Work in Progress: NSF IRES – Interdisciplinary Research in Korea on Applied Smart Systems (IRiKA) for Undergraduate Students

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Introduction

Interdisciplinary Research in Korea on Applied smart systems (IRiKA) for Undergraduate Students is an NSF International Research Experiences for Students (IRES) program that provides a cohort of five US undergraduate students per year with the opportunity to conduct research for eight (8) weeks at Seoul National University (SNU), Korea Advanced Institute of Science and Technology and Ewha Womans University in Korea. The purpose of this program is to engage undergraduate students in interdisciplinary research, help them develop a global perspective on collaboration, and motivate them to pursue a career in STEM research. Over the lifetime of this 3-year project (2019-2021), the participating institutions will have a cohort of 5 students every year for a total of 15.

The unifying research theme of IRiKA is smart systems with the subtopics of sensors, emerging electronics, and materials & process development. The theme leverages previous, ongoing, and new collaborations between the three US-based lead investigators and the Korean partner institutions. In addition to lab work and weekly cohort meetings to discuss progress, IRiKA students have the opportunity to visit Korea's government research institutions and global leaders in the tech industry such as Samsung, LG, and Hyundai and engage in cultural experiences. IRiKA includes a series of professional development sessions on research mentorship and science communication for both US participants and Korean partners.

In this Work-in-Progress paper, the three US-based lead investigators report and reflect on the first year of the IRiKA program, which ran from June 2019 to August 2019. The investigators are currently analyzing data collected from the Summer 2019 cohort. In response to the preliminary findings, adjustments have been made for the Summer 2020 program. Summer 2020 applicant data collection has been completed. *Due to the coronavirus pandemic, Summer 2020 program was cancelled.*

IRiKA Program

The objectives of this program are to engage undergraduate students in interdisciplinary research, help them develop a global perspective on collaboration, and motivate them to pursue a career in STEM research. Recruitment will focus on students underrepresented in STEM and/or with limited STEM research opportunities.

The unifying research theme of IRiKA is smart systems with the subtopics of sensors, emerging electronics, and materials & process development. Smart systems incorporate sensing, actuation, wireless connectivity, and machine learning, which requires interdisciplinary expertise in biomedical, computer, electrical, industrial, mechanical engineering for seamless implementation. IRiKA students will learn how the systems approach brings together interdisciplinary technological solutions for manufacturing, healthcare, energy, safety and security, transportation, and logistics.

Examples of research projects that individual students will conduct during their time in Korea include:

- Development of an air-borne particle sensing system for health monitoring and air quality monitoring
- Development of miniature and micro power generation systems to enable autonomous sensor systems
- Development of a lightweight, flexible point-of-care device consisting of microfluidic channels and reduced graphene oxide-based biosensors
- Development of sensors that comprise neuromodulation systems for deep brain stimulation system for Parkinson's disease
- Development of in vitro neural circuit and neurovascular unit on a microfluidic device for complete model of brain tissue

In addition to lab work and weekly virtual and in-person cohort meetings to discuss research progress, IRiKA students have the opportunity to visit Korean government research institutions and global leaders in the tech industry such as Samsung, LG, and Hyundai. The Global Engineering Center for Engineers in Korea (GECE) has committed to coordinate additional enriching cultural activities.

The schedule of the program is shown in Table 1.

Professional Development

One of the distinguishing features of IRiKA is the professional development components tailored for both its US participants and Korean partners and the availability of follow-on projects to foster continued mentorship. IRiKA takes a scaffolded mentorship approach that fosters students' growth from a relatively dependent status to as independent a status as their competence warrants.

Each participant has a senior member of the host lab in Korea as his or her direct mentor. The participant interacts with the principal investigator of the host lab on a regular basis – at least once a week. Training for the mentors draws from the resources of the Center for the Integration of Research, Teaching, and Learning (CIRTL) Network.

