Enhancing Participation and Education in CS through Guided Research Projects in Underserved Communities

Yonina Cooper  
Carnegie Mellon University  
in Qatar  
P.O. Box 24866  
Doha, Qatar  
+974-4454-8641  
yonina@cs.cmu.edu

M. Bernardine Dias  
Carnegie Mellon University  
5000 Forbes Avenue  
Pittsburgh, PA 15213 USA  
+1-412-268-9365  
mbdias@cs.cmu.edu

Ermine A. Teves  
Carnegie Mellon University  
5000 Forbes Avenue  
Pittsburgh, PA 15213 USA  
+1-412-268-1289  
eteves@cs.cmu.edu

Sarah Belousov  
Carnegie Mellon University  
5000 Forbes Avenue  
Pittsburgh, PA 15213 USA  
+1-412-268-7147  
sarahtbw@ri.cmu.edu

M. Freddie Dias  
Carnegie Mellon University  
5000 Forbes Avenue  
Pittsburgh, PA 15213 USA  
+1-412-268-1289  
mfdias@ri.cmu.edu

ABSTRACT

While the needs and applications for computing technology have been growing, the enrollment and interest in Computer Science (CS) at the university level has not been growing in proportion. Moreover, the increasing prevalence of globalization requires a new set of skills for future technology leaders. These skills include the ability to work well in multidisciplinary and globally distributed teams, cross cultural boundaries with ease, create innovative solutions for problems that arise in unfamiliar settings, and think outside the box to solve a variety of problems while building effectively upon related work in the literature. These changes are also reflected in the growing interest among youth in global issues and how we can make a difference in underserved communities. This paper reports on our experience in designing and deploying an innovative internship that addresses these issues and seeks to enhance participation and education in CS through guided research projects in underserved communities.

Categories and Subject Descriptors
K.3.2 [Computers and Education]: Computer and Information Science Education – computer science education.

General Terms: Design, Experimentation, Human Factors.

Keywords: Guided research, globally distributed team, interdisciplinary research, internship education, multidisciplinary team.

1. INTRODUCTION

The increasing prevalence of globalization in today’s corporate culture demands a new set of skills for future leaders in technology. Students looking to pursue a career in the technology field now need to be able to work well in globally distributed teams that are diverse in cultural and professional backgrounds. In 2008, the TechBridgeWorld research group began designing and deploying an innovative internship that seeks to enhance participation and education in CS through guided research projects in underserved communities. The concept for this internship program developed from student interest in summer opportunities which combined research with impact in developing community settings. Students also desire global experiences which enhance their teamwork skills, provide them with ways to work with people from a variety of cultural, academic, and professional backgrounds, and prepare them for real-world problem-solving. Students seek such experiences to build relevant work skills particularly generally-useful skills for this age of globalization. These are the kind of experiences that future technology leaders seek when pursuing an education in CS and considering jobs post-graduation.

1.1 Related Work

The benefits of working in a research group, such as students developing domain expertise, gaining an understanding and appreciation of the research process and its practice, and acquiring team, communication, problem-solving, and higher-level thinking skills, are accepted within the university community and have been extensively reported in technical education conferences (e.g. [6], [9], [4]). Additionally research experiences enhance recruitment and retention of students in computer science ([3], [8], [2]). Interdisciplinary research ([4], [9]) and real-world problem research [1] have been reported for these purposes as well. Wenderholm [11] and Ward [10] have examined strategies for success in undertaking or building undergraduate research projects. Not only are these goals of the iSTEP program but also the larger task of introducing students to working in multidisciplinary and globally distributed teams to find innovative solutions to real-world problems. The value of
using such guided research (in physics) as a teaching methodology is presented in [5].

No literature was found that specifically addresses designing guided field research to be carried out by multidisciplinary, globally distribute teams. However the changing needs of industry due to globalization require technologists who have these additional skills to work across cultural and disciplinary boundaries and create innovative solutions that address a variety of real-world problems.

1.2 Contributions
The contributions of this paper are our internship model, deployment experience, and lessons learned. We first describe the components of the internship model created by TechBridgeWorld faculty and staff, followed by aspects of student preparation, needs assessment, technology, dissemination and team experience outcomes, and lessons learned from the first two years of the program. We conclude with a summary of the key points of the paper and a brief exploration of future work.

