



Ubicomp without Borders:

International Experiences in Pervasive Computing

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Ubicomp systems present exciting opportunities to do good and to make life better for diverse groups, from consumers and office workers^{1,2} to populations with more specialized needs, such as first responders.³ At the same time, ubicomp itself is exciting because of the interdisciplinary nature of the research and development required to exploit these opportunities. Consequently, as ubicomp educators, we can inspire our students with technically challenging and socially impactful projects and can expose them to enriching experiences where they need (or are forced) to interact with professionals from different backgrounds.

Here, we make the argument for including international experiences in this already rich education and training space, reporting on our engagements on this front through two projects funded by the US National Science Foundation under the International Research Experiences for Students (IRES) program.

WHY INTERNATIONAL EXPERIENCES?

There are several key reasons to expose students to international experiences. First, research cultures differ between countries and regions. For example, in the European Union, researchers often organize international teams that include both industry and academic partners. In contrast, in the US, research

funding is more often awarded to academic institutions. Students can benefit from observing the strengths and limitations of such different systems.

Furthermore, ubicomp students ultimately must work toward creating systems that let people use technology that's embedded in the fabric of our everyday lives. To do this successfully, students should recognize that the world is a diverse place. They might believe this, even without first-hand experience in traveling to foreign countries, but they're much more likely to fully internalize this fact by spending time on foreign soil and interacting with people from those countries.

This is one aspect of an argument that Steve Jobs made in a 1996 interview in *Wired*: "A lot of people... haven't had very diverse experiences.... The broader one's understanding of the *human experience* [emphasis added], the better design we will have."⁴ IRES students gain this "human experience" living and working in a foreign country. More generally, we understand Jobs's argument as pointing out that there is a significant interplay between technology and society.

System designers are inspired, and informed, by exposure to their environments. International experiences expose students to different aesthetics, architectures, customs, myths, and politics, challenging them to identify

differences and similarities between what's familiar to them and what they're experiencing in the foreign country. This also further develops and sharpens their observation skills, which are critical when designing interactive systems for diverse users. These experiences also require students to design systems in their new environments, in collaboration with colleagues from those environments. Such exposures should lead to inspired and informed design. If our students are to follow careers with a global impact, these experiences should serve them well.

International experiences also help develop grit, or strength of character. During international experiences, students must overcome challenges by persevering at different tasks. In professional circles, they encounter unfamiliar research and education environments that have their own peculiar practices and customs. In social situations, they interact with people from all walks of life, from public transportation workers to shop owners and clerks to landlords. To be successful professionally (and socially), students must learn new customs and interact with new people, and this takes grit—which has been identified as a key ingredient in student success.^{5,6} We thus argue that international experiences can help students succeed in the classroom (and beyond) once they return to their home country.

LEADER SUPPORT

We asked 10 leaders in industry and academia about the value of having international experience, and seven responded:

Participating in an organization outside of the US fosters creativity by demonstrating how research can be conducted under different processes and perspectives, along with outstanding, rigorous and deep theoretical frameworks that will enrich the students' ability to create their own novel concepts. —Bo Begole, vice president at Huawei Technologies in San Jose and author of *Ubiquitous Computing for Business* (FT Press, 2011)

Students with international experience are exposed to a more diverse range of culture and viewpoints, learn to understand different methods and perspectives that make them more open minded, capable of thinking outside of the box, and are better prepared to tackle any issues and challenges with new and creative ideas. —Ellen Do, professor at Georgia Institute of Technology

Direct experience with other cultures helps to broaden people's perspectives and enables them to work better with folks from diverse backgrounds, something especially important when your work requires you to collaborate with people from around the world. —Maria R. Ebling, director of Embodied Cognition & Conversational Systems at the IBM T.J. Watson Research Center and Editor in Chief of *IEEE Pervasive Computing*

International experience provides you with the gift of being able to make a choice between your own behaviors and routines and those of other cultural contexts such that you can think out of the box, reflect on yourself, and, ultimately, make better decisions. —Florian Michahelles, head of the Web of Things Research Group, Siemens Corporate Research in Berkeley

International experiences are valuable because we learn about other people, other cultures, other ways of being, other value systems, and we thus approach asymptotically the status of full and humble personhood. —Michael Muller, Research Staff Member at IBM, ACM Distinguished Scientist, and IBM Master Inventor

I lived for four years in Switzerland—two at CERN during my PhD and two at ETH as a PostDoc—and found that the international experience was as important as what I learned technically in many ways. —Joseph A. Paradiso, Alexander W. Dreyfoos (1954) Professor in Media Arts and Sciences and director of the Responsive Environments Group at the MIT Media Lab

Human computer interaction means all humans, not just those from your corner of the world. —Garrett Weinberg, Siri Advanced Development, Apple

Finally, from a practical point of view, students with foreign experience have proven that they can adapt to change—that they can adapt to different cultural practices and management styles and overcome language barriers. These students will make confident employees who are more likely to take risks, ultimately helping their companies compete globally.