In addition, Prof. Moser offers a customized workshop for the undergraduate mentees and mentors. The workshop, titled "Advanced Professional and Presentation Skills for Undergraduate Mentees and Graduate Mentors," consists of a series of lectures and one-on-one coaching for US undergraduate participants in IRES and their mentors in Korea. It focuses on collaborative dialogue and the development of presentation skills necessary for success within academic research environment.

Recruitment

Between November 2018 and January 2019, we used various communication channels – web (https://nsfirika.org/), social media, e-mail, print, information sessions, and faculty referrals – to recruit students from the three US institutions (University of Florida, Louisiana State University,

and Northwestern University) where the lead investigators are/were based. To attract minority and/or underrepresented applicants in particular, the US leads reached out to active student organization chapters of groups including National Society of Black Engineers (NSBE), Society of Hispanic Professional Engineers (SHPE), and Society of Women Engineers (SWE). Only US Citizen/Permanent Resident were eligible to apply. Eligible graduate students were encouraged to apply with the understanding preference would be given to undergraduate candidates.

Applications were collected online through the program website. Required materials were:

- application form
- academic transcript
- CV/resume
- statement of interest
- up to two recommendation letters

A committee of the three US leads and host faculty in Korea reviewed the application packages. The reviewers considered completion of relevant foundational coursework and academic achievements as evidenced by a cumulative GPA of 3.3 or higher. The committee took into account that there are discrepancies in performance in the classroom and lab for some talented students.

Table 1: IRiKA Annual Schedule

Timeframe	Project Activities
Nov. – Feb.	• Recruitment and selection of five (5) students by the IRiKA faculty committee • Project matching and research mentor assignment • Decision letters sent in February
May	• Professional Development Workshop enrollment • Completion of the Responsible Conduct of Research (RCR) through the Collaborative Institutional Training Initiative (CITI) Program • Orientations (US and Korea via webcast and in-person at participants' respective home institution)
Week 1 (Jun.)	• Research fundamentals seminar • Research proposal preparation with research mentor • Depart for Korea • On-site orientation in host labs
Weeks 2 – 9	• Full-time research in lab • Weekly research reports + summative assessment • Weekly IRiKA web conferences • Professional Development Workshop sessions • Cohort visits among labs • Industry and national lab visits – Samsung, Hyundai, LG, KITECH

Week 10 (Aug.)	• Final report + summative assessment • Week 10 formative assessment
Aug.	• Return home
Oct.	• Presentations at home institutions
Jan.	• Student cohort and mentor interviews and formative assessment
Sep. 30 (following year)	• Publication Awards application due

