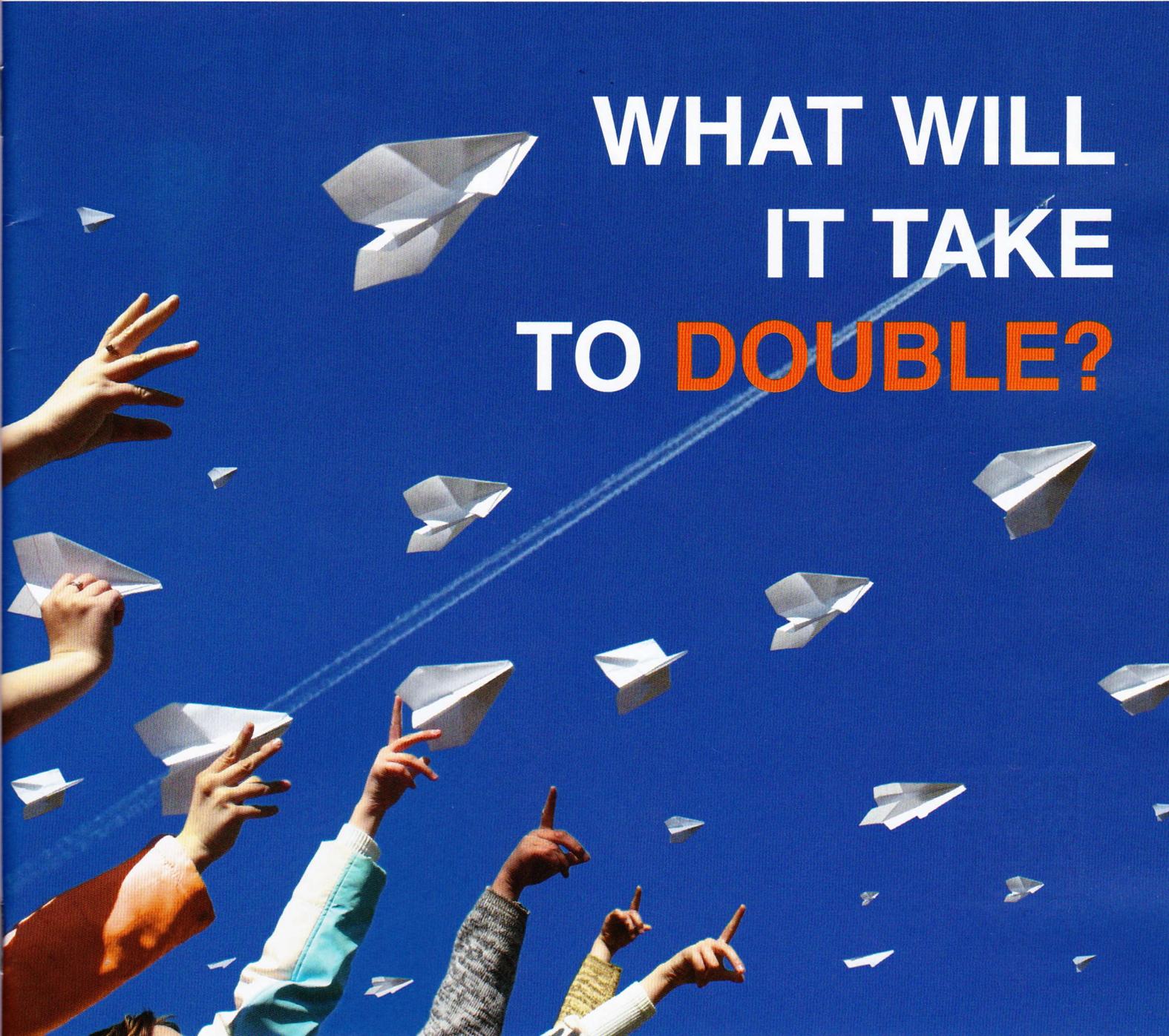


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WHAT WILL IT TAKE TO **DOUBLE?**

U.S. Study Abroad: A National Imperative

Reality Check: What the Numbers Tell us About Doubling

What Will it Take to Send More Underrepresented Students Abroad?

Expanding International Opportunities for Engineering and Science Students: A Case Study on the NanoJapan International Research Experience for Undergraduates Program

By Sarah R. Phillips and Cheryl A. Matherly

SCIENCE AND ENGINEERING research is increasingly characterized by international collaboration, yet the number of U.S. undergraduates in these fields who participate in study abroad still lags. In 2011/2012, only 3.9 percent of the students who studied abroad majored in engineering, 8.6 percent in the physical and life sciences, and 1.7 percent in mathematics and computer science (IIE, 2013). The small number of U.S. engineering and science students who seek international experiences is of particular concern given the importance of international scientific collaboration. In its 2014 Science Indicators, the National Science Foundation (NSF) reported that internationally co-authored papers now comprise one-fourth of all papers worldwide (National Science Board, 2014). The percentage of U.S. papers published in 2012 with international co-authorship in engineering was 35.9 percent and in physics was 45.8 percent (National Science Board, 2012, Table 5-42, 5-45). The NSF 2006–2011 strategic report concluded, “As science and engineering (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 (National Science Foundation, 2011).”

The Research Experience for Undergraduates (REU) Model

The National Council on Undergraduate Research (NCUR) defines undergraduate research as an “inquiry or investigation conducted by an undergraduate student that makes an original intellectual or creative contribution to the discipline.” The most familiar model is the NSF’s Research Experience for Undergraduates, typically 8-10 week summer programs that recruit students nationwide to participate in ongoing research programs. The NCUR lists among the benefits of REUs that they typically involve students from diverse types of higher education institutions;

they empower STEM students to make informed career choices; and they engage students with research in both domestic and international universities (National Council of Undergraduate Research, 2014).