These are our own arguments for promoting international experiences, but we're certainly not the only ones who strongly favor exposing students to such experiences. We asked leaders who make hiring decisions in industry and academia to tell us why an international experience is valuable, and we present their responses in the "Leader Support" sidebar.

US STUDENTS IN GERMANY

Two of us (Andrew L. Kun and Orit Shaer) received funding from the US National Science Foundation to act as principal investigators (PIs), organizing summer experiences for undergraduate and graduate students at two labs in Germany (where the other two of us work). For three years, between 2017 and 2019, approximately six students will spend approximately nine weeks conducting research under the supervision of either Susanne Boll or Albrecht Schmidt, who will act as the host researcher. As of the writing of this article, the first cohort of six students is wrapping up its stay in Germany. The effort, led by Kun and Shaer, builds on an earlier three-year effort

co-led by Kun, which funded 18 students who conducted research with Schmidt between 2014 and 2016. Thus, we report here on the experiences of 24 students over four years.

In recruiting students, we encourage applications from women and members of groups that are underrepresented in fields related to science, technology, engineering, and mathematics (STEM). As a result, our student population has been diverse. Fifteen of the 24 students (63 percent) we supported were female. Four (including three women) were African-American.

The students have also had diverse academic backgrounds. Seventeen were undergraduates, and seven were graduate students. Seven attended state schools, while 17 went to private schools. Thirteen studied engineering, computer science, or math, while eleven were in other fields, including media arts and sciences, psychology, personal health informatics, and cognitive science.

To date, we have conducted surveys to assess the student experiences for the 18 students who spent time in Schmidt's lab. We also conducted a "mid-experience" survey with the six students who went to Germany in 2017. Our most important goal was to determine whether students viewed the program as worthwhile and beneficial, so we asked if they would recommend it to others. We received responses from 23 of the 24 students, all of whom said they would recommend such a program to others. Some quotes from their responses appear in Table 1.

We also asked the 18 students who have completed the program if they felt more like global citizens after the experience. Responses to this question were more varied, with 13 of 18 students unequivocally stating they felt more like global citizens after the program. However, the detailed responses reveal that the experience made our students think about the world carefully:

Yes and no. I'm more global than before, after seeing the numerous countries and cultures, I have

TABLE 1

Quotes from students responding to the survey question, "Would you recommend a program like this to other students?"

Student/year	Response
Student 1, 2014	I would highly recommend the program or programs like it to other students as a great way to collaborate on research and meet a lot of people working on interesting research projects.
Student 1, 2015	I truly consider this the opportunity of a lifetime.
Student 2, 2015	I already have recommended it to another student who ended up getting in! It was one of the most valuable experiences of my life.
Student 1, 2016	Yes. The lab is welcoming and a fun environment to work in. People are doing all types of work here, and you get the opportunity to learn about different types of research just by talking to students a few doors down. You also have the unique opportunity to travel some around Europe and to learn a lot more about German culture.
Student 1, 2017	Yes, this program exposes you to a lot of difficult stuff but does so in a way that ensures that you are safe and taken care of. It's really the best situation you could ask for. I know that no matter what I go through while I'm here, I will be okay. Everyone I have met is interested in helping me grow professionally and personally.

a better understanding of the world. But at the same time I realize how little of the globe I [have] actually seen/been a part of. —Student 1, 2014

I think yes. Being able to live abroad and going somewhere for a longer period of time without knowing anyone there is a slightly scary thing to do.... I now feel like I can acclimate to other environments and cultures relatively easily. —Student 2, 2016

Students are selected, prepared, and supported upon their return by the PIs (Kun and Shaer). In Germany, they are mentored by the hosts (Schmidt and Boll) and their teams, who help the students become lab members and engage in research and development that supports the host lab's goals. The teams also help involve the students in local culture and social activities.

The students carry out their research for approximately two months, under the direction of the staff of their host laboratory. In addition to research progress meetings held at the discretion of the local staff, a weekly "IRES staff meeting," involving the entire student cohort and one or both US PIs, is held using videoconferencing.