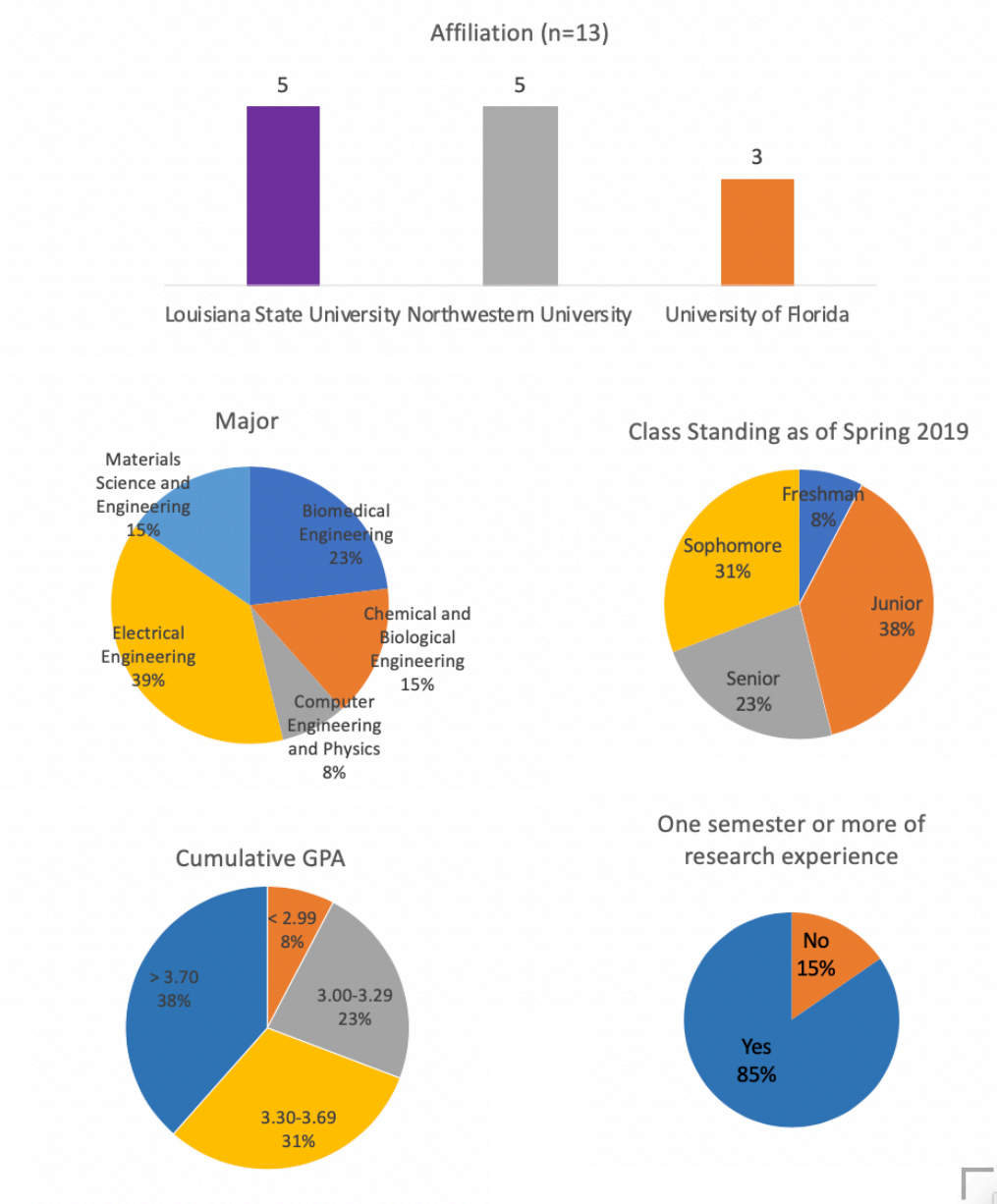

Figure 1: IRiKA Finalists (n=13) - Academic Background

After initial screening, 13 students remained. Figures 1 and 2 show the backgrounds (school affiliation to be included in final paper) and demographics of this pool, from which five students were selected and notified in February. Three among the five participants were underrepresented minority students (two African American female students, one Hispanic male student). The students were placed in four different research labs at Seoul National University (SNU).

