iSTEP Tanzania 2009: Inaugural Experience

Rotimi Abimbola, Hatem Alismail, Sarah Belousov, Beatrice Dias, Freddie Dias, M. Bernardine Dias, Imran Fanaswala, Bradley Hall, Daniel Nuffer, Ermine Teves, Jessica Thurston, Anthony Velázquez

CMU-RI-TR-09-33

The Robotics Institute
Carnegie Mellon University
Pittsburgh, Pennsylvania 15213

August 2009

August | 09

iSTEP Tanzania 2009

Inaugural Experience

August 14, 2009

iSTEP 2009 Interns:
Rotimi Abimbola
Hatem Alismail
Beatrice Dias
Bradley Hall
Daniel Nuffer
Anthony Velázquez

iSTEP 2009 Core Advisors:
Sarah Belousov
Freddie Dias
M. Bernardine Dias
Imran Fanaswala
Ermine Teves
Jessica Thurston

Carnegie Mellon

TechBridgeWorld

جامعة كارنيجي ميلون في قطر
Carnegie Mellon Qatar

Executive Summary

The innovative Student Technology ExPerience (iSTEP) is a new internship program offered by TechBridgeWorld research group at Carnegie Mellon University. iSTEP provides Carnegie Mellon students and recent graduates with an opportunity to work in a multidisciplinary and globally distributed team to develop needs-based computing technology solutions in collaboration with developing communities.

This year's iSTEP location was Dar es Salaam, Tanzania and the main community partner was the University Computing Centre (UCC), an information and communication technologies services organization based in the University of Dar es Salaam. The three projects created for the iSTEP 2009 internship were:

1. Information exchange protocol for para-social workers to report and receive information about AIDS orphans and vulnerable children (OVC) via SMS on mobile phones
2. Culturally-relevant educational technology game for enhancing children's English literacy
3. Braille Writing Tutor (BWT) for visually-impaired students

The three communities identified for these projects were para-social workers, primary school students, and visually impaired students in Tanzania. More specifically, the team worked with the Institute of Social Work (ISW) and Department of Social Welfare (DSW), Mlimani Primary School, and Uhuru Mchanganyiko Primary School, respectively.

Prior to the launch of the internship, the iSTEP 2009 interns completed a six-week mini course designed to prepare them for their summer work. The mini course, taught by TechBridgeWorld faculty member M. Bernardine Dias, included guest lectures and student-led presentations and discussions.

During the internship, the interns worked closely with the three communities to conduct needs assessment, develop appropriate technology solutions, and demonstrate those solutions. Near the end of the internship, the iSTEP 2009 team discussed project sustainability with these communities and delivered a final presentation to the UCC.

For Project 1, the team created a protocol for para-social workers to report and receive information about OVC via SMS (text message) on mobile phones. The team met with DSW to demonstrate the solution and discuss how the DSW can help with implementation. These interns also journeyed to the Tandika village to get feedback from some para-social workers. Overall, DSW received the developed solution very well, and TechBridgeWorld will continue to work with the different community organizations to further enhance and deploy the solution.

For Project 2, the team created a fun literacy game that can be played on mobile phones. The game provides exercises and quizzes to enhance the student user's English literacy skills and uses the scenario of a soccer (football) penalty kick to convert the exercises and quizzes into an entertaining activity that motivates children to learn more. The team of interns demonstrated the game to students and teachers at the Mlimani School and everyone enjoyed the game and found it easy to use. A team member also trained teachers to use the content authoring tool that was developed to complement the game. The authoring tool allows teachers to edit the educational content of the game to enhance lessons they are teaching in the classroom.

For Project 3, the team expanded upon the BWT in several ways. They started by adding the capability to provide instruction for writing Swahili braille and creating an audio menu to scroll between different modes on the tutor. With help from TechBridgeWorld staff, the iSTEP team also designed and implemented a MusicMaker game, which allows visually impaired students to create music using the BWT. The team successfully demonstrated the new capabilities of the BWT to students and teachers at the Uhuru School.

Overall, the inaugural year of iSTEP was a success. Technology solutions were developed based on the needs of its users, which all communities found useful. Furthermore, all solutions are at a stage for implementation and field-testing, which will be pursued by TechBridgeWorld and the UCC in the future. The iSTEP 2009 interns found the internship to be a unique experience filled with important lessons and new understandings. For the TechBridgeWorld team, the internship provided valuable insight for future iSTEP internships.

Acknowledgements

The iSTEP 2009 and TechBridgeWorld teams are thankful to the many people who made the inaugural year of our iSTEP internship a success! We would especially like to thank our main community partner, the University Computing Centre (UCC), who made it possible for us to conduct technology research projects in Tanzania: Professor Beda, Eric Beda Mutagahywa, Mama Duwe, Anthony Gesase, and Dorothy Mbonike. We would like to further thank the UCC for attending to the needs of our iSTEP 2009 ground team in Dar es Salaam. The teams would also like to acknowledge Mr. Mwakaje and Dr. Mwinuka from the University of Dar es Salaam for their assistance, as well as the University of Dar es Salaam students for their interest in continuing the research projects beyond the iSTEP internship.

We are extremely grateful to the Mlimani Primary School, the Uhuru Mchanganyiko Primary School, the Institute of Social Work (ISW), and the Department for Social Welfare (DSW) for their help with facilitating needs assessment and feedback for the three projects. We wish to thank Mr. Sipto; Mama Christina; Mr. Chikoti; Mr. Shayo; Mr. Pendo Naaman Kujerwa; and the teachers, and students from the Mlimani School for their assistance with the Literacy Tools project. We would like to acknowledge Mr. Noah, Mr. Ditrick Mkwela, Mama Mwalimu Mkuu Saidizi, Mr. Ngodu, the teachers, and students from the Uhuru Mchanganyiko Primary School for their help with the Braille Writing Tutor project. We are grateful to Dr. Theresa Kaijage, Bernard Sefu, Leah Omari, and Para-Social Workers from ISW for their help with the Social Workers project. We would also like to thank Sesil Charles Latemba and Prisca Mgomberi from the DSW for their help with the Social Workers project.

Special thanks are due to our iSTEP 2009 advisors, who guided the interns on the projects during the mini course and throughout the 10-week internship: Ameer Abdulsalam, Ed Barr, Tracy Baton, Brett Browning, Yonina Cooper, David Dausey, M. Freddie Dias, Imran Fanaswala, Wael Ghazzawi, Anna Greenstone, Karumuna Kaijage, Matthew Kam, Chris Labash, G. Ayorkor Mills-Tettey, Jack Mostow, Sorael Elias Nnko, Silvia Pessoa, Eric Pessoa, Roni Rosenfeld, and Jahanzeb Sherwani. Special thanks go to Matt Richards for his

presentation on documentation during the iSTEP 2009 mini course and to Christine Menand from the Office of International Education for leading the Work Abroad session with traveling students.

We are grateful to sponsors Paul Egerman, Don Shepard, and the Qatar Foundation for making the iSTEP 2009 internship financially possible. We wish to acknowledge Melissa Deschamps and Rachelle Emard from Student Affairs in Carnegie Mellon University in Qatar for all of their contributions to the internship.

Table of Contents

***APPENDIX IV:* LITERACY TOOLS PROJECT INTERVIEW QUESTIONS 158**

Table of Figures

Table of Tables

1. Introduction

In the summer of 2009, TechBridgeWorld launched iSTEP (innovative Student Technology ExPerience), a new internship program that provides Carnegie Mellon students and recent graduates with an opportunity to work in a multidisciplinary and globally distributed team to develop needs-based solutions in collaboration with developing communities.

1.1. TechBridgeWorld

The TechBridgeWorld research group at Carnegie Mellon University innovates and implements technology solutions to address sustainable development needs around the world. Founded in 2004 by Robotics Assistant Research Professor M. Bernardine Dias, TechBridgeWorld is pioneering research in the field of Information and Communication Technology for Development (ICTD).

TechBridgeWorld works closely with developing communities to create the essential technologies that will help them tackle their long - term challenges. This creation process is accomplished by inventing new tools, customizing existing technology, and inspiring a given community's future technologists. Coupled with the insight of partners in these developing communities and the knowledge and imagination of Carnegie Mellon faculty, staff, and students, TechBridgeWorld contributes its technical expertise to help realize a given community's vision of development.

Operating on the guiding principles of respect and empowerment, TechBridgeWorld does not go to a community uninvited and does not start a project unless a community has determined a need for TechBridgeWorld's expertise. TechBridgeWorld respects the communities it works with by staying true to their indigenous vision of progress. Moreover, TechBridgeWorld firmly believes that the community has an equal hand in coming up with and developing the solutions to their challenges. Furthermore, TechBridgeWorld aims to empower the communities it works with by creating locally relevant and sustainable solutions.

Since 2004, TechBridgeWorld has been working to fulfill its mission by developing numerous projects and programs, with a focus on education. Today, TechBridgeWorld's reach spans three continents: North America, Asia, and Africa. **Project Kané** explores the role that technology can play in improving English literacy in Africa using an automated English reading tutor. The **Automated Braille Writing Tutor** project explores the role that technology can play in improving braille literacy among visually impaired students in developing communities. The **Assistive Technology** project explores the role that technology can play in creating educational tools for both visually impaired and deaf populations in developing communities around the world. **Education e-Village**'s project objective is to create an online community for technology and development education between universities in developed and developing communities. **V-Unit**, or "Vision" Unit, is an independent study program for graduate students at Carnegie Mellon University to conduct non-traditional technology research. **iSTEP** is TechBridgeWorld's new internship program designed to give Carnegie Mellon students and recent graduates the opportunity to conduct technology research projects in developing communities.

Considered a leader in the field of ICTD, TechBridgeWorld organized the 3rd International Conference on ICTD, hosted at Carnegie Mellon University in Qatar in April 2009. ICTD 2009 (www.ictd2009.org) is the premier interdisciplinary conference on ICTs and international development. The conference's keynote speakers were Bill Gates (Chairman of Microsoft Corporation, and Co-Chairman of the Bill and Melinda Gates Foundation) and Carlos A. Primo Braga (Director, Economic Policy and Debt in the PREM Network at The World Bank). The conference was a great success, as over 300 participants from around the world came to Carnegie Mellon University in Qatar to participate in the conference's oral and poster presentations, demos, panels, and workshops.

For more information on TechBridgeWorld, please visit http://www.TechBridgeWorld.org.

1.2. iSTEP: innovative Student Technology ExPerience

The iSTEP internship was introduced in 2009 to provide a unique field experience opportunity for students interested in the field of Information and Communication Technology for Development (ICTD). TechBridgeWorld's primary hypothesis is that the iSTEP internship will provide a unique educational opportunity to highly talented and successful students, which will enhance their research, teamwork, creativity, and leadership skills while introducing them to the field of ICTD. A secondary hypothesis is that the project outcomes that result from this internship will positively impact developing communities, promote a positive image of computing technology, increase awareness and popularity of the ICTD field, and contribute to the ICTD literature. Our final hypothesis is that the combined outcomes of this internship will promote and enhance the mission of TechBridgeWorld.

The process diagram shown in **Figure 1** illustrates the principle components of the internship model, their relationship to each other, and their impact on the evaluation framework. Each of these components and their inter-relations are described in greater detail next.