In these meetings, students present brief summaries of the status of their research projects. This keeps the US-based PIs informed about progress while also enhancing the sense of community for the students who are otherwise separated into different project teams. Later in the summer, the US PIs visit each site, and the IRES students present results from their research projects to the PIs, local hosts, and other guests.

Students also report on their experiences by creating blog posts with two tracts: one documenting their international experience in a general sense, and the other focused strictly on their research. Figure 1 shows pictures provided by students in the 2017 cohort reporting on their research and cultural experiences. After the summer session ends, students are encouraged to collaborate remotely with German and US researchers to prepare papers for peer-reviewed publications. To date, students have co-authored six peer-reviewed conference papers, and more are in preparation.

This summer, our IRES students, joined by the PIs, participated in the ACM Łódź Summer School on Methods in HCI. The summer school was organized by Schmidt's lab, in collaboration with local organizers at the International Faculty of Engineering

of the Łódź University of Technology. The school brought together international HCI experts and students from across Europe. The program included daily keynotes, followed by hands-on workshops and social events (see Figure 2). The workshops covered a wide range of HCI methods ranging from requirement gathering, physical prototyping of muscle-powered interfaces, and sketching interaction. In the words of one IRES student: "This experience was great not only because I got to learn from incredible researchers but because I also was able to meet fellow students of HCI from all over Europe. It was great to interact with the international HCI community!"

Funding opportunities for international student experiences are scarce, which is true for students interested not only in pervasive computing but other disciplines as well. However, the benefits of international experiences for students, and educators, are significant. Students gain a new perspective of their profession and the world as a whole. We have leveraged NSF IRES funding to deepen existing research collaborations while engaging in new, rewarding collaborative efforts. We encourage educators, as well as funding agencies, to find