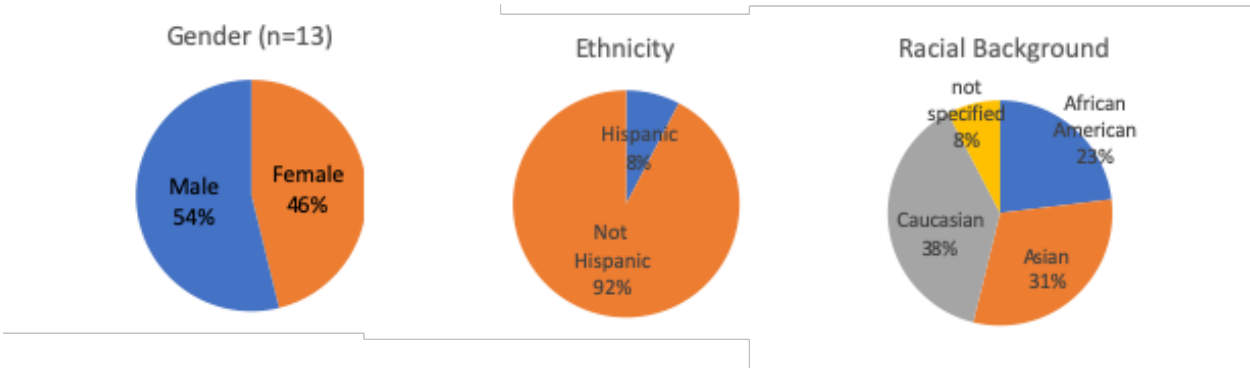

Figure 2: IRiKA Finalists(n=13) - Demographic Data

Summer 2019 Cohort: Pre-departure Activities

The selected students (three females, two males) were required to provide a picture and bio for the IRiKA website (https://nsfirika.org/), undergo Responsible Conduct of Research (RCR) through the Collaborative Institutional Training Initiative (CITI) Program and provide proof of health insurance before roundtrip tickets were purchased. Due to the geographical distance, all three pre-departure orientations (May 15, 2019; June 4, 2019; June 12, 2019) were held via web conference.

The three orientations covered the following topics:

- NSF IRES introduction and IRiKA curriculum overview
- Mandatory items - travel documents, weekly progress report, survey responses Korea - weather, packing tips, arrival information, meeting point at the airport, safety tips, must-have apps, getting around, accommodation
- Research - expectations, lab culture in Korea
- Professional Development workshop while in Korea

Students were assigned homework for orientation II (picking an attraction to visit and explaining how to get there using the recommended app) and orientation III (uploading questions to a live document on Dropbox).

Summer 2019 Cohort: In-country Activities

All the students arrived in Korea on June 15 (Sat), were greeted at the airport and shown to their accommodations by Prof. Kim. Students' accommodation was in two single-gender share houses near SNU, within walking distance to free SNU shuttle buses to campus. The share houses afforded students the chance to interact with other international students attending SNU.

The first day of their 8-week internship was June 17 (Mon). In addition to conducting research, the students had the opportunity to visit industry labs and government labs - LG (June 18), Korea Institute of Industrial Technology (June 24), Hyundai Mobis (July 2), and Samsung (July 4). Also, they participated in weekly Professional Development Workshop on science communication led by Prof. Moser of Northwestern University. The students' mentors in the lab were invited to attend the workshop as well.

The lab culture in Korea is such that members constantly interact with each other – the group goes for lunch and/or dinner together; there are biweekly or monthly lab socials in the evening; birthdays are celebrated together. As could be seen in the students' blog posts, the students were included in every aspect of this lab culture.

While the students were in Korea, weekly online meetings were held with Professors Kim and Choi as moderators. Each student gave a presentation on their research progress and an account of their cultural experience in Korea. All eight meetings were attended 100%. The students would finish drafting their blog posts within two days after the meeting and the posts would go live with minor edits. Research reports have been archived in Dropbox to protect the research data until published in journals or presented at conferences.

Summer 2019 Cohort: Post-internship Activities

The students have been very responsive to post-internship inquiries and requests for help in recruiting the Summer 2020 cohort. A summative survey will be administered to measure the impact of the research. It will also serve as a reminder to the students of the incentive the program is providing to publish their research.

Assessment

To evaluate the program, the investigators have utilized: 1) standardized instruments; 2) surveys, interview protocols, and rubrics that have been developed for use in evaluation of other training programs at SC; 3) survey and interview questions specifically tailored to IRiKA; and 4) students' weekly blog posts while they were in Korea.

Specifically, evaluation methods include:

1. Registration form: When the selected five students register, they will complete a form that includes questions (open-ended and Likert scales) about their expectations for the program and research & cultural preparation.
2. Pre-program survey: This survey will include questions about expectations (open-ended and Likert scales) as well as questions that gather baseline data regarding knowledge, perceptions, and self-efficacy. The latter questions will be matched to post-program survey questions.
3. Mid-program survey: This survey will collect formative feedback regarding the program experience and structure.
4. Post-program survey: In addition to the survey questions regarding knowledge, perceptions, and self-efficacy to be matched to the pre-program survey, this survey will

include opportunities for reflection about whether their own expectations and goals were met by the program, and other ways they may have benefited.