1.3. Internship Model

- ***TechBridgeWorld Team:*** A principal component of the internship model is the role of the TechBridgeWorld (TBW) team. The TBW team plays the crucial roles of identifying partners, working with the partners to identify projects, selecting interns, inviting advisors, and working with the interns and partners to create the outcomes of the project.
- ***Partners:*** The partners are the primary motivators for the projects. They work with the TBW team to select the projects that will be of impact in their community and work with the students to make the outcomes a success. The project outcomes should primarily benefit the partners and their community.
- ***Projects:*** The projects are chosen jointly by the partners and the TBW team, and determine the required skill set that in turn influences the

recruitment of the interns, as the interns need to possess the right skill sets to successfully complete the projects. The projects will be ICTD projects and will have some overlap with current or past TBW projects so that some of the developed expertise will translate to the new projects.

- ***Interns:*** The interns are chosen by the TBW team in accordance with the skill sets required to successfully complete the chosen projects.
- ***Advisors:*** The advisors are Carnegie Mellon University faculty and staff, as well as others (external to Carnegie Mellon University) who have expertise relevant to the projects. These advisors are recruited by the TBW team and introduced to the interns. The advisors volunteer small amounts of their time to offer guidance to the interns and to answer their questions.
- ***Outcomes:*** The outcomes of the projects are created primarily by the interns with assistance from the partners and the TBW team, and with the advice of the advisors.

1.3.1. Program Evaluation Framework

- ***TechBridgeWorld Team:*** The TBW team records its interventions and contributes its observations to the evaluation of the internship.
- ***Partners:*** The partners contribute their feedback to the evaluation process.
- ***Interns:*** The interns contribute their feedback to the evaluation process.
- ***Advisors:*** The advisors contribute their feedback to the evaluation process.
- ***Outcomes:*** The outcomes of the projects are analyzed to provide additional input to the evaluation.
- ***Feedback to internship model:*** The results of the evaluation are used to refine and enhance the internship model for future years.

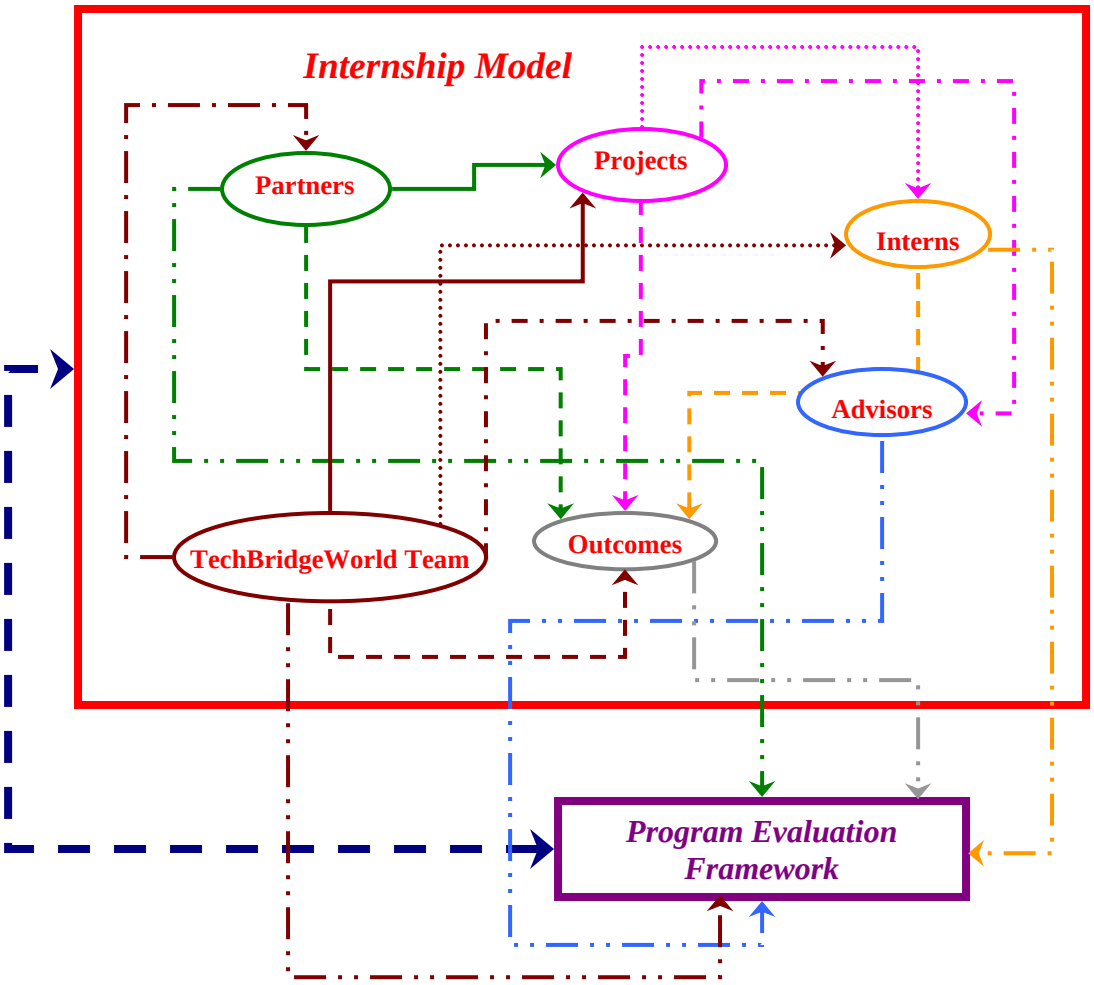

Figure 1: Process Diagram

1.4. Internship Logistics

To prepare the interns for the summer, the TechBridgeWorld team organized a six-week long mini course, a travel abroad session for those traveling to Tanzania, and a send-off session just before the launch of the internship.

1.4.1. iSTEP Mini Course

Once intern selections and acceptances were finalized, a meeting time was determined so that all students, faculty, and staff across Carnegie Mellon's Pittsburgh and Doha campuses could meet for the iSTEP

2009 mini course. The six-week mini course aimed to prepare interns for their summer internship experience by teaching them the practical skills necessary to conduct field research in the field of ICTD. Various speakers were invited to talk to students about the Tanzanian country and culture, challenges of research in low-resource environments, the importance of project sustainability, understanding research requirements, as well as the importance of documentation (photos, videos, etc.) and marketing and media.

The mini course commenced in the second mini of the Spring 2009 semester. The teams met Mondays and Wednesdays from 8:00 – 9:00 a.m. EST/3:00 – 4:00 p.m. GMT via videoconference from mid-March to the end of April 2009. A light breakfast was provided to students in Pittsburgh due to the unconventional class timing (the earliest typical university class time starts at 8:30 a.m. EST).

The mini course resulted in three major class assignments that the students engaged in and completed before the beginning of their summer internship. The interns created a background research report on Tanzania to help the traveling team prepare for their work. They created a work plan, which outlined the plans for each of the individual roles and for the team as a whole during the internship. The campaign assignment gave the team an opportunity to create a campaign and media plan to promote the three projects and the overall iSTEP program, which was incorporated into the actual media plan for the ISTEP 2009 internship.

1.4.2. Travel Abroad Session

Prior to the start of the mini course, the students set to travel to Tanzania met once with Study Abroad Coordinator Christine Menand from Carnegie Mellon's Office of International Education (OIE). In the one-hour travel abroad session, Christine spoke to students about how to prepare for their travel to and stay in Tanzania. Her presentation included information on Carnegie Mellon administrative procedures, health and safety, culture, and journaling and self-reflection. Christine also identified things to keep in mind while living and working abroad in Tanzania.

The interns were given a copy of the presentation slides as well as the Carnegie Mellon Study Abroad Handbook. During the session, the interns filled out forms for the OIE, including the Study Abroad Student Responsibilities Contract, Study Abroad Personal Data Sheet, and Study Abroad General Release and Waiver. The interns also filled out a visa application form for the TechBridgeWorld staff to process.

1.4.3. iSTEP Send Off

On Friday, May 22, the TechBridgeWorld and iSTEP 2009 teams met via videoconference to discuss any remaining issues prior to the start of the internship (Monday, May 25). The agenda for the meeting included discussions on travel health and safety, research compliance, logistics, and partnerships, and a reception with iSTEP 2009 advisors. TechBridgeWorld provided the traveling team with a medical kit from Carnegie Mellon Health Services in case of illnesses, injuries, accidents, or emergencies.

2. Team

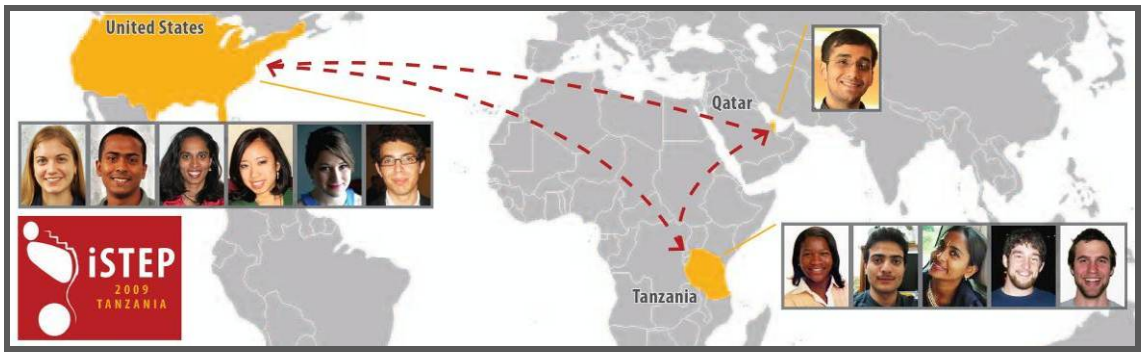

Figure 2: iSTEP 2009 Team

The inaugural iSTEP team was truly a multidisciplinary team consisting of undergraduate and graduate students and recent alumni from the different colleges within Carnegie Mellon University's Pittsburgh and Doha campuses. More specifically, the interns hailed from the School of Computer Science, the College of Humanities and Social Sciences, and the Carnegie Institute of Technology. During the internship, the globally distributed iSTEP 2009 and TechBridgeWorld teams conducted three technology development projects on the ground in Dar es Salaam, Tanzania and remotely from Pittsburgh, USA and Doha, Qatar.

2.1 iSTEP Intern: Rotimi Abimbola

Rotimi Abimbola is a rising senior at Carnegie Mellon University in Pittsburgh, PA. She is pursuing two majors, Political Science and International Relations, as well as a minor in African Studies. Rotimi is determined to pursue a career with a focus on politics and governance in Africa. She was born in London, England, but grew up in Nigeria in West Africa. In the summer of 2008, Rotimi worked in Senegal as an intern for ACEP, a microfinance group in the country. Her work with impact assessment and credit risk deepened her interest in the economics of developing countries. At

Figure 3: Rotimi Abimbola

Carnegie Mellon, Rotimi has been elected as the Student Body President for the upcoming academic year. She has also held several other leadership positions, including Chair of the Undergraduate Student Senate, Resident Assistant, Varsity Track and Field Athlete, and founding member of the African Student Organization.

Rotimi was our Needs Assessment and Evaluation Coordinator stationed in Dar es Salaam. Working with fellow intern Beatrice, she took the lead on needs assessment and evaluation of all three projects, and assisted with necessary field-testing.

