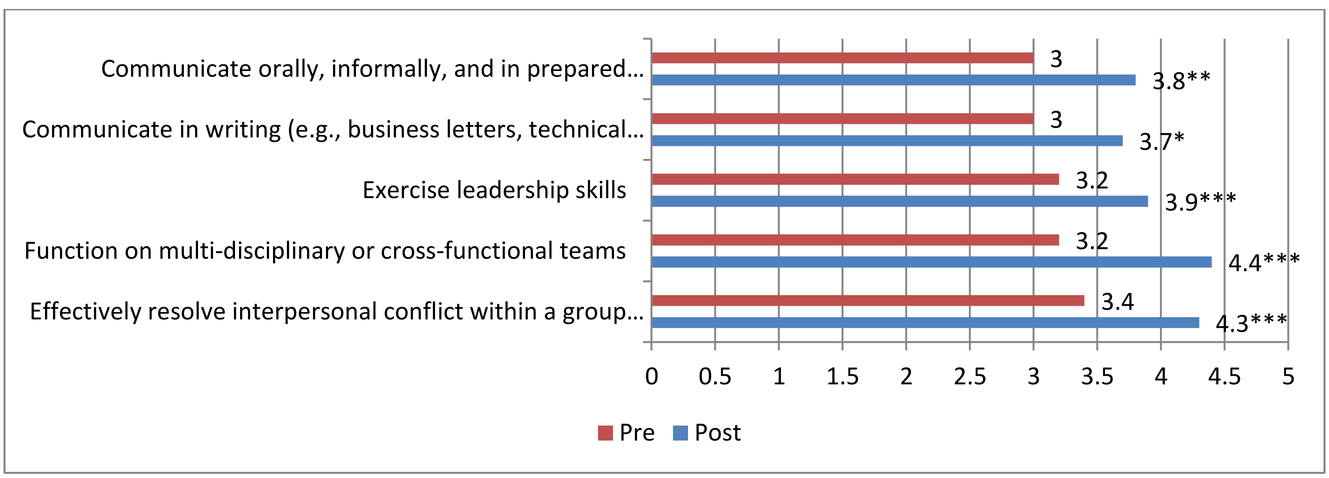
- *Intercultural competency skills*: Ability to effectively function in your host country's culture and society; practice your discipline in different social or cultural settings; communicate in your host country's language in a social setting (conversational fluency); communicate in your host country's language in a professional setting (professional/technical fluency); professionally collaborate with persons in your host country's workplace environment; work effectively and efficiently in a cross-cultural environment; approach problems from different perspectives; the impact your professional practice has on society and culture; and your host country and their culture(s) beliefs and values within a global and comparative context. (Figure 4)

Figure 2: NanoJapan Pre-Post Differences in Preparation: Technical and Research Items