2. INTERNSHIP MODEL
In the summer of 2009, the TechBridgeWorld research group (http://www.techbridgeworld.org) in the School of Computer Science at Carnegie Mellon University launched a new internship program: iSTEP (innovative Student Technology ExPerience). iSTEP (www.techbridgeworld.org/istep). iSTEP provides Carnegie Mellon students and recent graduates from both the Pittsburgh and Doha campuses with an opportunity to work in a multidisciplinary and globally distributed team to develop needs-based computing solutions in collaboration with underserved communities. TechBridgeWorld’s primary hypothesis is that the iSTEP internship will provide a unique educational opportunity that enhances the research, teamwork, creativity, and leadership skills of talented and motivated students while introducing them to the different ways in which technology can impact underserved communities. The intern in the Needs Assessment Lead role will plan for and execute the projects. The community partners are the primary stakeholders. The iSTEP team for the next summer. Typically the partners and projects are determined in the previous summer, recruiting is conducted in the fall, and the team is chosen by the end of the fall.

The interns are selected to satisfy a diversity of skills. Key criteria for success in all the team roles are the willingness to work together as a team, willingness to work hard and be totally dedicated to the success of the team, ability to adapt to unforeseen and challenging situations, and ability to persevere and work towards success despite many challenges in living and working conditions. Field work in developing communities, especially when it involves technology, can be frustrating, very difficult, and even overwhelming at times, but in the end, the work is extremely rewarding and teaches the interns many important skills that will be useful in their future professional life.

2.2 The Team
The team of interns consists of several necessary roles. Key roles in the team are Technical Leads for each project, Technical Floater(s), a Needs Assessment Lead, and a Documentation Lead. The intern in the Needs Assessment Lead role will plan for and manage on-site relationships with partners as well as tasks such as explaining and obtaining consent forms from research participants and ensuring research compliance procedures are followed appropriately. The Technical Lead roles require the interns to manage and lead the design, implementation, and iterative enhancements to the technology solution for each project as well as participate in the needs assessment and dissemination tasks. The intern in the Documentation Lead role must effectively collaborate with all members of the team to capture the team’s experiences and stories through video, photos, and text in a creative and compelling manner, and format this content for distribution to diverse audiences. The interns in the Technical Floater roles focus on technology development (predominantly software development and troubleshooting) under the direction of the Technical Leads. At least one Technical Floater is always stationed at “home base” at our Pittsburgh or Doha campus and thereby ensures that the team has access to all of the infrastructure and resources available on campus.

The iSTEP teams have been multidisciplinary teams consisting of undergraduate and graduate students from the different colleges within Carnegie Mellon. For example, the 2009 iSTEP team included members from the School of Computer Science, the College of Humanities and Social Sciences, and the College of Engineering while the 2010 team hailed from the School of
Business, School of Computer Science, the College of Humanities and Social Sciences, the School of Information Systems and Management, and the School of Public Policy and Management.

2.3 The Partners

Working with a community partner is imperative to selecting projects that are feasible, relevant, and significant to the community as well as sustainable. Extensive interactions – e.g. visits, correspondence, phone calls, and online chats – with potential partners precede formalization of a partnership agreement and identification of project areas. TechBridgeWorld fundraises to cover operational expenses of running the program, the interns’ summer stipend and their international airfare and visa expenses. The partner provides local housing, local transportation and work space for the interns. Additionally the partners are instrumental in coordinating multiple aspects of the partnership, for example assisting with travel visas, research permits, and residency permits, connecting with local organizations as field partners for specific projects, establishing housing and transportation support for interns, and liaising between TechBridgeWorld and any local officials and local students involved with the projects.

Partners are chosen based on their understanding of the local community needs, their leadership in the community, and their capability to sustain the projects locally. The primary partner for iSTEP 2009 in Tanzania was the University Computing Centre (UCC), a limited-liability company owned by the University of Dar es Salaam (UDSM). UCC provides information and communication technology (ICT) products to both the UDSM community and the general public (www.ucc.co.tz). The primary partner for iSTEP 2010 in Bangladesh was the Asian University for Women (AUW) located in Chittagong, Bangladesh (www.asian-university.org). AUW is a leading institution of higher education based on the firm belief that education—especially higher education—provides a critical pathway to leadership development, economic progress, and social and political equality. Both 2009 and 2010 partners were enthusiastic about local university students becoming more involved with technology development and research projects. The local students work as liaisons to the community partners, facilitating communication between stakeholders and translating between the local language and English. They contribute significantly to the needs assessment process and to the design and testing of the technology solutions.