2.2 iSTEP Intern: Hatem Alismail

Hatem Alismail graduated from Carnegie Mellon University's Doha, Qatar campus with a bachelor's degree in Computer Science and a minor in Mathematics in May of 2009. Over the last four years, Hatem has gained significant programming and project leading experience. His areas of interest include sustainable technology development. In particular, Hatem is interested in the creative use of widely available computing platforms, such as consumer grade cameras and cell phones. Hatem looks forward to pursuing a Masters degree at Carnegie Mellon's Robotics Institute in Pittsburgh this fall.

Figure 4: Hatem Alismail

Hatem was the team's Technical Lead for the Literacy Tools project. He was stationed in Dar es Salaam and took the lead on all technical development and testing for the project.

2.3 iSTEP Intern: Beatrice Dias

Beatrice Dias is in her third year as a Ph.D. student in the Engineering and Public Policy Department at Carnegie Mellon University in Pittsburgh. She volunteers with TechBridgeWorld to assist with marketing, events, fundraising, and strategic planning. She earned her undergraduate degree at Hamilton College in Clinton, New

Figure 5: Beatrice Dias

York with concentrations in Mathematics and Physics. Her current research involves measuring the impact of the USA PATRIOT Act and the Bioterrorism Preparedness Act on Microbiological Research in the USA. Beatrice is a native of Sri Lanka and hopes to pursue a career in policy evaluation.

Beatrice was the Dar es Salaam team leader and Monitoring and Evaluation Coordinator in Dar es Salaam. With fellow intern Rotimi, she also worked on needs assessment and evaluation for all three projects and assisted with necessary field-testing. Beatrice also conducted broader evaluation of the iSTEP program and other TechBridgeWorld projects.

2.4 iSTEP Intern: Bradley Hall

Figure 6: Bradley Hall

Bradley Hall is a Mechanical Engineering student at Carnegie Mellon University in Pittsburgh expected to graduate in May 2010. As a fifth year scholar this coming year, Brad will continue his undergraduate experience next year under a full scholarship. He is the current president of Engineers without Borders-CMU and works as the Community Adviser for Donner House, an on-campus student residence. He is also active in the American Society of Mechanical Engineers as its social chair and design project leader, as well as the Robotics Club and the Mechanical Engineering Student Advisory Board. Brad has worked as an engineering design intern for both Sensata Technologies and Blade Diagnostics Corporation. His professional interests are centered on designing sustainable technology solutions to problems faced by developing nations.

Brad took on the role of Technical Lead for the Braille Writing Tutor project and was working in Dar es Salaam, taking the lead on all technical development and testing for the project.

2.5 iSTEP Intern: Daniel Nuffer

Figure 7: Daniel Nuffer

Daniel Nuffer graduated in May of 2009 from Carnegie Mellon University in Pittsburgh with a bachelor's degree in Computer Science. He has completed two internships with Microsoft, in Redmond and in New York, and is particularly interested in programming languages and their applications. After the internship, Dan will be working for Jane Street Capital in New York.

Dan was the Technical Lead for the Social Workers Applications project and was stationed in Dar es Salaam. He took the lead on all technical development and testing for the social workers project.

2.6 iSTEP Intern: Anthony Velázquez

Figure 8: Anthony Velázquez

Anthony Velázquez is a rising senior pursuing a bachelor's degree in Computer Science from Carnegie Mellon University in Pittsburgh. He works with Development Solutions Organization, a student organization on campus, to raise awareness of global development issues and help connect peers with opportunities. He remains interested in issues revolving around computer science education and the intersection between technology and global development.

Anthony took on the role of Technical Floater in Pittsburgh, with the primary role of assisting the three leads with technology development for the three projects as needed, and the secondary role of assisting with report writing, media coordination, and logistics as needed.

2.7 TechBridgeWorld: Sarah M. Belousov

Sarah M. Belousov is a Project Manager for TechBridgeWorld and is based in the Robotics Institute at Carnegie Mellon University's School of Computer Science. Her primary responsibilities involve extending the activities of the TechBridgeWorld research group at Carnegie Mellon University's campuses in Doha and Pittsburgh through strategic planning, fundraising, logistical coordination, and administrative duties. She earned her bachelor's degree in International Studies and French at Johns Hopkins University and l'Institut d'Études Politiques in Paris, and her Masters degree in Public Policy and Management from Carnegie Mellon's H. John Heinz III College.

2.8 TechBridgeWorld: M. Bernardine Dias

M. Bernardine Dias is the Founder and Director of TechBridgeWorld, an Assistant Research Professor in the Robotics Institute at Carnegie Mellon University's School of Computer Science, and a member of the Computer Science faculty at Carnegie Mellon University in Qatar. Her research experience is in technology for developing communities, assistive technology, technology education, autonomous team coordination, and automated planning and navigation. Dr. Dias is a native of Sri Lanka. Her career goal is innovating means of developing and disseminating suitable and sustainable technology for empowering developing communities. She is a strong supporter and mentor for women in science and technology.

2.9 TechBridgeWorld: M. Freddie Dias

M. Freddie Dias is a Research Engineer for TechBridgeWorld and is based in the Robotics Institute at Carnegie Mellon University's School of Computer Science. He assists with robotics research in the Field Robotics Center, supporting projects related to multi-robot coordination. He also serves as a technical consultant for projects related to technology and development under TechBridgeWorld. His work in both categories bridges Carnegie Mellon University's campuses in Doha and Pittsburgh. Originally from Sri Lanka, he graduated from Hamilton College in New York with a double major in Physics and Computer Science.

2.10 TechBridgeWorld: Imran Fanaswala

Imran Fanaswala is a Research Programmer for TechBridgeWorld's Assistive Technology project. He is working at Carnegie Mellon University in Qatar and is involved on projects related to human-robot interaction, creation and deployment of assistive technologies for visually impaired and deaf populations, and tools to assist team coordination in disaster/emergency response. His goal is to add value to technology in order to improve quality of life. He graduated from the American University of Sharjah with a BS.c in Computer Science.

2.11 TechBridgeWorld: Ermine A. Teves

Ermine A. Teves is a Project Assistant for TechBridgeWorld and is an alumna of Carnegie Mellon University. She graduated in May of 2008 with a bachelor's degree in Business Administration with a concentration in Marketing. Her responsibilities include expanding TechBridgeWorld's programs, marketing, and fundraising efforts. In summer of 2008, Ermine spent 10 weeks in Bangalore, India interning with Microsoft Research India and the Mathru School for the Blind to field test the second version of the Automated Braille Writing Tutor.

2.12 TechBridgeWorld: Jessica M. Thurston

Jessica Thurston is an Administrative Intern for TechBridgeWorld and is an alumna of Carnegie Mellon University. She graduated in May of 2009 with a Bachelor's of Humanities and Arts degree in Urban Design and Professional Writing and a minor in Hispanic Studies. Jessica helps develop TechBridgeWorld's media materials and expand awareness of the research group on campus and around the city of Pittsburgh. As the group's administrative intern, she also does work related to program support and event planning for TechBridgeWorld. Jessica is now working toward her Masters in Public Policy and Management in the H. John Heinz III College.

3. Locations

Project work for this summer's internship was conducted in three locations: Pittsburgh, United States; Doha, Qatar; and Dar es Salaam, Tanzania. Carnegie Mellon University's campuses in Pittsburgh and Doha were the work locations for remote members of the team while five iSTEP interns worked on-site with partners in Dar es Salaam. Since the focus of this summer's projects was with partners in Dar es Salaam, Tanzania, we provide detailed background information on this location in section 3.1 as well as a few details on the Pittsburgh and Doha locations in sections 3.2 and 3.3.

Figure 9:
An Elephant at the Mikumi National Park

3.1. Dar es Salaam, Tanzania

Dar es Salaam is the largest city and former capital of the United Republic of Tanzania. A coastal city of over 2.5 million people, Dar es Salaam is an economic and educational hub within Tanzania and is the home of the country's largest university, the University of Dar es Salaam.[1]

> ***"Tanzania has historically been a harbinger of peace and tranquility in Africa. Over the years, the country has experimented with various social, political, and economic reforms that impacted millions of people. Despite these salient efforts, only modest achievements can be claimed to bringing about meaningful development. Tanzania continues to struggle with numerous social and economic problems. Diminishing investments in the education and health sectors; widespread corruption; and public mismanagement are at the root cause of most problems facing the country. However, there are promising signs of positive turnaround in the country, signified by an***

[1] "Dar es Salaam," Wikipedia article. Available at: http://en.wikipedia.org/wiki/Dar_es_Salaam.

increasingly transparent and accountable central government; an engaged citizenry; and the growing role of non-governmental organizations. Such transformations have led to a rise in entrepreneurship; increase in productivity and a myriad of international partnerships and collaborations that can only help Tanzania achieve its full potential. The iSTEP 2009 students have done a tremendous job in contributing to the long-term development of Tanzania. Their creative work and dedication will impact many live for years to come. I can only hope hat they will continue to build on the partnerships they have established while in Tanzania."

Karamuna Kaijage, iSTEP 2009 Advisor

3.1.1. Population and Geography

Figure 10: Sunset at the Mikumi National Park

Roughly 41 million people live in the United Republic of Tanzania. The majority of Tanzanians live in rural areas and 80 percent of the labor force is involved in the agricultural sector. The median age in Tanzania is 18 years and the average life expectancy is 52 years. Tanzania's land size is slightly larger than two times the size of the U.S. state of California, or roughly equivalent in size to the country of Nigeria. Its climate varies across the country and is tropical along the coast and temperate in the highlands.[2]

Tanzania is located in East Africa on the Indian Ocean. It shares its largest borders with Kenya to the Northeast and Mozambique to the South. Zambia and Malawi border Tanzania to the Southwest. Tanzania is bordered to the Northwest by Uganda, Rwanda, and Burundi and is across Lake Tanganyika from the Democratic Republic of Congo. During civil conflict in neighboring countries, Tanzania has been a safe haven for large numbers of refugees.[2]

[2] "History of Tanzania," Wikipedia article. Available at: http://en.wikipedia.org/wiki/History_of_Tanzania.

The natural beauty and diverse wildlife of Tanzania makes it one of the premier destinations for safaris and outdoor adventures. The top destinations in Tanzania are Mount Kilimanjaro, the Serengeti Plain, Ngorongoro Crater, and the island of Zanzibar, although there are many other smaller national parks as well as interesting towns and cities to visit.

Figure 11: Tanzania
Source: CIA WorldFactbook[3]

3.1.2. History and Government

The area of Tanzania has a long history of human settlement; in fact, some of the earliest settlements of mankind were located within the country's current borders. Some fossil bones and footprints from early human ancestors found in Tanzania are millions of years old. In northern Tanzania, such discoveries in and around the Olduvai Gorge have granted the area the name "The Cradle of Mankind."[2]

Pre-colonization in the areas of Tanganyika and Zanzibar, which later became modern-day Tanzania, were already melting pots of culture and commerce. The coastal regions were especially popular among merchants from the Persian Gulf and Western India. Kiswahili, a Bantu language, spread to Tanzania from Kenya, and was reinforced through trading partners in Africa and beyond. The peak of Swahili

civilization was 1200-1500 B.C.E. followed by strong influence from Europeans and Arabs who were interested in the physical and human resources of the land. In 1840, the Omani sultanate moved his capital to Zanzibar, and this area became the center of the Arab slave trade.[2]

Tanganyika was a German colony from the 1880s to 1919, after which it became a British protectorate under the League of Nations, until its independence in 1961. Zanzibar was historically a trading hub, which was controlled by the Portuguese, the Sultanate of Oman, and then the British until its independence in 1963.[2]

The United Republic of Tanzania was founded in 1964 when mainland Tanganyika joined with the Zanzibar archipelago. Zanzibar has a separate legal system from the mainland and enjoys autonomy in many areas of government. Dodoma serves as the legislative capital of Tanzania, although Dar es Salaam is still the location for most government offices.