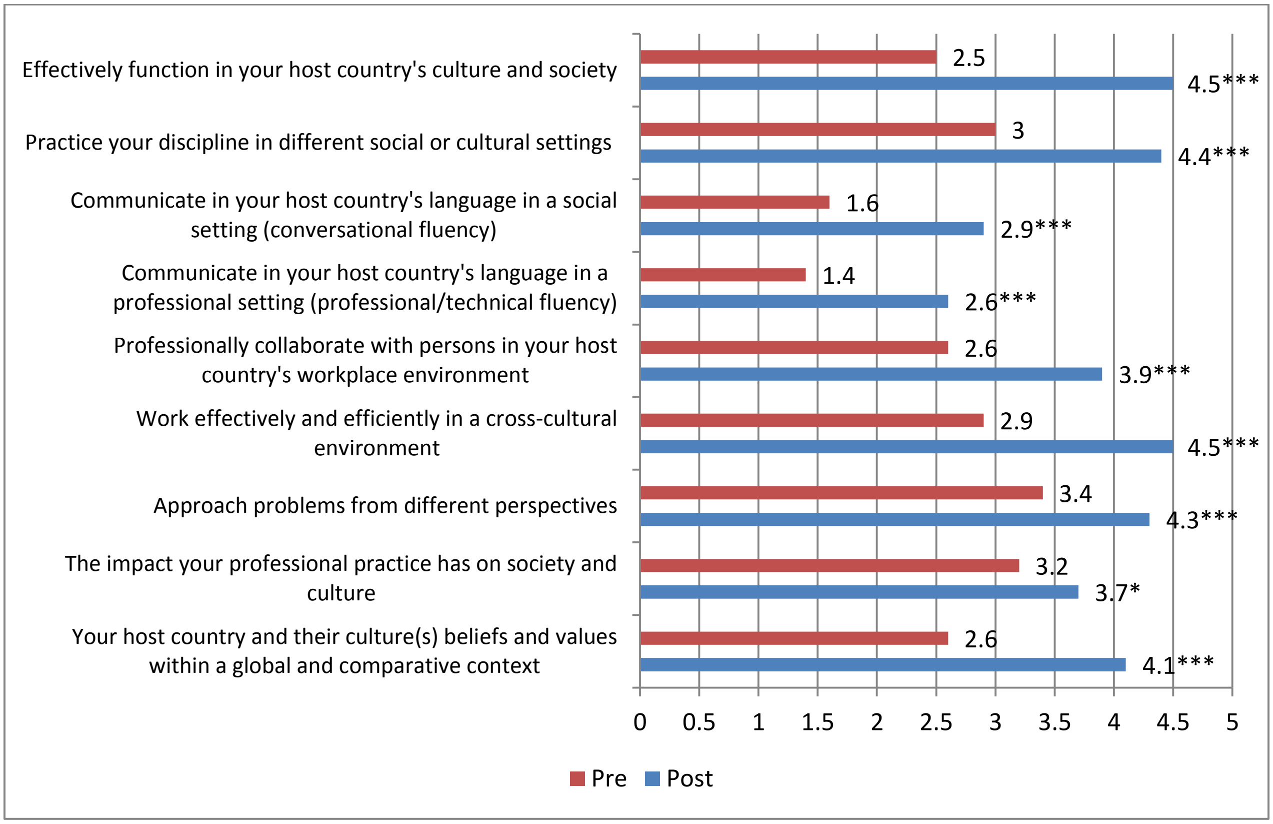
Note: *p<.05, **p<.01, ***p<.001

Figure 3: NanoJapan Pre-Post Differences in Preparation: Communication and Teamwork Items



Note: *p<.05, **p<.01, ***p<.001

Figure 4: NanoJapan Pre-Post Differences in Preparation: Intercultural Competency Items



Note: *$p<.05$, ***$p<.001$

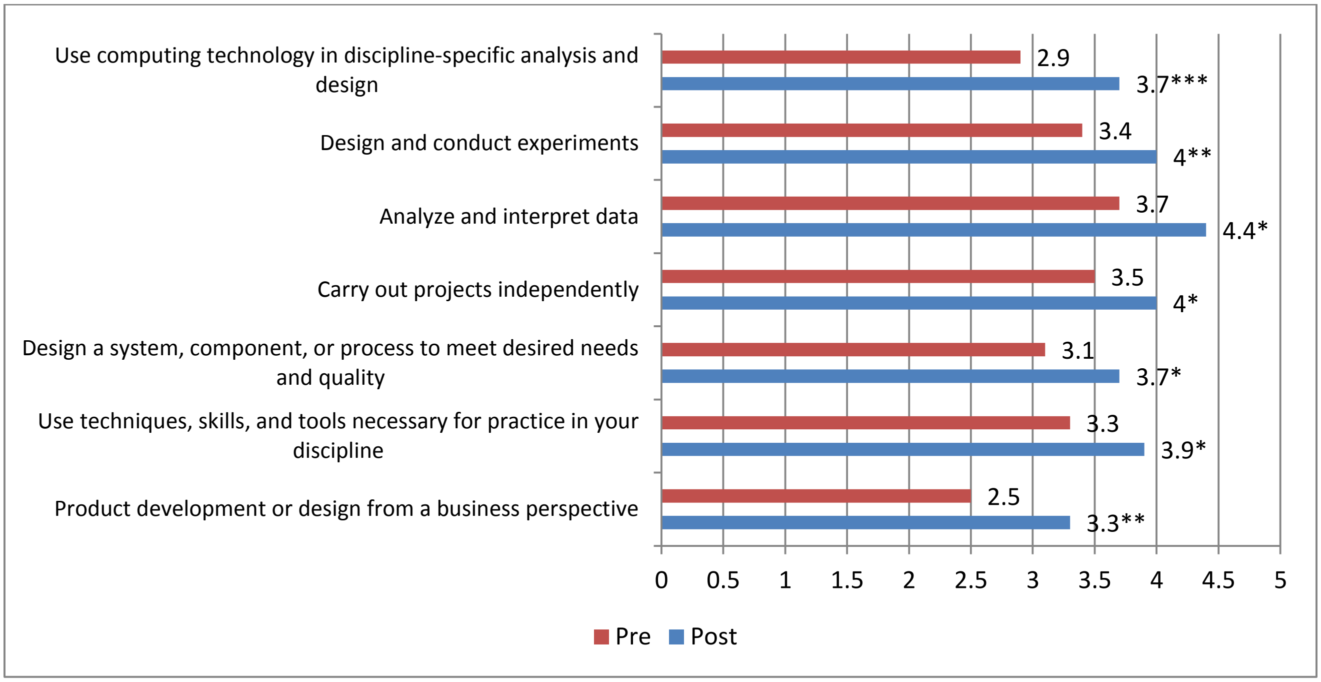
Within-group differences for RQI students: The RQI students reported significant gains in perceived preparation on the following GITIIS items post-program:

- *Technical and research skills*: Ability to use computing technology in discipline-specific analysis and design; design and conduct experiments; analyze and interpret data; carry out projects independently; design a system, component, or process to meet desired needs and quality; use techniques, skills and tools necessary for practice in your discipline; and product development or design from a business perspective. (Figure 5)

- *Communication and teamwork skills*: Ability to communicate orally, informally, and in prepared presentations (Figure 6).

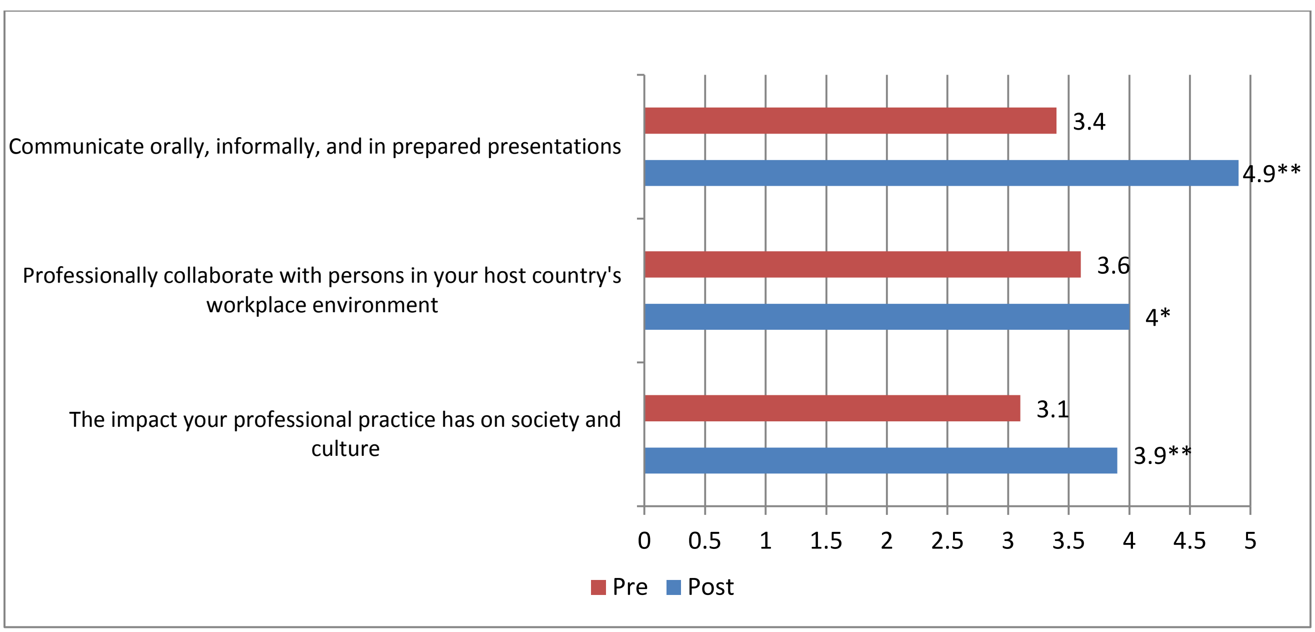
- *Intercultural competency skills*: Ability to professionally collaborate with persons in your host country's workplace environment and the impact your professional practice has on society and culture (Figure 6).