While the majority of REU programs are domestic, some international funding is provided through the NSF International Research Experience for Undergraduates and Partnerships for International Research and Education (PIRE) programs (National Science Foundation, IRES; National Science Foundation, PIRE). The goal of these programs is to support the “development of globally engaged U.S. science and engineering students capable of performing in an international research environment.” A report on NSF-funded international research programs found that they were highly effective at sustaining transcultural collaborations and with developing and extending research communities beyond the United States (Chang & Hirleman, 2008).

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 (University of Michigan Optics; Arzberger, Wienhausen, Abramson, ... Shinji, 2010). IREUs supported by sources other than the NSF include the German Academic Exchange Service (DAAD) Research Internships in Science and Engineering (RISE) Program, the American Chemical Society’s IREU Program, and the University of Tokyo’s Research Internship Program (UTRIP) (DAAD; American Chemical Society; University of Tokyo).

The NanoJapan Program: IREU Case Study

NanoJapan, the key educational initiative of a NSF PIRE grant focused on nanoscale research that was awarded to Rice University in 2006, is a case study for how an IREU can increase participation of STEM students in programs abroad. NanoJapan annually

recruits 12 high-potential freshman and sophomore students from universities nationwide to conduct a cutting-edge nanoscale science research internship in Japan. Before beginning their research, students complete a three-week orientation program in Tokyo that combines 45 hours of Japanese language instruction, an orientation to Japanese society and an introduction to nanoscale science in Japan. Following the orientation, students complete an eight-week research internship in a Japanese laboratory. At the end of the summer, students present posters on their research at Rice University as part of a three-day re-entry program (Matherly, Phillips, & Kono, 2013). Since 2006, 130 students representing 43 different universities have participated.

NanoJapan was recognized in 2008 with IIE’s Heiskell Award for Innovation in International Education and as a best practice in the National Academy of Engineering’s 2012 report, “Infusing Real World Experiences into Engineering Education” (IIE, 2008; National Academy of Engineering, 2013). The program features that are most salient to institutions developing IREUs include:

High Quality Mentoring: NanoJapan students are integrated into an existing international research team, advised by both a Japanese and a U.S. professor, and closely mentored by an English-speaking graduate student. This ensures that the students’ work is closely aligned with the overall research objectives of the program and that the students receive on-going feedback about their research performance.

Development of Well-Articulated Student Projects: The program ensures that students are assigned a meaningful research question that can be examined in the course of a summer. The students’ projects are developed jointly between the Japanese and U.S. professor prior to the student’s departure for Japan. An early challenge for the Japanese hosts, who had little prior experience with U.S. undergraduates, was to define a project

that could be conducted in eight weeks. An ongoing challenge with the students is to set realistic expectations about what can be reasonably accomplished in a short timeframe.

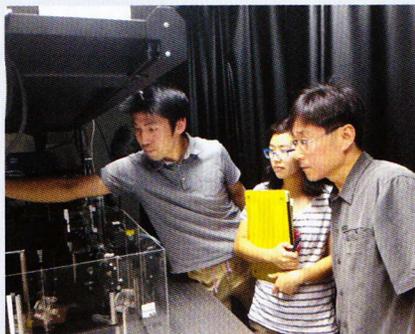
Integration of Language Instruction and Cross-Cultural Reflection: NanoJapan weaves language and cross-cultural instruction throughout the program. Most participants have never studied Japanese, so the formal instruction that they complete during the three-week orientation is critical to prepare them with foundational language skills. Equally important, the program challenges students to reflect on the cross-cultural aspects of research through weekly blogging about topics such as hierarchy in Japanese vs. U.S. labs, gender issues in international research, and cross-cultural communication. The re-entry program includes exercises in which students practice communicating what they learned about research and working in culturally diverse teams with potential employers.

Program Outcomes and Assessment

In assessment of program outcomes (Matherly, Phillips, & Kono, 2013), students identified three major impacts of NanoJapan:

- **Enhanced confidence:** Students report the experience conducting nanoscience research and living independently in Japan simply made them more confident in general. One student shared, “[R]elocating to a different lab in the U.S. will always pale in comparison to relocating to a lab on the other side of the world.”
- **Training for graduate school:** Many students report that the NanoJapan experience provided a first exposure to the realities of graduate school. One shared, “...my NanoJapan lab gave me a realistic taste of graduate school life (the good and the bad) that many students lack when they apply for graduate school. I know more than a few people that have left their graduate programs because research was not what they expected.”
- **Professional network:** Many alumni report remaining in contact with their Japanese research hosts. They also say that NanoJapan provided them with a network of motivated peers in their field to discuss graduate school and career options.

Finally, and perhaps most relevant for expanding opportunities for STEM students, 80 percent of NanoJapan alumni report that the international dimension of the research strongly influenced their decision to join



NanoJapan 2014 participant Lisa Chiba and her research mentor (left) demonstrating her research project set-up to Prof. Junichiro Kono (right). Lisa is a sophomore at Rice University majoring in Chemical Engineering and conducting research in the LaSIE lab at Osaka University under the advisement of Prof. Satoshi Kawata.

the project. We know from program evaluations that students apply because they see this program as combining the best aspects of a traditional study abroad program with an intensive research experience. This suggests that IREUs can be an important model for engaging STEM students in meaningful programs abroad and advancing the goals for Generation Study Abroad.

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NanoJapan 2012 participant Mika Tabata (right) attending Osaka's Tenjin Matsuri festival with members of her research lab. At the time of participation, Mika was a sophomore Bioengineering major at Rice University who conducted research in Prof. Masayoshi Tonouchi's lab at Osaka University.

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