Tanzania is a republic and was under one-party rule until 1995, when the first democratic elections were held in the country since the 1970s. Zanzibar's semi-autonomous status with the country as well as popular opposition have contributed to two contentious elections since 1995, which saw the ruling party win, despite concerns over fairness.[3]

Tanzania is known as one of the most politically stable countries in Africa today, in large part due to the leadership of its government, despite corruption remaining a major problem.

Tanzania's first president, Dr. Julius Nyerere, is still revered as a very distinguished figure in Tanzanian and African history. He had served as the leader of the former British protectorate of Tanganiyika and was able to ensure a peaceful transition from colonialism to independence. His government's Arusha Declaration in 1967 emphasized self-reliance and is seen as one of the most important political documents in the developing world. This concept of self-reliance led to certain unsuccessful economic policies, such as the implementation of community-based farming collectives.[4]

[3] CIA World Factbook – Tanzania, from the U.S. Central Intelligence Agency website. Available at: https://www.cia.gov/library/publications/the-world-factbook.html.


Figure 12: Former President Julius Nyerere (left) and Current President Jakaya Kiwete (right) Source: BBC News[4] [5]

Current President Jakaya Kikwete was elected to office in 2005 after several years of serving as the country's foreign minister. Kikwete has been working to continue economic reform policies started by his predecessor former president Benjamin Mkapa, yet he has also been a strong supporter of Nyerere.[5]

3.1.3. Economy and Development

Tanzania sits in the bottom ten percent of the world economies for per capita income. The nation's economy is heavily dependent upon agriculture, which accounts for more than 50 percent of its GDP, 85 percent of exports, and 80 percent of the labor force, and yet only 4 percent of Tanzania's land is used to cultivate crops. Tanzania's agricultural products include coffee, sisal, tea, cotton, cashew nuts, and tobacco and industries include agricultural processing, mining (diamonds, gold, iron), cement, oil refining, and wood products. The World Bank, IMF, and other foreign donors have provided funds in the past to revitalize Tanzania's aged economic infrastructure.[2]

---

[4] "Julius Nyerere: The conscience of Africa," *BBC News*, October 14, 1999. Available at: http://news.bbc.co.uk/2/hi/africa/441768.stm.

[5] Country Profile – Tanzania, *BBC News*. Available at: http://news.bbc.co.uk/2/hi/africa/country_profiles/1072330.stm.

Tanzania is one of several dozen countries, most of which are in Africa, which are approved as highly indebted nations and will receive a combined support of $51 billion in debt relief over time through a joint initiative between the International Monetary Fund (IMF) and World Bank.[6] Tanzania also receives high levels of financial and technical support from groups such as the United Nations Development Programme and the United States Agency for International Development. The U.S. government has also assisted Tanzania through PEPFAR (President's Emergency Plan for AIDS Relief), launched in 2003 to support global HIV/AIDS programs. Since 2004, Tanzania has received over $800 million in support through PEPFAR.[7]

In recent years, Tanzania has been working toward the United Nations Millennium Goal targets for poverty reduction. The country is currently on track to halve the proportion of people living below the poverty line by the 2015 target only in Zanzibar; progress on the mainland has been slower.[47] Despite continued high levels of poverty, Tanzania has experienced strong economic growth in recent years. The cancellation of a large part of their foreign debt through the IMF and World Bank initiative has been a great asset to Tanzania's economic growth. This growth has been negatively impacted by the current global economic crisis, although President Kikwete has announced that the country's economic growth was roughly 7.7 percent in 2008 and is still expected to reach a 7.3 percent growth rate in 2009, although original estimates were slightly higher.[8]

3.1.4. Language and Culture

Tanzania has a great deal of diversity, with citizens from over 120 ethnic groups, many of which have their own languages. Ninety-five percent of Tanzanians have Bantu origins. The official languages in

[6] "Debt Relief Under the Heavily Indebted Poor Countries Initiative" International Monetary Fund Factsheet, June 2009. Available at: http://www.imf.org/external/np/exr/facts/hipc.htm.

[7] PEPFAR – Tanzania. Available at: http://www.pepfar.gov/countries/tanzania/index.htm.

[8] "Tanzania Cuts 2009 economic growth forecast to 7.3%," *Ghana Business News*, January 2, 2009. Available at: http://ghanabusinessnews.com/2009/01/02/tanzania-cuts-2009-economic-growth-forecast-to-73/.

Tanzania are Kiswahili and English, although Arabic is also widely spoken, especially on the island of Zanzibar. On the mainland of Tanzania, the main religions practiced are Islam (35 percent), indigenous beliefs (35 percent), and Christianity (30 percent), although on the island of Zanzibar, more than 99 percent of the population is Muslim.[3]

This diversity is quite evident in Dar es Salaam, where people from different ethnic groups and lifestyles interact often and do so very peacefully. In TechBridgeWorld's staff and faculty members' first experience in Tanzania in the summer of 2008, the team saw men and women in business suits, women wearing dresses made of kangas, and Maasai families wearing their own traditional clothing all walking on the streets of Dar es Salaam.

3.1.5. Current State of ICT

Internet and computer use in Africa is still not very prevalent, and this is the case in Tanzania specifically. The figure below shows the small percentage of Internet users in Africa versus the rest of the world. According to the CIA World Factbook, the number of Internet hosts in 2008 in Tanzania was 24,271 and in 2007 users were 400,000, which is a very small proportion of Tanzania's total population.[3]

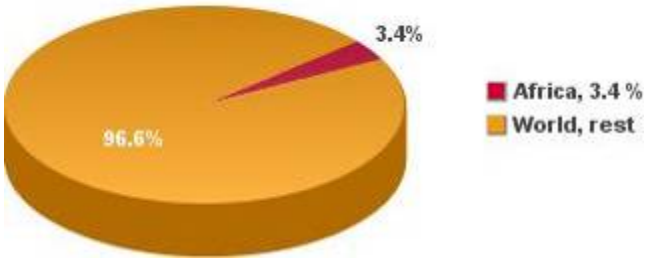

Figure 13: Internet Users in Africa vs. World, March 2009
Source: www.internetworldstats.com[9]

[9] "Internet Usage Statistics in Africa," Internet World Statistics, Copyright Miniwatts Marketing Group. Available at: http://www.internetworldstats.com/stats1.htm.

ICT Infrastructure and Usage in Tanzania	
Indicator	**Number**
Telephone lines	138,227 (2006)
Mobile phone subscribers	5.7 million (2006)
Internet users	333,000 (2005)
Television stations	29 (2006)
Internet hosts	8609 (2006)
Radio stations	47 (2006)

Table 1: ICT in Tanzania
Source: World Bank InfoDev Survey on ICT in Education in Africa, Tanzania country report[10]

Nevertheless, there are growing trends in the use of information and communications technology in Tanzania. A report on the rural-urban digital divide in Tanzania described a very fast increase in the number of Internet users in Tanzania from 60,000 in 2000 to 333,000 in 2005, a 455 percent increase.[11] A table summarizing the use of ICT in Tanzania (shown in **Table 1**) can be found in the country report on Tanzania from the infoDev Survey of ICT and Education in Africa.

From the table above, we can see that the most widespread ICT application in Tanzania is the use of mobile phones. "An alien landing in Tanzania could be forgiven for thinking that the only business here was the mobile phone. Over the last few years they have completely taken over the landscape," reported Simon Hancock from the BBC. Further, Hancock added, "some 97 percent of Tanzanians say they can access a mobile phone." Hancock also mentions "novel" uses of mobile phones. For example, fishermen in Zanzibar use their mobile phones to

[10] "ICT in Education in Tanzania," by Harry Hare, part of,Survey of ICT in Education in Africa, infoDev, July 2007. Available at: http://www.infodev.org/en/Project.7.html.

[11] "A Rural-Urban Digital Divide? Regional Aspects Of Internet Use In Tanzania," by Bjørn Furuholt Stein Kristiansen, Agder University College, May 2007. Available at: http://www.comminit.com/en/node/223792.

check current fish prices, and based upon that information they either sell their fish in Zanzibar, or head to Dar es Salaam for better prices.[12]

The boom of mobile phones in Tanzania is particularly interesting and is likely to have an impact on the development of the country in the future. It seems reasonable to assume that the use of mobile phone is an effective way of reaching a large number of people in Tanzania; however, the percentages of mobile phone access among particular groups in Tanzania remain unclear.

Some of the challenges faced by ICT projects in Tanzania include:

- High cost of deploying ICT
- Most projects use English as the main interaction interface, but the majority of Tanzanians are more comfortable using Kiswahili
- Frequent electricity and power outages make it hard to use computers and maintain them for a long time
- Inadequate ICT training and support staff to maintain projects involving the use of computers

3.2. Pittsburgh, United States

Carnegie Mellon University's main campus is located in Pittsburgh, a city of 310,000 people in the state of Pennsylvania.[13] Pittsburgh had a strong industrial past particularly in the early 1900s, when the region produced nearly half of the United States' steel. The strong industrial base also led to a tradition of philanthropy among some of the most successful business

---

[12] "Mobile phones boom in Tanzania," by Simon Hancock, BBC News, July 22, 2005. Available at: http://news.bbc.co.uk/1/hi/programmes/click_online/4706437.stm.

[13] "Pittsburgh dips to 60th in population among U.S. cities," by Brian Bowling, *Pittsburgh Tribune-Review*, July 1, 2009. Available at: http://www.pittsburghlive.com:8000/x/pittsburghtrib/news/pittsburgh/s_631739.html.

leaders in Pittsburgh. In this vein, steel industrialist and philanthropist Andrew Carnegie founded Carnegie Mellon University in 1900.[14]

Pittsburgh's steel industry declined by the 1980s, devastating the local economy and leading to increased unemployment among working families. Since then the local economy has made significant progress. Although some sections of the Pittsburgh region are still suffering as a result of the decline of manufacturing businesses, the fields of health care, biotechnology, and robotics have helped keep Pittsburgh's economy relatively stable during the current economic crisis. Pittsburgh recently celebrated its 250th anniversary and it is often ranked as one of the United States' most livable cities.[15] One of the most exciting announcements made over the summer of 2009 is that the city of Pittsburgh will be hosting the September 2009 G20 Summit.[16]

Carnegie Mellon University is one of the world's leading research universities, with especially strong programs in computer science, business, and the arts. Carnegie Mellon includes 10,000 students, 70,000 alumni, and 4,000 faculty and staff, the majority of which are connected to the Pittsburgh campus.[17]

3.3. Doha, Qatar

Doha is a quickly changing city of 400,000 people and is the capital of Qatar. The State of Qatar is a small peninsular nation with over 830,000 residents, the majority of which are foreigners. The al-Thani royal family has governed Qatar since the mid-1800s and the nation became independent from the British in 1971. Doha is now one of the largest construction sites in the world. Qatar's economic growth has remained relatively strong despite the current economic crisis. Qatar's economic

[14] Carnegie Mellon University – History website. Available at: http://www.cmu.edu/about/history/index.shtml.