Figure 5: RQI Pre-Post Differences in Preparation: Technical and Research Items



Note: *p<.05, **p<.01, ***p<.001

Figure 6: Significant RQI Pre-Post Differences in Preparation: Communication and Teamwork and Intercultural Competency

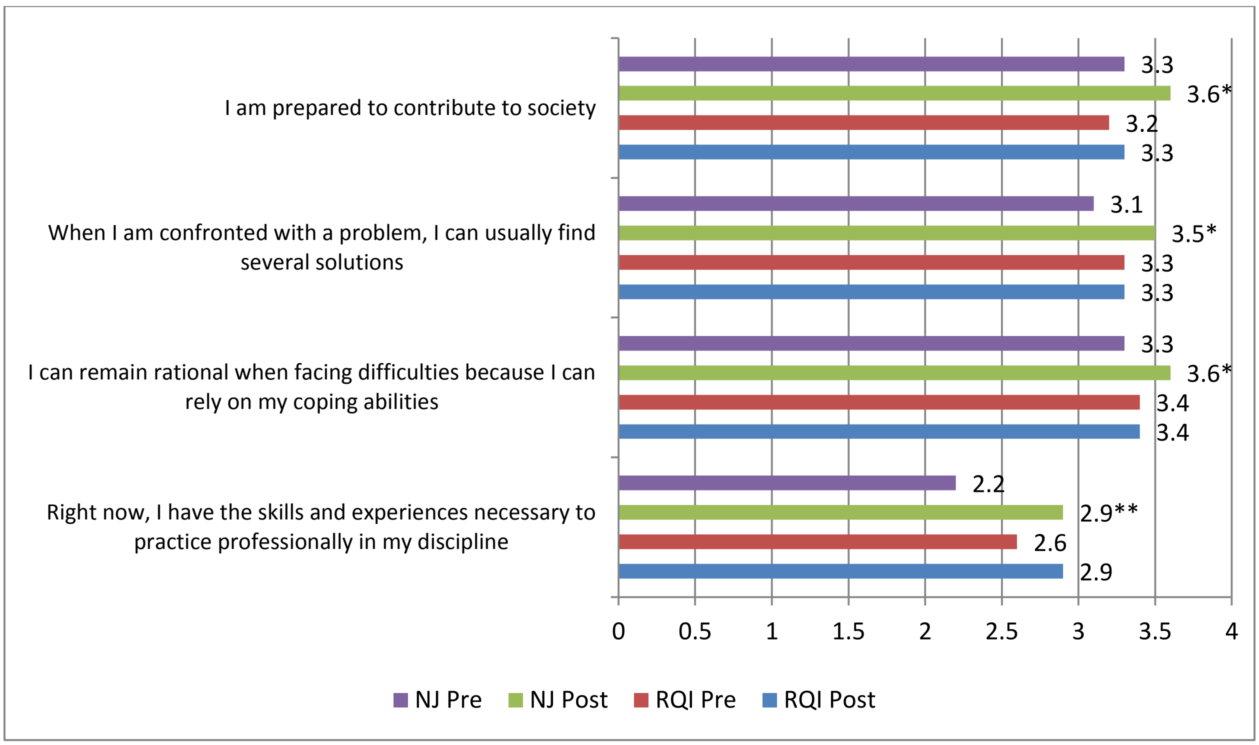


Note: *p<.05, **p<.01

5.2 Self Efficacy

The NanoJapan program students reported significant within-group differences from pre- to post-program on the following GITIIS self-efficacy items: I am prepared to contribute to society; when I am confronted with a problem, I can usually find several solutions; I can remain rational when facing difficulties because I can rely on my coping abilities; and right now, I have the skills and experiences necessary to practice professionally in my discipline (Figure 7). There were no significant within-group differences reported for the RQI students on any of the GITIIS self-efficacy items, and there were no significant between-group differences.

Figure 7: Post-Program Measures of Self-Efficacy



Note: *p<.05, **p<.01; all significant differences indicated are within-group differences.

6.0 Conclusion, Implications, Limitations and Future Directions

6.1 Conclusion and Implications

This study suggests that after completing both REUs, students assessed that their skills associated with the research itself had improved. Both groups demonstrated significant gains on key skills associated with conducting academic research and communication, suggesting that students considered both programs effective with preparing them with the general knowledge and skills required for research.

The results of the GITIIS also suggest that the international experience, as distinct from the domestic REU, did impact students' self-assessment on measures of intercultural competency skills and self-efficacy. On almost all measures in which students assessed their preparation for international or cross-cultural engagement, the NanoJapan students reported substantial gains, suggesting that students perceive that the program is effective in meeting its stated learning objectives. These gains may reflect the program elements of the NanoJapan IREU that scaffold intercultural learning and provide regular and mentored opportunities for written and group moderated discussion of intercultural experiences and challenges while abroad. Some of these program elements include training during the pre-departure orientation on how to critically analyze intercultural communications; weekly written reflections in which students submit 'blogs' that summarize both progress in their research and cultural adjustment; and a structured re-entry program in which students evaluate how their experiences abroad impact their long-term career planning.[41,42]

These program design elements are consistent with research on learning outcomes from study abroad that suggests that simply being immersed in an international setting is not sufficient for student learning – intercultural learning does not happen by proximity. Rather, students make the greatest gains in intercultural learning when they actively reflect on their experiences, through written reflections or engaging with a 'cultural interpreter' who is able to help students make sense of the country, culture, or environment in which they are living.[43] Undergraduate research programs that couple intercultural learning curricula with technical preparation for the research projects may be more effective as models for educating globally prepared S&E graduates.