2.4 Research Projects

The projects are chosen jointly by the partners and the TechBridgeWorld team, and determine the required skill sets that in turn influence the recruitment of the interns. The projects often have some overlap with current or past TechBridgeWorld projects so that some of the developed expertise translates to the new projects. In addition, the projects must be scoped to have a significant component that can be completed within a ten-week internship. Examples of projects we have undertaken in the iSTEP program are creating a mobile phone tool for use by para-social workers to track information on services provided to AIDS orphans and vulnerable children, creating culturally-relevant educational technology and games for child literacy, and customizing a low-cost Braille Writing Tutor for visually impaired students. While projects are scoped to a certain degree before the internship begins, the needs assessment process when the interns arrive on site is vital in order to ensure that the final outcomes of each of the projects is relevant and has a positive impact on the community.

2.5 Logistics

Maintaining a good working relationship with the primary partner organization is critical to the success of the internship. As a result, TechBridgeWorld staff meets weekly with the partner to discuss administrative, legal, and financial issues related to the internship. The weekly meetings typically last one hour and are conducted via phone or online chat at a time mutually convenient for both parties. The meetings provide our partner with an opportunity to voice any concerns and provide us with the opportunity to discuss any concerns related to the safety and well-being of the interns.

Equally important is ensuring the professional and personal well-being of the interns. Thus, weekly meetings are held usually via online voice chat with the iSTEP team to discuss work updates and other concerns. Chats with all of the team members, as a group, highlight areas needing better team coordination as well as any potential team tension. Chats with individual team members are also held to address individual concerns.

An important aspect of TechBridgeWorld’s research philosophy is that the community partner invests significantly in the endeavor to ensure joint ownership and sustainability of outcomes. The primary investment that the community partners make for this internship model is to provide housing and local transportation for the iSTEP interns at no cost to the interns. For example, during the 2009 iSTEP internship, the interns resided in housing provided by the primary partner, two or three kilometers away from their workplace. Due to safety concerns, the interns were provided with transportation to and from the work location. In contrast, for the 2010 internship, the housing provided for the interns was on the site of the campus where they worked. In both cases, other transportation options were provided by the community partners as needed so that the interns and partners could conduct work at various field locations for the projects.

TechBridgeWorld provides guidance and feedback for every stage throughout the project including needs assessment, technology development, solution demonstrations, and project sustainability. A final presentation summarizing the interns’ work is given to the partners along with a final report, which formally documents the experiences and outcomes of the internship. Letters and emails are sent to community partners to thank them for their time, resources, and cooperation and to discuss sustainability options for the projects. The final report is also typically published in the form of a technical report.

3. STUDENT PREPARATION

Since there is no assumption that the interns have relevant prior knowledge, a six-week long preparation course plus some additional preparation sessions have been designed to prepare the interns for their summer work. Specifically, faculty members take the lead on introducing students to good research practices, teamwork skills, and preparation for the project work, and also supervise the projects. Staff members take the lead on logistical, financial, and legal matters pertaining to the internship, and also participate in some of the technical planning and development.
The interns are also provided with an emergency number which they can call at any time of the day and any day of the week. This number forwards any phone calls to a member of TechBridgeWorld who is on call and different members of the team take turns being on call during the internship.

3.1 Preparation Course
All selected interns are required to complete a six-week course designed to teach students the practical skills necessary to conduct field research in the context of an underserved community. The course is taught during the first half of the spring semester, and meets for one hour, twice a week at a time convenient for both the Pittsburgh and Doha campuses. Videoconferencing technology allows iSTEP team members at the different campuses to participate in the course sessions. The course is also open to students who are not participating in the internship and to those who wish to apply to iSTEP in future years. Various speakers are invited to speak to students about topics such as background information on the country and culture of the specific location of that year’s internship, challenges of research in low-resource environments, importance of project sustainability, understanding research requirements, and dissemination and marketing techniques. The course requires the interns to complete three significant group assignments: (1) a background research report on the iSTEP location to help the traveling team prepare for their work; (2) a work plan, which outlines the tasks for each of the team roles and for the team as a whole during the internship; and (3) a documentation and media plan. The interns then enroll in a six-week independent study course in the second half of the spring semester. This enables the interns to prepare independently for their specific team role.