[15] Allegheny Conference on Community Development, Pittsburgh 250 website. Available at: http://www.alleghenyconference.org/Pittsburgh250.asp.

[16] The Pittsburgh G-20 Partnership website. Available at: https://www.pittsburghg20.org/index.aspx.

[17] Carnegie Mellon University – About Us. Available at: http://www.cmu.edu/about/index.shtml.

strength comes primarily from its oil and natural gas industries. In the early 1900s, Qatar's economy depended on fishing and pearling; however; after the discovery of oil resources in the 1930s, Qatar's economy and wealth changed dramatically. The nation's leaders are currently working to diversity the Qatari economy into other sectors.[18]

Carnegie Mellon University joined Education City in Doha, Qatar in 2004 upon the invitation of the Qatar Foundation.[19] Education City is a unique initiative to increase educational and research opportunities for people within Qatar and the Middle East region. The Qatar Foundation has engaged six world-class research universities from overseas to establish branch campuses in Education City. Carnegie Mellon offers undergraduate programs in computer science, information systems, and business to students at the Qatar campus.

[18] Wikipedia article on "Doha,".available at: http://en.wikipedia.org/wiki/Doha. CIA World Factbook page on Qatar, available at: http://en.wikipedia.org/wiki/Doha.

[19] Carnegie Mellon University in Qatar – About. Available at: http://www.qatar.cmu.edu/about/.

4. Partner

The University Computing Centre (UCC) is a limited-liability company owned by the University of Dar es Salaam. The UCC provides information and communication technology (ICT) products to both the University of Dar es Salaam community and the general public, including but not limited to Internet and web development, web hosting, software development, PC maintenance, end user training, professional and diploma classes, and further ICT research.[20]

Figure 14: The University Computing Centre (UCC)

The UCC is known for excellent technology products and services as well as honesty and integrity in its business relationships. The UCC is headquartered at the University of Dar es Salaam with additional offices in the city centre of Dar es Salaam, as well as Arusha, Dodoma, Mbeya, and Mwanza. The UCC employs over 150 staff throughout the country that are mostly Tanzanian along with a few international staff.[21]

> ***"Professionalism, customer care and technological foresight set us among the best ICT Players in Tanzania and Region."***
>
> From the UCC Homepage, www.ucc.co.tz

In the summer of 2008, TechBridgeWorld faculty and staff were introduced to the Managing Director of the University Computing Centre, Professor Beda Mutagahywa, during a weeklong trip to Tanzania. We were impressed by our meetings with Professor Mutagahywa and his colleagues while in Dar es Salaam, and were very interested in pursuing a partnership that would leverage our respective strengths and interests.

[20] UCC website, About UCC. Available at: http://www.ucc.co.tz/about_ucc/background.php.

[21] UCC website, Staff list. Available at: http://www.ucc.co.tz/about_ucc/staff_list.php.

In addition to its business activities, the UCC has conducted several ICTD projects at the national and international level.[22] Professor Mutaghaywa indicated an interest in conducting new ICTD projects in the future. After a follow-up conversation to solidify our partnership in the fall of 2008, he connected us to Eric Beda who would be our main contact in managing our partnership and projects for the summer of 2009.

Eric Beda is a Systems Administrator in the UCC's UDSM Net Services Department; however, he had expressed an interest in facilitating research coordinated with the UCC and was enthusiastic to get University of Dar es Salaam students more involved with technology development and research projects. Eric was instrumental in coordinating multiple aspects of our partnership in Dar es Salaam, including assisting with travel visas, research permits, and residency permits, connecting with two local schools as partners for our specific projects, establishing housing and transportation support for our interns, and liaising between us and University of Dar es Salaam officials and students.

The University of Dar es Salaam (UDSM) is the largest institution of higher learning in Tanzania, offering a wide range of certification, bachelors, masters, and doctoral degree programs to over 20,000 students. Undergraduate programs alone include 63 undergraduate degree, four certificate, and five diploma programs. UDSM is also the oldest public university in Tanzania, fully established in 1970 through an act of parliament. The university began as an affiliate college of the University of London with a small law program of 14 students in 1961 and in 1963 it became a constituent college of the university of East Africa (along with Uganda's Makerere University and Kenya's Nairobi University College). The University of Dar es Salaam has a large, green campus located a few kilometers to the east of the city centre.[23] The University of Dar es Salaam is beginning to offer Distance Learning programs through the computer facilities at the University Computing Centre branch offices in Mwanza and Arusha.[24]

---

[22] UCC website, ICT for Development. Available at: http://www.ucc.co.tz/ict_development/is.php.

[23] University of Dar es Salaam website. Available at: www.udsm.ac.tz.

[24] UDSM/UCC Distance Learning program, Certificate in Computer Science for 2009.2010. Available at: http://www.udsm.ac.tz/store/2009-7-16-0-34-12_advertisement%20cert%20e-learning.pdf.

5. Project Overview

In discussions with partners in Tanzania in the summer and fall of 2008, TechBridgeWorld and the University Computing Centre identified three projects of interest for our Summer 2009 collaboration.

5.1. Social Worker Project

There is a great need for social workers in Tanzania, particularly to provide services to individuals affected by the country's HIV/AIDS epidemic. Currently the number of formally trained social workers is very small. To address this challenge, several groups in Tanzania are involved with training a corps of thousands of para-social workers to provide services to HIV/AIDS victims and their families, especially orphans and vulnerable children (OVC).

Figure 15: A Para-Social Worker

Technology can play a role in alleviating some of the tremendous burden placed on social workers that are attempting to serve the millions of children across Tanzania left vulnerable due to the onset of deadly HIV. Accurate data entry into central databases improves monitoring and evaluation of orphaned and vulnerable children, by providing more complete information for decision-making on how best to tackle this huge problem. Such databases exist in Tanzania, although there are difficulties in maintaining up-to-date and accurate information in the databases.

TechBridgeWorld learned about these challenges through meetings in the summer of 2008 with the Institute of Social Work, their partners from the Jane Addams College of Social Work at the University of Illinois at Chicago, and a non-governmental organization called WAMATA, which provides a variety of services to HIV/AIDS victims and their families. Dr. Theresa Kaijage, a faculty member at the Institute of Social Work and founder of WAMATA, facilitated all of these meetings. Our discussions

led to the idea that mobile phones could potentially improve methods of data transmission.

Since many people in Tanzania own or have access to a mobile phone, including many social workers and the growing network of para-social workers, we decided to focus the project on developing a mobile phone application that would help social workers transfer pertinent information more regularly into central databases.

Figure 16: ISW

TechBridgeWorld iSTEP advisors Roni Rosenfeld and Jahanzeb Sherwani assisted with gathering further information for this project during their brief visit to Tanzania in April 2009. They were able to conduct meetings with the Institute of Social Work and the Department of Social Welfare to learn more about how information is currently transferred by social workers through various local government levels up to national-level databases.

We decided that the Institute of Social Work and Department of Social Welfare would be important partners for assisting with our needs assessment process for the projects as well as identifying test groups of para-social workers for providing feedback on any technology prototypes. The Institute of Social Work is an academic institution that is working with several partners to train para-social workers as well as the trainers of new groups of para-social workers through programs throughout Tanzania. The Department of Social Welfare is a government office associated with Tanzania's Ministry of Health and Social Welfare. It currently maintains a national database of OVC.

5.2. Literacy Tools Project

At the time of Tanzania's independence in 1961, Tanzania had a literacy rate of only 30 percent.[49] Partially through government campaigns, the current adult literacy rate in Tanzania has drastically improved since independence to 69.4 percent[3] and some statistics have shown this rate to be even higher. Although Kiswahili is the national language in Tanzania, English is taught in schools and is an important language for both

educational and employment opportunities. Most teachers of English classes are not native speakers, so teaching children English can be a challenging process.

The iSTEP team sought to develop a program that would help enhance English literacy skills by playing educational games relevant to the local culture on technological devices. We expected technological resources at local primary schools in Tanzania to be limited, so we planned to evaluate the technology opportunities locally during our needs assessment.

Figure 17: Students at the Mlimani Primary School

The University of Dar es Salaam campus includes a public primary school called Mlimani Primary School where children from the local community attend classes. iSTEP advisor Karumuna Kaijage attended this school as a child, and the TechBridgeWorld team learned from him that it has an active alumni organization with former students now living all over the world. Eric Beda from the UCC visited the Mlimani School in advance of the iSTEP interns' arrival in Tanzania to gauge the school's interest in collaborating on a project to explore educational games for improving literacy skills provided through computing technology. The UCC was willing to facilitate usage of a computer lab for the project if needed.

The Mlimani School includes approximately 1,500 students, many of which are from families with limited resources. There are about 42 active teachers at the school and it is common for individual teachers to teach a variety of classes. They teach Tanzanian Standards 1 through 7. Each classroom has 60 students on average. As is the case for all public primary schools in Tanzania, the Mlimani School teachers also instruct classes in Kiswahili, except in the case of English, which is taught as one subject out of nine in total. The Mlimani School does not have electricity or computers, and in general has very few educational materials and poor infrastructure.

5.3. Braille Writing Tutor Project

The availability of trained teachers to educate visually impaired students in Tanzania is rather limited. Thus, there is a great need for additional educational resources that will enable these children to realize their potential. Learning to write braille is an essential skill but can be a difficult process for visually impaired students. In developing communities, the most common braille writing tool is the slate and stylus, which is typically a plastic or metal frame in which a piece of paper is inserted and dot patterns, which correspond to letters, are imprinted with a stylus. Writing with a slate and stylus requires students to write dot patterns backwards so that the paper can be removed, flipped over, and read forwards. Learning to write braille in this way can be very challenging, especially for younger students who may have difficulty understanding basic braille concepts.

Figure 18: A student and teacher using the BWT at the Mathru School, Summer 2008

Over the past few years, TechBridgeWorld has worked with a small number of schools for the blind to address the challenges associated with learning to write braille. The idea of a computing device based on the traditional slate and stylus was initiated during TechBridgeWorld student researchers' communications with the Mathru School for the Blind near Bangalore, India. TechBridgeWorld developed the resulting Automated Braille Writing Tutor through dialogue between Carnegie Mellon researchers, blind adults in United States, and continued discussions with the Mathru School, as well as feedback from other colleagues and overseas partners.

A low-cost braille writing tutor can be useful to teachers who lack resources or are overwhelmed by the number of students they are responsible for. The advantages of the Automated Braille Writing Tutor are that it is low-cost, has low-power requirements, is easily operated and understood, and works in harmony with the traditional method of learning braille by slate and stylus. Before this summer's work, TechBridgeWorld researchers had already created language capabilities in English, Arabic, Chinese, and French braille as

well as a few educational games. The tutor's software has been designed to be easily customizable for multiple languages and modes.

The UCC knew of a blind school in Dar es Salaam, and Eric Beda from the UCC visited the Uhuru Mchanganyiko Primary School to discuss a potential collaboration in advance of the iSTEP interns' arrival in Tanzania. The Uhuru School has a diverse range of students. Those who are visually impaired take classes through the blind section at the school but eventually are integrated with sighted students. Eric explained our interest in collaborating and our past work to officials connected to the Uhuru School. The school has a small computer lab that we felt could be a benefit to this project.