Of perhaps greater interest, the NanoJapan students also report gains on items measuring self-efficacy as compared with their domestic counterparts, especially confidence to solve problems and deal with adversity. The RQI students indicated no significant differences on measures of self-efficacy. This may reflect that the challenge of simply living independently and conducting research in an international setting contributes to the NanoJapan students developing a greater self-confidence in general. This is consistent with previous research with NanoJapan alumni in which students reported that the international experience affected their self-confidence. NanoJapan alumni cited increased confidence which led them to pursue additional international opportunities, greater confidence in their ability to adapt to different domestic research lab cultures, describing themselves as adaptable to different cultures in a professional or academic environment, increased appreciation for the interdisciplinary nature of scientific research, and more realistic expectations of the expectations and day-to-day life of a graduate student in S&E.[44]

This has particular implications for the importance of IREUs, beyond the preparation of students for international collaborations. If the goal for undergraduate research programs is to encourage students to pursue graduate study, then programs that affect students' self-confidence as researchers may be important for retaining students in STEM fields. Given that international programs tend to be effective at recruiting women, this may also have implications for retaining women in STEM fields. The NanoJapan Program has a strong track record of recruiting underrepresented S&E students, with 13.8% of the 130 participants to date representing diverse ethnic groups in S&E fields. Female students represent 33.8% of NanoJapan participants overall. The representation of women within the program is particularly impressive given that NSF data shows that in 2010, the last year for which data is available, conferred bachelor's degrees for female undergraduate students represented just 16.98% of all engineering degrees conferred and 20.41% of physics degrees.[45]

6.2 Limitations

This study involved a small population of students and used a single attitudinal measure in order to assess student learning. The results suggest differences between the groups that may be associated with differences in completing a domestic versus an international REU, which should be examined further using a larger sample and a combination of direct and indirect measures of intercultural effectiveness. Additionally, this study only examined post-program between group and within group differences on student self-assessment of preparation. Future studies should consider how REUs and IREUs affect how students rate the importance of knowledge, skills, and attitudes related to research, and how the perceived importance affects students' sense of preparation for their chosen career path. This study suggests reasons for the differences between groups that may be associated with students' ability to navigate challenges associated with living and working abroad generally and with educational interventions that prepare students for intercultural engagement. These reasons should be further investigated in that they have potential to have most impact on the design of other domestic and international REUs.

Appendix: Georgia Tech International Internship Survey

Georgia Tech International Internship Survey Items, Means by Program, and Significant Differences

	NanoJapan				RQI			
	Pretest		Posttest		Pretest		Posttest	
The ability to:	IMP	PREP	IMP	PREP	IMP	PREP	IMP	PREP
Communicate orally, informally, and in prepared presentations	4.70^{3}	$3.09^{**,3}$	$4.87^{a,3}$	$3.70^{**,3}$	4.56^{5}	$3.36^{**,2}$	$4.44^{a,5}$	$3.88^{**,4}$
Communicate in writing	4.48^{3}	$3.00^{*,3}$	4.61^{3}	$3.70^{*,3}$	4.52^{5}	3.50^{2}	4.48^{5}	3.79^{4}
Use computing technology in communications	4.35^{3}	3.61^{3}	4.26^{3}	3.70^{3}	4.08^{5}	3.82^{2}	4.16^{5}	3.79^{4}
Use computing technology in discipline-specific analysis and design	4.30^{3}	$2.70^{*,3}$	4.39^{3}	$3.26^{*,3}$	4.16^{5}	$3.00^{***,2}$	4.38^{4}	$3.57^{***,3}$
Exercise leadership skills	3.61^{3}	$3.26^{***,3}$	3.87^{3}	$3.91^{***,3}$	3.80^{5}	3.59^{2}	3.80^{5}	3.83^{4}
Function on multi-disciplinary or cross-functional teams	4.35^{3}	$3.17^{***,3}$	$4.70^{b,3}$	$4.35^{***,a,3}$	4.32^{5}	3.73^{2}	$4.12^{b,5}$	$3.83^{a,4}$
Effectively resolve interpersonal conflict within a group or team	4.35^{3}	$3.35^{***,3}$	$4.52^{b,3}$	$4.26^{***,a,3}$	3.92^{5}	3.52^{1}	$3.92^{b,4}$	$3.79^{a,4}$
Effectively function in your host country's culture and society	$4.35^{a,3}$	$2.48^{***,c,3}$	$4.61^{b,3}$	$4.43^{***,a,3}$	$3.71^{a,4}$	$3.76^{c,1}$	$3.83^{b,3}$	$3.91^{a,2}$
Design and conduct experiments	4.61^{3}	$2.83^{**,3}$	4.41^{2}	$3.43^{**,3}$	4.64^{5}	$3.36^{**,2}$	4.44^{5}	$3.96^{**,4}$