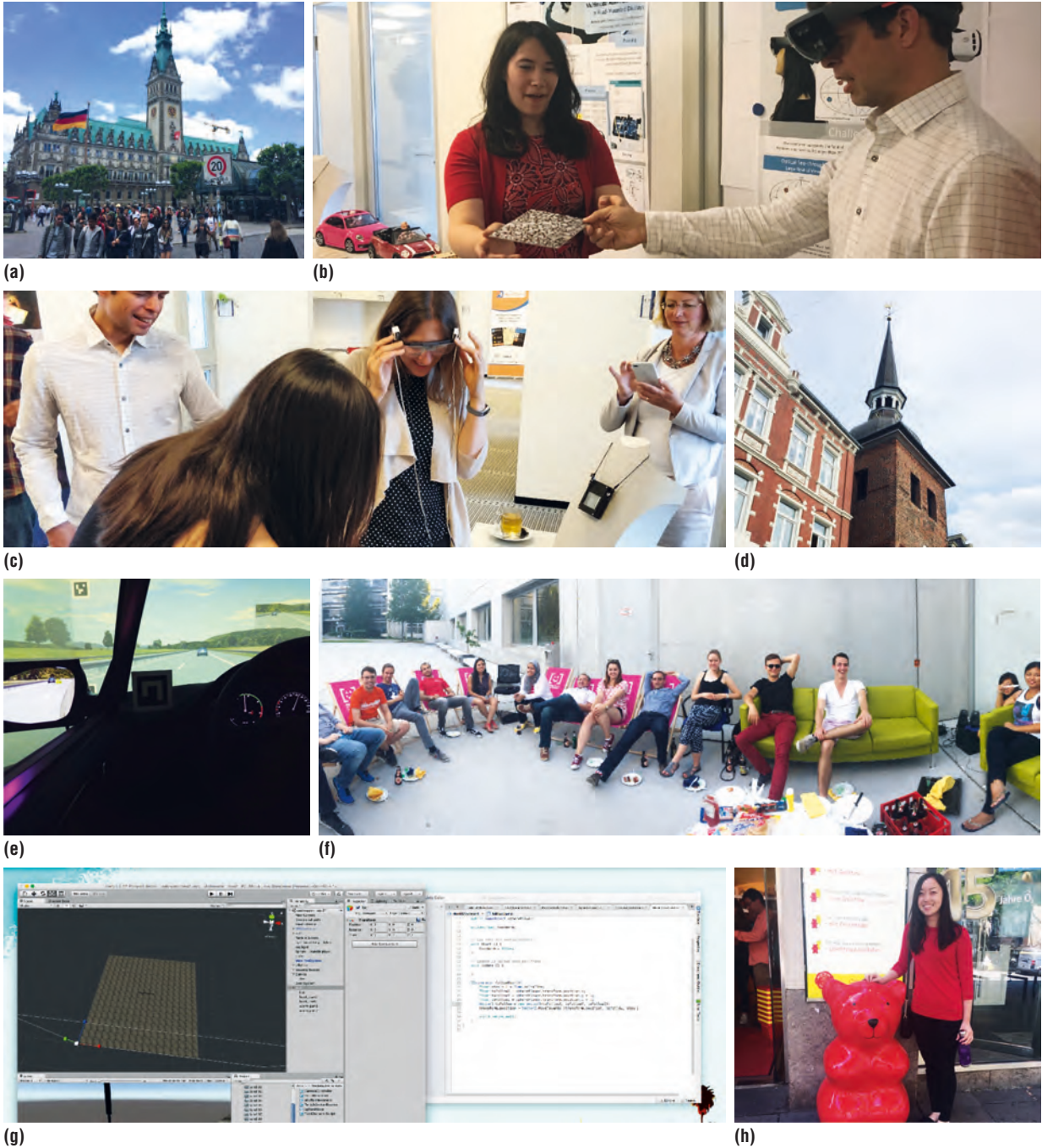


Figure 1. Six students conducted research in the summer of 2017 with either Susanne Boll in Oldenburg or Albrecht Schmidt in Stuttgart. The students supplied these photos: (a) visiting the port city of Hamburg, (b) experimenting with augmented reality glasses, (c) demonstrating a vibrotactile and auditory display, (d) viewing Oldenburg's Town Hall, (e) experimenting with ambient displays in a driving simulator, (f) attending a lab barbeque in Stuttgart, (g) developing software for augmented and virtual reality displays, and (h) stopping by a gummy bear advertisement while exploring the city.

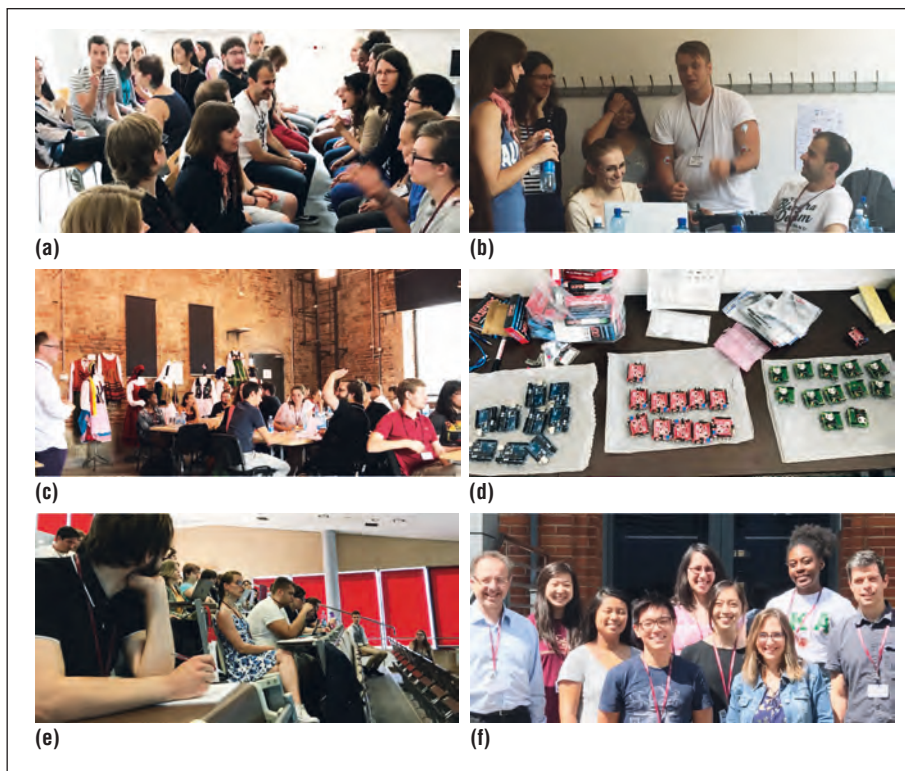


Figure 2. In the summer of 2017, six National Science Foundation (NSF) International Research Experiences for Students (IRES) students participated in the Summer School on Methods in HCI in Łódź, Poland, organized by Schmidt's lab in collaboration with local organizers at the International Faculty of Engineering of the Łódź University of Technology: (a) student introductions, (b) building functional prototypes, (c) group discussions in a historic mill building, (d) electronics for prototypes, (e) daily keynote lectures, and (f) the IRES team at the summer school—Schmidt (far left), Kun (far right), Shaer (front row, just left of Kun), and the six IRES students.

avenues (and funds!) to promote international student research experiences. And we encourage students to seek out opportunities to gain international experiences. ■

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