Figure 19:
A Classroom in the Uhuru School

The Uhuru School is a large public primary school located in the Ilala district of Dar es Salaam. The school includes approximately 900 students, including 90 visually impaired students, 12 deaf/blind students, and several students with mental or developmental disabilities. Some of the children with disabilities live on the school premises year-round. The Uhuru School employs 58 teachers, 14 of which are specialists in teaching visually impaired students and 16 of which specialize in teaching deaf/blind students. All subjects are taught in Kiswahili, with the exception of English. They teach Tanzanian Standards 1 through 7, and also offer some extracurricular classes.

6. Community Overview

In advance of their summer work, the iSTEP interns conducted background research on the challenges of our partner communities in general to better understand the potential obstacles and opportunities they could face during their summer research.

6.1. Social Worker Project

The main issue affecting social work in Tanzania is the impact of the HIV/AIDS epidemic. iSTEP students researched issues surrounding HIV/AIDS, OVC, and social work in Tanzania in advance of their summer work.

6.1.1. HIV / AIDS

Scientists first identified the Human Immunodeficiency Virus (HIV) in 1983 as the cause of Acquired Immunodeficiency Syndrome (AIDS).[25] As of 2007, an estimated 33 million people across the globe were infected with HIV.[26] This disease has evolved into an epidemic that devastates the lives of millions of people in the world. AIDS is the final stage of HIV, at which point the body can no longer fight infection that then leads to death. Therefore, exposure to infectious diseases can prove to be fatal for a person living with HIV. Recent developments in medicine have successfully prolonged the lives of HIV patients; however, the disease remains incurable once contracted. Thus, great efforts have been made to promote awareness about the disease as well as practices that can help prevent transmission of HIV.

[25] Centers for Disease Control and Prevention. Available at: http://www.cdc.gov/hiv/resources/qa/qa3.htm.

[26] UNAIDS; Global Facts and Figures. Available at: http://data.unaids.org/pub/GlobalReport/2008/20080715_fs_global_en.pdf.

6.1.2. Orphans and Vulnerable Children (OVC)

In the United States, the prevalence of HIV/AIDS among adults (aged 15-49) was approximately 0.6% in 2007; in contrast, prevalence among Tanzanian adults was 6.2%, an order of magnitude greater. Furthermore, Tanzanians are at a high risk of contracting other infectious diseases such as hepatitis A, typhoid fever, and bacterial diarrhea. HIV renders people more susceptible to infection, so exposure to these diseases increases the likelihood that HIV-positive Tanzanians will develop AIDS, which is terminal. In fact, in 2007 alone, Tanzania reported 96,000 deaths due to HIV/AIDS. As a comparison, in the same year, the U.S., which has a population of about 10 times that of Tanzania, reported 22,000 HIV/AIDS-related deaths.[27] This staggering statistic on adult mortality in Tanzania has left about 970,000 children (aged 0 to 17) parentless and in an extremely vulnerable position.[28] The number of OVC in Tanzania varies greatly. The HIV/AIDS Twinning Center reports that "nearly 2.5 million Tanzanian children have been orphaned or made vulnerable by HIV/AIDS, and the number is expected to reach 4 million by 2010 if effective prevention and treatment measures are not implemented."[29]

Poverty is another factor that further cripples those afflicted by HIV and AIDS. According to the World Bank, 36 percent of the Tanzanian population falls below the national poverty line.[30] Women's e News reports that "the vast majority of the population lives on less than $2 a day."[31] Economic hardship exacerbates the HIV/AIDS epidemic by

[27] CIA World Fact Book. Available at: https://www.cia.gov/library/publications/the-world-factbook/index.html.

[28] UNAIDS profile on Tanzania. Available at: http://www.unaids.org/en/CountryResponses/Countries/united_republic_of_tanzania.asp.

[29] HIV/AIDS Twinning Center, Tanzania Social Work Partnership Launches Training to Support Orphans, Vulnerable Children. Available at: http://www.aiha.com/en/WhatWeDo/TC%20FIELD%20NOTES/TC%20Field%20Notes%2002-WINTER2007/TC%20Field%20Notes%20W2007%20PDFs/TCFNW07-ISW%20Launch.pdf.

[30] Tanzania at a glance, World Bank Data & Statistics. Available at: http://devdata.worldbank.org/AAG/tza_aag.pdf,

[31] Damaso Reyes, "Tanzanian AIDS Clinic Offers Frayed Lifeline". Available at: http://www.womensenews.org/article.cfm/dyn/aid/2766/context/archive.

limiting the healthcare resources accessible to patients. The social stigma concerning HIV/AIDS is an added burden borne by Tanzanians who contract the disease as well as their families and loved ones. Women face additional social condemnation for contracting the disease: Even if they were infected by their husbands, women are often blamed for bringing the disease into the family.[31] The Tanzania Commission for AIDS reports, "Mother-to-child transmission appears to be on the increase, as more and more women continue to become infected and pregnant. The youth and the women have been the most affected groups because of economic, social-cultural, biological and anatomical reasons."[32] Fear of being ostracized deters many from even getting tested for HIV and therefore contributes to the continued spread of the deadly virus.

With an ailing adult population, the country's youth have fallen into the impossibly difficult position of caring for themselves and in many cases for their younger siblings as well. School dropout rates are as high as 30 percent during the seven years of primary school and 20 percent in secondary school, according to the Deputy Minister for Education and Vocational Training. These rates are on the rise, as reported by President Jakaya Kikwete in one of his monthly national addresses.[33] The situation is dire for these children as evidenced by the poignant story of Rehema, a 13-year-old HIV/AIDS orphan who became a victim of abuse at the hands of her guardians and later fell into a life of prostitution and drugs. Ultimately, HIV claimed her life, and her baby was left at risk of suffering a similar fate.[34] This type of story is not uncommon among Tanzanian youth, who are in desperate need of assistance and guidance.

---

[32] Tanzania Commission on AIDS, HIV/AIDS in Tanzania. Available at: http://www.tanzania.go.tz/hiv_aids.html.

[33] TANZANIA: Concern over school drop-out rate. Available at: http://www.irinnews.org/Report.aspx?ReportId=72628.

[34] Keely Stevenson, "An AIDS Orphan's Journey: We Know, but Do We Care?" Available at: http://www.socialedge.org/blogs/from-tribeca-to-tanzania/archive/2007/03/28/an-aids-orphan-s-journey-we-know-but-do-we-care.

6.1.3. Social Work in Tanzania

Figure 20: The iSTEP team with Dr. Theresa Kaijage

With the increasing number of HIV/AIDS adult deaths, the concurrently rising number of OVC, and the breakdown in family support structures due to greater migration of rural people to the city, there is an equivalent escalation in need for social workers to provide care to those affected.[35] Although need is abundant, human and financial resources available to social welfare groups is limited at best. Dr. Theresa Kaijage, the founder of WAMATA (People's Groups Fighting Against AIDS in Tanzania), points out that much of the development aid that comes in does not go through the government so as to circumvent bureaucratic delays. However, this results in less assistance flowing to NGOs, who in turn have to compete for these scarce funds.[36] WAMATA provides preventative as well as supportive services, by way of counseling, to HIV/AIDS victims. However, continuing their work with insufficient resources is a constant challenge.[31]

Tanzania needs at least 8,000 additional social workers, according to the Institute of Social Work (ISW), to meet the current demand for services. To meet this need the ISW is working with partners to train para-social workers, many of which are already community development officers or representatives of community-based organizations.[35] These para-social workers can aid in bridging the gap between the number of trained social workers and the number of needed social workers. An estimated two-thirds of Tanzania's 127 districts are left with no social welfare support due to a lack of trained welfare workers. Thus, in 2007, the HIV/AIDS Twinning Center

[35] Dan Dickenson, Tanzanian care revolution begins. Available at: http://news.bbc.co.uk/2/hi/africa/7239047.stm.

[36] Theresa J. Kaijage, HIV and AIDS: The Global Inter-Connection: There are lessons to be learned. Available at: http://www.undp.org/hiv/publications/book/bkchap20.htm.

joined with the Tanzanian Institute of Social Work and the University of Illinois at Chicago's Jane Addams College of Social Work and the Midwest AIDS Training and Education Center to launch their Para-Social Worker Training Program, "designed to arm community-based caregivers with critical skills needed to help improve the lives of orphans and vulnerable children (OVC)."[37] Through their efforts, these organizations have trained 516 Para-Social Workers, 40 district social workers, and 55 master trainers in Tanzania. Together, they are able to meet more of the demand for this invaluable service in the country, and "more importantly, the newly trained Para-Social Workers are identifying new children and families in need and connecting them with critical support and assistance." [37] However, the supply of social workers still falls short of the number needed to reach all OVC around the country, and therefore there may be many children in Tanzania who are left without support.

Social workers and community-based para-social workers can provide OVC with at least a portion of the care they would have received from a loving parent or guardian. Home visits are conducted to gather information on the children and their current situation. Christine Mummert, Vice-chair of the Board of Division for Global Mission, talks about how arduous home-visits in rural Tanzania are compared with the home-visits she conducted in Philadelphia.[38] Getting to the homes was difficult in itself, she has described, as one must work his or her way through dirt roads and a maze of pathways. Coupled with this issue is the extremely dire situation of those residing in these communities. Many people live in basic mud and stick huts with few amenities. She encountered single parents, relatives, and siblings caring for each other, just trying to survive. The group she was with, HUYAWA, was able to offer some aid in the form of food and medical care, which are scarce in these communities. Additionally, social welfare organizations such as HUYAWA, the Institute of Social Work,

[37] Twinning Center, "Building Capacity to Provide Comprehensive Care and Support to Orphans and Vulnerable Children." Available at: http://www.twinningagainstaids.org/documents/OVCProgramOverviewSummer2008_001.pdf.

[38] Christine Mummert, Home Visits to AIDS Orphans in Africa From a Social Worker's Perspective: Available at: http://www.standwithafrica.org/stories/mummert1.asp.

and WAMATA provide OVC and their families with school supplies, counseling services, and advice on a range of life-skills such as caring for family, managing with a small budget, as well as family planning and HIV/AIDS prevention.[39]

Furthermore, there is a national effort to monitor and evaluate HIV/AIDS data in Tanzania by way of the Tanzania Output Monitoring System for HIV&AIDS (TOMSHA). This national system is dedicated to collecting information on the impact of the disease in Tanzania, which includes data on OVC. The Department of Social Welfare maintains a database specifically on OVC. The hope is such monitoring will enable leaders to make more informed decisions on how to combat the spread of and devastation caused by HIV/AIDS in the country.

6.2. Literacy Tools Project

As a former educator, Tanzania's first president, Julius Nyerere, emphasized the importance of education and the instruction of the Kiswahili language in post-independence Tanzania. During Tanzania's first two decades of independence, the country experienced dramatic increases in primary school enrollment. The institution of Kiswahili as a national language was one of President Nyerere's most enduring legacies.

> ***"For poor people like us, education should be an instrument of liberation."***
>
> **Julius Nyerere, first president of Tanzania**

Literacy statistics in Tanzania are relatively strong compared to other countries in Sub-Saharan Africa. However, since English is offered as a second language in addition to Kiswahili language training, and since most

[39] Dan Dickenson, "Tanzanian care revolution begins." Available at: http://news.bbc.co.uk/2/hi/africa/7239047.stm.

teachers in Tanzania are not native English speakers, there are challenges in instructing students in English.