Note: *IMP*: Importance; *PREP*: Preparedness; Within-group: $*p \le .05$, $**p \le .01$, $***p \le .001$; Between-groups: $^{a}p \le .05$, $^{b}p \le .01$, $^{c}p \le .001$; Number of participants: ^{0}=20, ^{1}=21, ^{2}=22, ^{3}=23, ^{4}=24, ^{5}=25; Means reported are overall means and may differ from those reported in the Figures

Georgia Tech International Internship Survey Items, Means by Program, and Significant Differences

	NanoJapan				RQI			
	Pretest		Posttest		Pretest		Posttest	
The ability to:	IMP	PREP	IMP	PREP	IMP	PREP	IMP	PREP
Analyze and interpret data	4.65^{3}	$2.83^{***,c,3}$	4.52^{3}	$3.52^{***,c,3}$	$4.84^{*,5}$	$3.73^{*,c,2}$	$4.52^{*,5}$	$4.29^{*,c,4}$
Think critically and logically	4.83^{3}	$3.70^{**,a,3}$	4.87^{3}	$4.13^{**,3}$	4.76^{5}	$4.23^{a,2}$	4.68^{5}	4.21^{4}
Carry out projects independently	3.91^{3}	$2.96^{***,3}$	4.04^{3}	$3.74^{***,3}$	4.36^{5}	$3.50^{*,2}$	4.40^{5}	$3.96^{*,4}$
Identify, formulate, and solve problems within your discipline	4.52^{3}	$2.74^{***,b,3}$	4.57^{3}	$3.65^{***,3}$	4.56^{5}	$3.50^{b,2}$	4.40^{5}	3.88^{4}
Design a system, component, or process to meet desired needs and quality	4.00^{3}	$2.74^{***,3}$	4.39^{3}	$3.39^{***,3}$	4.00^{5}	$3.09^{*,2}$	4.12^{5}	$3.71^{*,4}$
Synthesize and integrate knowledge across disciplines	4.17^{3}	$3.04^{*,a,3}$	4.57^{3}	$3.61^{*,3}$	4.24^{5}	$3.68^{a,2}$	4.20^{5}	3.79^{4}
Use techniques, skills, and tools necessary for practice in your discipline	4.30^{3}	$3.00^{***,3}$	4.52^{3}	$4.05^{***,2}$	4.56^{5}	$3.32^{*,2}$	4.52^{5}	$3.83^{*,4}$
Engage in lifelong learning	4.39^{3}	$4.09^{*,3}$	4.57^{3}	$4.65^{*,3}$	$4.60^{*,5}$	4.36^{2}	$4.28^{*,5}$	4.43^{3}
Practice your discipline in different social or cultural settings	$3.91^{*,a,3}$	$3.00^{***,3}$	$4.57^{*,c,3}$	$4.39^{***,b,3}$	$3.21^{a,4}$	3.05^{1}	$3.33^{c,4}$	$3.65^{b,3}$

Note: IMP: Importance; PREP: Preparedness; Within-group: *p ≤ .05, **p ≤ .01, ***p ≤ .001; Between-groups: ap ≤ .05, bp ≤ .01, cp ≤ .001; Number of participants: 0=20, 1=21, 2=22, 3=23, 4=24, 5=25; Means reported are overall means and may differ from those reported in the Figures

Georgia Tech International Internship Survey Items, Means by Program, and Significant Differences