3.2 Additional Preparation
In addition to the six-week course, the iSTEP interns participate in several other mandatory sessions. The team members traveling to the international location meets with the Study Abroad Coordinator from Carnegie Mellon’s Office of International Education (OIE) to learn how to prepare for their travel. This presentation includes information on administrative procedures, health and safety, culture, and the importance of journaling and self-reflection. The TechBridgeWorld team and the iSTEP interns also meet to discuss a variety of issues including travel, health, safety, research compliance procedures, logistics, and partner contacts. A reception is also hosted to provide an opportunity for the interns to meet with advisors. Additionally, the interns are provided with a medical kit to use in the case of illnesses, injuries, accidents, or emergencies.

4. OUTCOMES
Within the ten-week span of the internship, after the initial needs assessment, the iSTEP interns with the TechBridgeWorld team brainstorm possible solutions. At this phase, overextending is a possible pitfall and the team may need assistance in scoping a solution achievable in the ten-week timeframe. Typically the interns spend the first few weeks conducting needs assessment, they then spend a few weeks developing a prototype technology solution to address those needs, and then in the final weeks they run pilot field testing of the projects. The goal is to present the prototype to the partners and constituents in a timely manner so they can receive feedback and make modifications as needed as well as evaluate the solution. Thus far, the iSTEP interns have been able to implement prototype solutions for all projects and obtain initial feedback from the local partners.

4.1 Needs Assessment
Although the projects are chosen to address needs identified by the community partners, the iSTEP research interns conduct a more detailed needs assessment to explore the feasibility of these projects and the features needed for each solution, prior to developing prototypes and field testing. As part of the preparatory course they conduct initial research to educate themselves on the challenges that the partner communities face. However, on-the-ground needs assessment remains an important factor for success. This process also teaches the interns valuable soft skills such as initiating, fostering and maintaining a direct line of communication with the various communities based on honesty, mutual respect, and trust. Understanding the needs of the various communities involved also ensures that the solutions created are practical, sustainable, and relevant.

The needs assessment process often involves individual as well as group interviews. These interviews frequently reveal issues that were not manifested in the preparatory research or communications prior to arrival on-site. Failure to address such issues will result in solutions which are not sustainable. Developing solutions that are viewed favorably by the end-users is equally important for sustainability. Guided by results from the initial needs assessment phase, as well as feedback from the partner organizations, the interns begin designing and developing relevant technology solutions.

4.2 Technology Outcomes
The technology outcomes of the internship are largely based on the combination of the project requirements and the skills of the interns. Therefore the outcomes vary depending on the projects and the teams. Two examples of project outcomes are described next for illustrative purposes.

The first example, from iSTEP 2009, is a project where the interns were aiming to improve the efficiency of reporting information from rural social workers to the national database for orphans and vulnerable children (OVC). Based on the needs assessment conducted by the 2009 team, the most cost-effective way to transfer information from the social workers in rural areas to the district level administration was through SMS (text...
The interns designed a solution that used a key code style format SMS message similar to that used by the LINKS [7] project which they discovered during their literature review. In this solution scenario, each social worker is given a small card, which contains all of the codes to be used in the SMS message. The social workers use these codes to transmit specific information about the AIDS orphans and vulnerable children (OVC) they are serving via SMS to a central server, where the information is automatically processed into the national database.

A second example, also from iSTEP 2009, was related to improving English literacy education at a primary school in Tanzania. Given the lack of electricity and the challenges of teaching English at this school, the interns chose to implement an English literacy game on a mobile phone platform. The implemented solution consists of two parts: (1) a quiz-based educational game that students can access via mobile phones and (2) an online content authoring tool for teachers to create new content that can be downloaded to the phones.

### 4.3 Dissemination

Another important aspect of the learning experience through the iSTEP internship is effective dissemination. Throughout the summer the interns document their work and stories from the field, reach out to media to promote the partnerships and projects, and create a final report and presentation. Initial planning and understanding of the purpose of the dissemination aspect of their experiences and outcomes begin in the six-week preparation course. Interns created websites in both years of the iSTEP internship to convey information about the internship, team, projects, and partners (http://isstep2009.techbridgeworld.org and http://isstep2010.techbridgeworld.org). Given the effectiveness and popularity of social media, the interns have also shared their experiences and outcomes through Facebook, Twitter, Flickr, YouTube, and blogs. TechBridgeWorld also facilitates interviews between interns and local media. The final report provides a more formal documentation of the internship experiences and outcomes and is published as a technical report. Finally, the students prepare and deliver a variety of presentations to disseminate their work. Through these different modalities, the interns learn effective means of dissemination to a variety of audiences.