6.2.1. Timeline and History of Education in Tanzania[40]

Pre-1880s: Formal education was introduced in the 1860s and 70s. The structure of the educational system at this time was one that focused on cultivating the "good citizen" during colonialism. The older system of education was still very much prevalent in less developed and colonized areas, with the elders in communities educating the children.

1885-1918: The early colonial period in Tanzania was marked by the reinforcement of formal education under German rule, in 1893. In the same year, the first government school was created. The impact of the First World War had a negative effect on formal education in Tanzania.

1919-1945: There were several missionary and government establishments focusing on enhancing the education system. Missionaries and government appointed educators began to work together to enhance the education system. The first Director of Education was appointed in 1920. By 1945, there were 92 government and native authority schools.

1946-1960: At this time there were many anti-discriminatory initiatives from civil society in order to push for an inclusive education system, despite great income disparity. Local authorities fought for more power to provide oversight to the education system in the communities they represented.

1961-1970: Up to independence, all or part of the territory of Tanzania was ruled under trusteeship agreements by former colonial powers and the United Nations. The first political party in Tanzania, Tanganyika African National Union (TANU), pushed the trusteeship government to open more technical schools, as well as created a separate Ministry of education. During this post-independence period, the previous education system, which was put in place by the colonial powers, was

[40] Content obtained from "A Brief History of Education in Tanzania," Tanzanian Education Network. Available at: http://tenmet.org/public_html/index.php?option=com_content&task=view&id=19.

abolished. The government did not allow for private primary schools in an effort to open education to as many students as possible. Most schools were nationalized, and enrollment increased drastically.

1971-Early 1990s: A universal primary education program that was introduced all over the country. The government eventually began to allow for primary schools to be privately owned and run. During this time there was a massive surge of enrollment into the school system, because the government abolished school fees. By 1984, the government returned to the system of attaching fees to education for primary and secondary school, which led to a decrease in overall enrollment.

Mid 1990s-Present: Once again, the government changed its policy on primary education, moving to a system that was introduced in 1997. In 2001, the non-governmental organization HakiElimu worked in conjunction with the government to create the Primary Education Development Plan (PEDP), which was followed by the Secondary Education Development Plan, in 2003.[41]

6.2.2. Current Structure of the Education System

The Tanzanian educational system is based on the 2-7-4-2-3 system[42]:

- 2 years of pre-primary education (not compulsory, mostly available in urban areas only)
- 7 years of primary education (compulsory and free; covers Standards 1 to 7, starting at age 7)
- 4 years of ordinary secondary education
- 2 years of advanced secondary education
- 3 years of university education

[41] Implementation of the Primary Education Development Plan: Voices from the Community, from HakiElimu, by Suleman Sumra, Working Paper Series No. 2003.7. Available at: http://www.streetwise-africa.org/mss/pdf/primaryeduc.pdf.

[42] "Education in Tanzania," Southern and Eastern Africa Consortium for Monitoring Educational Quality, SACMEQ 1995-2009. Available at: http://www.sacmeq.org/education-tanzania.htm.

Although primary education is provided without charging school fees, because it is mandatory, schools have become overcrowded with the influx of students and many schools are under-resourced.[43]

There are a few major national assessments integrated into the Tanzanian educational system. A national assessment examination is conducted in the second year of students' secondary school; by passing this exam, students are then permitted to continue their studies for an additional two years and then take the O-level exams in nine subjects (also known as the Certificate of Secondary Education Exam or CSEE). Two years later, students are given the A-level exam in nine subjects, which is an internationally recognized assessment. After passing the A-level exam, those who pursue their bachelor's degree spend on average three years in university.[44]

Kiswahili, the official language in Tanzania, is used as the medium of instruction in primary schools. English is taught as a subject in primary schools and is the medium of instruction in secondary schools and other institutions of higher learning. All primary school textbooks, except English textbooks, are written in Kiswahili. English textbooks are used in secondary schools and institutions of higher learning.

6.2.3. School Enrollment in Tanzania

Primary school enrollment rates have varied over time, but there has been major improvement in the past few years according to data from the United Nations Statistics Division.[45]

[43] "Education in Tanzania," Wikipedia article. Available at: http://en.wikipedia.org/wiki/Education_in_Tanzania.

[44] Tanzanian Educational System description, prepared by Frida Mwenegoha Cultural Affairs Assistant and Educational Advisor (date unknown). Available at: http://www.bibl.u-szeged.hu/oseas_adsec/tanzania.htm.

[45] Net enrollment ratio in primary education, both sexes – United Republic of Tanzania, data from United Nations Statistics Division. Searchable from database at: http://mdgs.un.org/unsd/mdg/Data.aspx.

Tanzania's net enrollment ratio in primary education, for both boys and girls (1999-2006)	
Year	Value
1999	49.7
2000	53.5
2001	58.5
2002	74.1
2003	83.2
2004	88.0
2005	92.7
2006	98.0

Table 2: Enrollment in Primary Education
Source: United Nations Statistics Division[45]

The United Nations defines the net enrollment ratio in primary education as "the number of children of official primary school age who are enrolled in primary education as a percentage of the total children of the official school age population."[46] In recent years, Tanzania has been successfully working to reach the United Nations Millennium Development Goal targets for enhancing education. By 2005, the country had already achieved the targeted level for primary gross enrollment ratio in primary school education, and was on track to meet most of the other education-related MDGs by 2015.[47]

6.2.4. Quality, Access, Equity, and Disease

There are great disparities in the Tanzanian education system. Wealthier families are able to support their children's attendance in well-equipped private schools while the public (government-run)

[46] Indicator metadata for net enrollment ratio in primary education, Millennium Development Goals Indicators, from the United Nations Statistics Division. Available at: http://mdgs.un.org/unsd/mdg/Metadata.aspx?IndicatorId=6&SeriesId=0.

[47] United National Millennium Development Goals, Progress Report – Tanzania, from the Ministry of Planning, Economy and Empowerment, December 2006. Available at: http://www.tz.undp.org/docs/MDGprogressreport.pdf

schools are overwhelmed with their financial inability to provide students with a quality education.

Children with special needs, such as orphans, or those with physical or mental challenges, are at an even greater disadvantage if their families are poor because there are only a handful of programs for children that need special facilities and attention as a part of their education. HIV/AIDS has had a major impact on many communities in Tanzania, especially educational communities. The epidemic has decreased the pool of teachers and orphaned many students, making it difficult for them to continue their education. Teacher shortage is a major challenge at all education levels.[48]

6.2.5. Literacy in Tanzania

At the time of independence, nearly 70 percent of adult Tanzanians were illiterate. Adult education helped address the country's problems of hunger, ignorance, disease, and soil erosion through education programs providing knowledge relevant to their socio-economic needs. During this time, the Tanzanian government achieved great success in expanding education among adults. Adult education was seen as vital to the spread and implementation of African Socialism in the countryside.[49]

> ***"Literacy is seen as a gateway enabling individuals to learn new skills in both the classroom and the workplace, while assuming their rights and responsibilities in society."***
>
> **United Nations Educational, Scientific, and Cultural Organization**[50]

[48] "Identifying the Issues," Tanzanian Education Network. Available at: http://tenmet.org/public_html/index.php?option=com_content&task=view&id=18&Itemid=55.

[49] Kadege, Nyasugara P, *Peasants and Educators: A Study of the Literacy Environment in Rural Tanzania*, 1992. Available at: http://www.eric.ed.gov/ERICWebPortal/custom/portlets/recordDetails/detailmini.jsp?_nfpb=true&_&ERICExtSearch_SearchValue_0=ED362773&ERICExtSearch_SearchType_0=no&accno=ED362773.

[50] LAMP Topic (Literacy Project), from the United Nations Institute for Statistics. Available at: http://www.uis.unesco.org/ev_.

Reading achievement levels among Grade 6 students in Tanzania, 2000		
Level	**Description**	**Percentage of pupils at this level**
Level 1	Pre Reading	2.8%
Level 2	Emergent Reading	5.5%
Level 3	Basic Reading	9.4%
Level 4	Reading for Meaning	18.9%
Level 5	Interpretive Reading	21.4%
Level 6	Inferential Reading	20.6%
Level 7	Analytical Reading	18.8%
Level 8	Critical Reading	2.7%

Table 3: Reading Achievement in Tanzania
Source: SACMEQ II Project Report, 2000[42]

In Tanzania, literacy is typically defined as the population aged 15 or older who can read and write in one of three main languages (Kiswahili, English, or Arabic). As of the 2002 census, the total population over age 15 who were considered literate in Tanzania was 69.4 percent (77.5 percent of men and 62.2 percent of women).[51]

Despite these positive outcomes, detailed statistics of reading achievement among primary school students showed much lower results in the SACMEQ II research project conducted by the Southern and Eastern Africa Consortium for Monitoring Educational Quality.[42] Their report found the following levels of achievement in Grade 6 students in primary schools in Tanzania:

Since primary school students in Grade 6 take courses in Kiswahili, we can assume these reading levels relate to their achievement in Kiswahili language. Similar statistics for English reading achievement levels are not available; however one could perhaps draw the conclusion that if the Kiswahili reading achievement levels shown in this report were true

[51] Information on Tanzania Literacy, from Index Mundi (source: CIA World Factbook). Available at: http://www.indexmundi.com/tanzania/literacy.html.

for Tanzanian children generally, achieving high levels of English reading would be very challenging.

6.3. Braille Writing Tutor Project

According to the World Health Organization, nearly 90 percent of the world's 314 million blind and visually impaired individuals live in developing communities.[52] Despite the importance of literacy to employment, social well-being, and health, experts have estimated the literacy rate of this population to be very low.

6.3.1. Status of Visually Impaired in Tanzania

There is a significant population in Tanzania who are challenged by physical and mental impairments. According to WHO estimates, roughly 10 percent of the 2002 Tanzanian population was classed as people with disabilities (PWD). Of this population 27 percent were visually impaired or blind.[53] The senior program officer in Tanzania for the NGO Sightsavers, Sixbert Mzee Mbaya, provides a horrifying statistic: "In Tanzania, half of all blind children die before they are two. It's not hard to work out why: poor children live rather dangerous existences here. They wander into the open fires on which many people cook; they totter into the road, which in most places is not marked off in any way from "not road"; they fall down holes or wander off and get lost. Their sight is not tested as infants and, not surprisingly, Sightsavers is lobbying for such tests to take place with the usual babyhood check-ups and vaccinations."[54] With the spread of diseases

[52] World Health Organization, "Fact sheet 282: Visual impairment and blindness," World Health Organization, May 2009. Available at: http://www.who.int/mediacentre/factsheets/fs282/en/index.html.

[53] Lupi Mwaisaka Maswanya, Disabled People and MDGs in Tanzania. Paper presented at The Workshop help in Bratislava: http://www.make-development-inclusive.org/docsen/euconf/Presentations/LupiMMaswanyaDISABLEDPEOPLEANDMDGsINTANZANIA.ppt

[54] Sue George, Seeing Tanzania: http://www.guardian.co.uk/journalismcompetition/globalreporting/seeing.tanzania

such as river blindness, or Onchocerciasis, in Tanzania, there is great need for support for the visually impaired.