	NanoJapan				RQI			
	Pretest		Posttest		Pretest		Posttest	
The ability to:	IMP	PREP	IMP	PREP	IMP	PREP	IMP	PREP
Communicate in your host country's language in a social setting	3.78^{3}	$1.61^{***,c,3}$	3.83^{3}	$2.96^{***,3}$	3.50^{4}	$3.52^{c,1}$	3.58^{4}	3.52^{1}
Communicate in your host country's language in a professional setting	3.96^{3}	$1.39^{***,c,3}$	3.74^{3}	$2.61^{***,3}$	3.83^{4}	$3.14^{c,1}$	3.88^{4}	3.29^{1}
Professionally collaborate with persons in your host country's workplace environment	4.39^{3}	$2.52^{***,c,3}$	$4.65^{a,3}$	$3.91^{***,3}$	4.25^{4}	$3.70^{*,c,0}$	$4.08^{a,4}$	$3.90^{*,1}$
Work effectively and efficiently in a cross-cultural environment	$4.48^{a,3}$	$2.83^{***,a,3}$	$4.70^{b,3}$	$4.43^{***,b,3}$	$3.96^{a,4}$	$3.43^{a,1}$	$4.00^{b,4}$	$3.81^{b,1}$
Approach problems from different perspectives	4.74^{3}	$3.39^{***,3}$	4.70^{3}	$4.26^{***,3}$	4.63^{4}	3.81^{1}	4.38^{4}	4.18^{2}

Note: *IMP*: Importance; *PREP*: Preparedness; Within-group: $^*p \leq .05$, $^{**}p \leq .01$, $^{***}p \leq .001$; Between-groups: $^{a}p \leq .05$, $^{b}p \leq .01$, $^{c}p \leq .001$; Number of participants: ^{0}=20, ^{1}=21, ^{2}=22, ^{3}=23, ^{4}=24, ^{5}=25; Means reported are overall means and may differ from those reported in the Figures

Georgia Tech International Internship Survey Items, Means by Program, and Significant Differences

	NanoJapan				RQI			
	Pretest		Posttest		Pretest		Posttest	
An understanding of:	IMP	PREP	IMP	PREP	IMP	PREP	IMP	PREP
Product development or design from a business perspective	3.04^{3}	2.39^{3}	3.52^{3}	$2.70^{a,3}$	3.08^{5}	$2.41^{**,2}$	3.46^{4}	$3.32^{**,a,2}$
Professional and ethical responsibility within your discipline	4.30^{3}	$3.83^{*,3}$	4.65^{3}	$4.26^{*,3}$	4.44^{5}	4.05^{2}	4.28^{5}	4.30^{3}
Environmental impact or professional practice within your discipline	4.09^{3}	3.17^{3}	4.30^{3}	3.48^{3}	3.76^{5}	$3.23^{*,2}$	3.72^{5}	$3.78^{*,3}$
The impact your professional practice has on society and culture	4.26^{3}	$3.22^{*,3}$	4.13^{3}	$3.65^{*,3}$	3.72^{5}	$3.18^{**,2}$	3.92^{5}	$3.83^{**,3}$
The role of your discipline in solving global problems	$4.48^{b,3}$	3.39^{3}	$4.26^{a,3}$	3.83^{3}	$3.80^{b,5}$	3.36^{2}	$3.60^{a,5}$	3.65^{3}
Your host country and their culture(s) beliefs and values within a global and comparative context	$4.30^{b,3}$	$2.52^{***,a,3}$	$4.43^{b,3}$	$4.09^{***,3}$	$3.42^{b,4}$	$3.29^{a,1}$	$3.71^{b,4}$	3.71^{1}

Note: *IMP*: Importance; *PREP*: Preparedness; Within-group: $*p \le .05$, $**p \le .01$, $***p \le .001$; Between-groups: $^{a}p \le .05$, $^{b}p \le .01$, $^{c}p \le .001$; Number of participants: ^{0}=20, ^{1}=21, ^{2}=22, ^{3}=23, ^{4}=24, ^{5}=25; Means reported are overall means and may differ from those reported in the Figures

Georgia Tech International Internship Survey Items, Means by Program, and Significant Differences