### 4.4 Team Experience

A final key element of the internship is the experience of the interns. The multidisciplinary and globally distributed nature of the team allows iSTEP interns to draw on the different strengths of their teammates and take advantage of resources available in different geographic locations. The internship also gives the iSTEP interns the opportunity to positively impact several communities. One intern reflected, “Seldom does one get an internship experience that allows students to conduct research and find their own solutions to problems that positively impact developing communities in the world.” Furthermore, iSTEP provides interns with the opportunity to interact directly with the people being impacted by the developed solutions. Another intern states, “Not many internships allow their participants to see how people interact with their work ... It completely changes the purpose of the work, to really know whom you’re developing for and to really understand why your work is valuable.”

The interns face many challenges and frustrations during the internship, mainly while they learn to deal with new environments and cultures. Furthermore, for most of the interns, this is their first experience conducting field research. “Field research, in my opinion, is a struggle. Field research involving people is even tougher. There are so many unknowns that it is impossible to anticipate everything.” However, the interns learn to adapt over the course of the internship and gain new skills and knowledge in problem solving despite the challenges. As one intern recommends, “It’s important to expect the unexpected and to react strategically and leverage my resources when those unexpected challenges arose.” “Despite the challenges, I still see this field as something I’m passionate about and want to do further work in.”

Figure 2. Interns from iSTEP 2009 and iSTEP 2010 interact with local community partners.

The interns also value and appreciate the importance of working closely with the communities. “Regardless of how wonderful and powerful the technology solution is, community involvement is the most important. Technology cannot overcome challenges on its own. Rather, the community and its people are the ones who can transform the technology into a solution.”

### 5. LESSONS LEARNED

In this paper we have described our internship model for providing guided opportunities for students to engage in computing research in real-world settings. The model is successful based on currently obtainable indicators. Next, we highlight some of the important lessons we have learned through the first two years of this program.

- Strong partnerships are vital and the partners’ time and effort must be valued and appreciated. Partners with technical expertise can be an asset to sustainability of the work.
- It is important to learn as much as possible about local constraints and operational procedures through partners and other means prior to the start of the internship.
- Preparation is essential. However, interns will not always remember what they learned once they are in the field and need reminders of key lessons throughout the internship.
- Team building is important since the interns will need to adjust to each others’ living and working styles.
- Working in a multidisciplinary team can be challenging but these challenges can be mitigated by establishing clearly defined team roles and value for each person’s skills.
- Accomplishing needs assessment, technology development, and field testing is challenging in a summer time frame of...
roughly ten weeks, but participating with all of these aspects of the research projects is highly valuable for the interns.

- Effective team communication between all involved parties is crucial. The interns working on-site in the community as well as those working remotely must communicate frequently and keep each other informed about progress.
- Documentation and dissemination are important aspects of this work and should be accounted for in planning.
- Structured deliverables help keep the team on track.

6. CONCLUSIONS AND FUTURE WORK
In this paper we have presented a new model for a computing research internship, sample outcomes and lessons learned from the program’s first two years. Feedback from the interns at the end of the internship program has revealed that they found iSTEP to be a positive experience and would recommend the program to their colleagues and friends. The interns’ response to a post-internship survey revealed they were also able to improve their research skills, real-world project learning, multidisciplinary team learning, globally-distributed team learning, cross-cultural experience, cultural knowledge of their community partner, creative problem solving skills, image of computing/technology, communication skills, leadership skills, and confidence. Furthermore, the interns felt that having a multidisciplinary team was important for the internship, that they were able to work well together in accomplishing tasks, and that being globally distributed was challenging, but useful to their work. The feedback from the interns each year is considered when organizing the following year’s internship so that the internship feedback from the interns each year is considered when planning. Structured deliverables help keep the team on track.

7. ACKNOWLEDGMENTS
We are grateful to the many people and organizations that have made this internship program possible. We especially thank our community partners, research interns, and advisors, in Pittsburgh and Doha who have participated in the planning and implementation of iSTEP. This research was supported in part by Yahoo!, the Qatar Foundation for Education, Science, and Community Development, the Qatar National Research Fund National Priorities Research Program grant #30-6-7-91, Carnegie Mellon University in Qatar, the Holleran Scholars Fund, the University Computing Centre, Ltd. located at the University of Dar es Salaam in Tanzania, the Asian University for Women, and discretionary gifts to TechBridgeWorld. The opinions expressed in this paper are solely those of the authors and do not necessarily represent the views of any of our sponsors.

8. REFERENCES