5. Post-program interviews: Three-four months following the program and after the student graduates from his or her undergraduate institution, the evaluator will conduct one-on-one telephone interviews. The aim is to gauge the degree to which the IRES Site experience has been a lasting influence in the students' career paths. Incentives will be used to maximize sample sizes and mitigate response bias, given that students will no longer be part of the program. Interviews will be used to gather qualitative data about their experiences regarding the international nature of the program, the mentoring they received, and whether particular aspects of the program led to increased confidence. Other interview questions will be informed by the prior survey findings.
6. Data management and analysis assessment rubric: A simple two-part rubric will be developed for assessing students' ability to manage data and to analyze data.
7. Communications assessment rubric: A rubric will be developed to measure several dimensions of communication skills, which are inclusive of both written and verbal communications. Rubric scores will allow for comparisons between communication skills demonstrated at the beginning and end of the program.
8. Qualitative analysis of mentor feedback: The program instructors will conduct a comparative analysis of written feedback given by mentors at the beginning of the program and the end of the program.

The evaluation plan includes opportunities to gather formative data and to understand students' perspectives of the programs' impacts, even if those impacts are outside the anticipated or desired outcomes articulated by the program. Summative and formative evaluation plans in Table 2 shows specifically how the desired learning objectives will be measured through the methods described above.

Table 2: Methods for measuring learning objectives

Student learning objectives	**Methods**
Students have an increased interest in pursuing STEM careers	pre-post survey; post-program interviews
Students have increased confidence in designing experiments	pre-post survey; post-program interviews
Students competently manage and analyze data	data management and analysis assessment rubric
Students can clearly articulate their research questions and findings in public presentations	communications assessment rubric: week 1 presentation on research project and final presentations
Students develop an awareness of and sensitivity toward cultural differences and how they manifest in a research lab context	mid-program survey; post-program survey; post-program interviews
Mentors are able to deliver feedback to students that is clear and utilizable	qualitative analysis of mentor feedback

Discussion

The unquestionable leadership of the U.S. in technology-related areas has led to the misconception that what works here must work around the world as well. U.S. engineering students are poorly prepared for the task of working in multicultural teams, and even less prepared for working in foreign environments. The National Academy of Engineering, the National Science Foundation, and the National Research Council have called upon engineering schools to develop globally competent workforce [1][2][3].

According to the National Association of State Universities and Land Grant Colleges Committee for International Education [4], the five characteristics of a globally competent student are:

1. Diverse and knowledgeable worldview
2. Understanding of international dimensions in their area of study
3. Communication skills in another language
4. Cross cultural sensitivity and adaptability
5. Lifelong dedication to building global competencies

International engineering programs offered by US Schools of Engineering can be categorized into eight types [5]. According to that classification, IRiKA falls under international internships.

The investigators are currently analyzing data collected from the Summer 2019 applicants and cohort. The preliminary finding indicate that some of the key lessons students took home from the program were:

- Willingness to adapt to and integrate into different cultural environment
- Increased awareness of diversity within and across cultures in problem solving in engineering
- Increased motivation to obtain proficiency in another language
- Confidence in the ability to work as a member of a cross-cultural engineering team
- Increased understanding of how their career is impacted by global engineering practices

These learning outcomes map well onto the aforementioned five characteristics of global competency and therefore are bode well going forward. We plan to provide a follow-up report upon complete analysis of the data.

In response to the feedback the cultural experience aspect of IRiKA, adjustments have been made for the Summer 2020 Program. Summer 2020 applicant data collection started in October 2019 and was completed in February 2020. *Due to the coronavirus pandemic, Summer 2020 program has been cancelled. We will offer students selected for the Summer 2020 program the opportunity to participate in 2021.*

Acknowledgment

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