Current Skills and Abilities	NanoJapan Pretest	NanoJapan Posttest	RQI Pretest	RQI Posttest
I am prepared to enter the workforce after graduation	3.05^{2}	3.13^{3}	3.26^{3}	3.20^{5}
I am confident that I will be able to successfully interview and obtain my first job after graduation	3.59^{2}	3.57^{3}	3.35^{3}	3.32^{5}
If I am in a difficult situation, I can usually think of a solution	3.41^{2}	3.43^{3}	3.38^{4}	3.28^{5}
I can always manage to solve difficult problems if I try hard enough	3.41^{2}	3.48^{3}	3.38^{4}	3.44^{5}
Thanks to my resourcefulness, I know how to handle unforeseen situations	3.09^{2}	3.35^{3}	3.08^{4}	3.16^{5}
I am prepared to make significant professional contributions within my discipline	3.27^{2}	3.35^{3}	3.21^{4}	3.24^{5}
I am prepared to contribute to society	$3.27^{*,2}$	$3.61^{*,3}$	3.17^{4}	3.32^{5}
When I am confronted with a problem, I can find several solutions	$3.09^{*,2}$	$3.43^{*,3}$	3.29^{4}	3.33^{4}

Note: *IMP*: Importance; *PREP*: Preparedness; Within-group: $^{*}p \leq .05$, $^{**}p \leq .01$, $^{***}p \leq .001$; Between-groups: $^{a}p \leq .05$, $^{b}p \leq .01$, $^{c}p \leq .001$; Number of participants: ^{0}=20, ^{1}=21, ^{2}=22, ^{3}=23, ^{4}=24, ^{5}=25; Means reported are overall means and may differ from those reported in the Figures

Georgia Tech International Internship Survey Items, Means by Program, and Significant Differences

	NanoJapan		RQI	
Current Skills and Abilities	Pretest	Posttest	Pretest	Posttest
I can usually handle whatever comes my way	3.36^{2}	3.57^{3}	3.17^{4}	3.40^{5}
If someone opposes me, I can find the means and ways to an acceptable solution	3.32^{2}	3.48^{3}	3.33^{4}	3.36^{5}
I can remain rational when facing difficulties because I can rely on my coping abilities	$3.27^{*,2}$	$3.65^{*,3}$	3.38^{4}	3.36^{5}
It is easy for me to stick to my aims and accomplish my goals	3.45^{2}	3.39^{3}	3.42^{4}	3.28^{5}
I can solve most problems if I invest the necessary effort	3.86^{1}	3.65^{3}	3.63^{4}	3.48^{5}
I am confident that I could deal efficiently with unexpected events	3.29^{1}	3.43^{3}	3.25^{4}	3.25^{4}
Right now, I have the skills and experiences necessary to practice professionally in my discipline	$2.18^{**,2}$	$2.83^{**,3}$	2.58^{4}	2.84^{5}

Note: *IMP*: Importance; *PREP*: Preparedness; Within-group: $*p \le .05$, $**p \le .01$, $***p \le .001$; Between-groups: $^{a}p \le .05$, $^{b}p \le .01$, $^{c}p \le .001$; Number of participants: ^{0}=20, ^{1}=21, ^{2}=22, ^{3}=23, ^{4}=24, ^{5}=25; Means reported are overall means and may differ from those reported in the Figures

Georgia Tech International Internship Survey Items, Means by Program, and Significant Differences

Within the next five years:	NanoJapan Pretest	NanoJapan Posttest	RQI Pretest	RQI Posttest
I will most likely work in a position related to your field of study	3.64^{2}	3.39^{3}	3.52^{3}	3.52^{5}
I plan to work/have worked in a position in a foreign country	$2.50^{***,2}$	$3.30^{***,c,3}$	2.04^{3}	$2.25^{c,4}$
I intend to participate in a study abroad experience	$3.32^{b,2}$	$3.65^{c,3}$	$2.43^{b,3}$	$2.50^{c,4}$
I will pursue/continue to pursue foreign language proficiency	3.05^{2}	$3.48^{c,3}$	2.48^{3}	$2.42^{c,4}$
I plan to work in a position with considerable international responsibilities	$3.05^{**,c,2}$	$3.57^{**,c,3}$	$2.26^{c,3}$	$2.42^{c,4}$
I plan to pursue a graduate or professional degree	3.86^{2}	3.78^{3}	$3.75^{*,4}$	$3.48^{*,5}$
I will travel abroad for nonacademic or non-work related reasons	3.41^{2}	$3.61^{b,3}$	3.09^{3}	$2.91^{b,2}$

Note: *IMP*: Importance; *PREP*: Preparedness; Within-group: $*p \leq .05$, $**p \leq .01$, $***p \leq .001$; Between-groups: $^{a}p \leq .05$, $^{b}p \leq .01$, $^{c}p \leq .001$; Number of participants: ^{0}=20, ^{1}=21, ^{2}=22, ^{3}=23, ^{4}=24, ^{5}=25; Means reported are overall means and may differ from those reported in the Figures

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