6.3.2. Education of Visually Impaired in Tanzania

Figure 21:
Uhuru School Teacher Shows Student How to Use the BWT

Currently, there are few schools specifically geared towards serving the visually impaired population. The Buigiri School for the Blind serves students from rural villages in the Dodoma district.[55] The Mitindo primary school is home to 70 albino Tanzanians. Many of them suffer from visual impairment, which is a common among albino populations.[56] These schools, which provide an invaluable service, are severely under-resourced. There is currently a call for an inclusive education system in Tanzania, which serves students with all types of abilities.[57] However, this would require teachers trained to cater to the needs of all types of students, which is currently not realistic given limited resources. Yet there is some progress being made to provide access to education for all children, particularly children with disabilities in rural areas: The Kilimanjaro Blind Trust, Inc. partners with the Perkins School for the Blind to focus on braille literacy programs operated in Tanzania, Uganda and Kenya.[58] Still many visually impaired children are left out of the education system in

[55] TravelBlog: Buigiri School for the Blind: http://www.travelblog.org/Africa/Tanzania/Centre/Dodoma/blog-247183.html

[56] Donna Simpson, Giving Hope to Tanzania's Albino Kids: http://www.fifetoday.co.uk/fife-free-press-news/Giving-hope-to-Tanzania39s-albino.4993546.jp

[57] The Daily News in Tanzania, Tanzania wants inclusive education: http://media-dis-n-dat.blogspot.com/2008/10/tanzania-wants-inclusive-education.html

[58] Kilimanjaro Blind Trust: http://www.perkins.org/give/Kilimanjaro/

Tanzania, partially due to a dearth in schools and also because of social stigma around disabilities. "Some parents tend to hide their disabled kids from public by denying them the rights to education," says Dr Sai Vayrynen, who is an Education Adviser in Tanzania.[57]

Limited information was known prior to the iSTEP interns' arrival in Tanzania about the Uhuru School's blind section. TechBridgeWorld did find that the school had received a relatively large donation of supplies from the Tanzania Education Authority in 2007, which included assistive devices for both learning and mobility.[59]

6.3.3. Challenges of Writing Braille

The availability of trained teachers to educate visually impaired students in Tanzania is rather limited. However there is a great need for schools where these children's potential can be realized. Braille is the mode of communication currently taught in existing schools for the blind in Tanzania. There is also a Kiswahili braille translator now available.[60]

In wealthier communities, visually impaired individuals have greater access to technologies such as braille typewriters (such as the Perkins Brailler) or note-takers to write braille. In developing communities, braille is almost always written with a slate and stylus. For visually impaired children, learning to write braille in this manner can be a formidable process. Some of the students' challenges are as follows:

- Braille is written in reverse of how it is read. For example, in English braille, dot patterns are written from right to left, so that the page can be read from left to right when it is flipped over. Consequently, students must learn the mirror images of all the letters, which essentially doubles the alphabet.

[59] "TEA handover assistive learning devices worth TSHS. 80M/-for the disabled to Uhuru Mchanganyiko Primary School," TEA Press Release. Available at: http://www.tea.or.tz/news/PRESSRELEASES/020507-Uhuru_Mchanganyiko_Devices.htm.

[60] Kiswahili (Swahili) Braille Translator. Available at: http://www.duxburysystems.com/lan_Swahili.asp

- Students receive delayed feedback from teachers since the teacher must remove, flip, and then read the embossed paper. This may take them significantly longer to identify and correct students' mistakes.
- Students do not always receive the individual attention and guidance needed to learn given limited numbers of specialized teachers.
- Students must use paper supplies that are expensive or in limited supply.

It is imperative that students master writing braille, using a slate and stylus, which will significantly help their foundation for education. Braille literacy assists students in taking notes in braille during their classes can provide them with educational and employment opportunities in their futures.

7. Needs Assessment

Before our team arrived in Tanzania, we conducted extensive research to educate ourselves on the challenges that the communities face. Nevertheless, needs assessment remains a crucial part of the work the interns completed in Dar es Salaam, Tanzania. The needs assessment process is used to determine the needs of a population or geographic area. Understanding the needs of the three target populations/communities that we worked with allowed us to create technology solutions that were practical, sustainable, and relevant. As a result, we initiated, fostered and maintained a direct line of communication with the three communities based on honesty, mutual respect and trust.

We employed a needs assessment strategy called the Community Based Participatory Research (CBPR) approach. Under CBPR, there are four modes of participation:[61]

- Contractual - people are contracted into the researcher's project
- Consultative - people are asked for their opinions
- Collaborative - researchers and local people work together on projects designed, initiated, and managed by researchers
- Collegiate - researchers and local people work together as colleagues with different skills to offer, in a process of mutual learning where local people have control over the process

Despite limitations and constraints, we were able to adhere to the four modes of participation.

As planned, we began with a consultative approach, which evolved into a collaborative and collegiate level of participation over the course of our time in Tanzania. Work with our partner, the UCC in Dar es Salaam, reached the collegiate level within the first two to three weeks of the internship. Our work with the UDSM students began in the sixth week, while our work with the three partner communities and associated organizations gradually progressed to the collaborative level by the ninth week.

[61] Source: Dias, Bernardine; "ICTD" – iSTEP course 13-502 lecture notes March 30th. http://www.techbridgeworld.org/istep/15-302/lectures/March_30_ICTD.pdf

The CBPR approach allowed us to obtain an in-depth understanding of the needs of the communities and focus accordingly on what we could realistically accomplish in the available time frame. The needs assessment process required us to speak with as many of the community members as possible, and we had to ensure that we were clearly communicating the solutions we would be able to provide, as well as the ways in which we factored their voice and opinions into our decision making process. The information that was obtained from the needs assessment process guided the approach and direction that our technical team took to design the technology.

Tasks	Pre-iSTEP	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Post-iSTEP
Revise and finalize interview questions	■											
Obtain IRB approval for interview questions	■											
Build trust and collegiate relationship with UCC		■										
Initiate conversation with communities: ask about their stories		■										
Blog Entries		■	■	■	■	■	■	■	■	■	■	
Formal needs assessment initiated			■									
Share findings with team			■	■	■	■	■	■	■	■	■	
Continue community visits and obtain feedback (try to talk to students and more people involved)				■	■	■	■	■	■			
Contingency plans if needed							■	■	■			
Obtain post intervention feedback and compare with initial data										■	■	
Contribute to final report											■	
Presentations about iSTEP 2009											■	■

Table 4: Initial Timeline for Needs Assessment Lead

The table above shows our initial timeline plan for the needs assessment process. We were met with some unanticipated challenges that forced us to change the process we had initially proposed. As is evident from the details of this report, we made every effort to engage the community members during our time in Tanzania.

7.1. Social Worker Project

Before developing a technology solution that would allow the para-social worker (PSW) community to better support and care for OVC in their communities, the iSTEP team needed to understand the challenges that PSW face with the work that they do, the solutions that they desire, as well

as the existing infrastructure, that has been created by associated organizations, to support them. We intended to interview the PSW one-on-one and in a large group, but time constraints did not allow us to do so. By the time we were able to reach the consultative mode (interview phase) of the needs assessment process, we proposed a very specific idea of the mobile phone application to the PSW and, based on their response, began creating a solution.

7.1.1. Contractual Mode

Since the iSTEP team was foreign to the end users (beneficiaries), initial and subsequent contacts with each community were made in consultation with one of our local contacts, Dr. Theresa Kaijage, and our local partner, the UCC. On May 25, the ground team began the first phase of the needs assessment process by conducting initial meetings with the Institute of Social Work (ISW), WAMATA, and the Capacity Project.

7.1.2. ISW Initial Meeting

Figure 22:
Tandika Village Community

At the ISW, the interns met with Dr. Theresa Kaijage, Mrs. Leah Omari, and Mr. Bernard Sefu. The team was informed about the ISW's program for supporting OVC, which started in October 2006 and is sponsored by USAID. At the inception of the program, the office trained community members that already work with OVC in order to empower and motivate them to continue to provide services to the OVC. After a social worker symposium, a curriculum was developed for training supervisors that train para-social workers. The ISW partnered with the Jane Addams College of Social Work to deploy the "Train the Trainer" approach. The ISW has been able to train more than 600 PSW under the new curriculum. There are currently about 60 para-social workers per district, and there are 132 districts in total. The workers are all trained in their respective districts. There are currently

eight Social Welfare Officers that serve as trainers for the para-social workers. The identification process for OVC is a portion of the training that is emphasized.

7.1.3. Data Collection Issues (according to ISW)

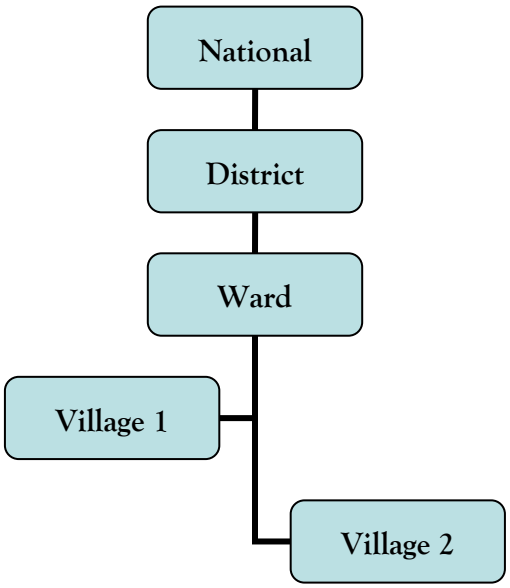

Figure 23: Diagram of Data Flow

At our initial meeting with ISW, we found out that data transfer from the ward level to the district level is very slow.

The ISW visit was the first initial visit that we made to the organizations that we worked with, so the meeting did not go as smoothly as it could have. The team was not prepared to answer questions about the technology development; rather, we intended for the conversation to be about the challenges of the data transfer. Our partners at ISW expected see a prototype at the meeting, which we explained would only be developed after the needs assessment process.

We were told that there are two main issues: 1) lag time to transport the paperwork and 2) misplaced documents along the way. Out of 132 districts, only 48 districts report to the national database. Out of those 48, only two report comprehensibly. The flaws in the reporting process affect the flow of communication. We were told that the Department of Social Welfare (DSW) is in charge of the database at the national

level, and they provide the data to government officials and donors in order for them to make decisions, provide aid, and observe the progress of the OVC in Tanzania. At the district level, the data is used for mapping and referrals for the OVC.

Our initial meeting with the ISW was quite challenging for the group, because it was our second day in the country and our first initial meeting with one of our partnering organizations. Nevertheless, we were able to introduce our entire team to the employees in the office that trains PSW. We also introduced TechBridgeWorld and began to clarify what we had to offer at Week 1 and what we were hoping to have by Week 10, and the community involvement that would have to take place in order for us to create a new and applicable technology solution.

7.1.4. Capacity Project Initial Meeting

We learned through our discussions that the ISW is focused on working with the Capacity Project to train para-social workers and provide them with methods for monitoring their progress as well as the success of the para-social worker program in general. Their original hope was that we would create an application that would facilitate the transfer of completed forms (M&E tools) to the Capacity Project once a week from these newly trained para-social workers.

The ISW connected us with Mr. Kaijage at the Capacity Project and Sesil Charles Latemba, OVC/MVC Data Management Specialist, at the DSW. After our meeting with the ISW, we went downtown to meet the team at the Capacity project. Our contacts at the ISW connected us with Mr. Kaijage at the Capacity Project office because they were under the impression that the technology that we would eventually develop would help the Capacity Project with MVC and OVC data collection. By the end of our meeting with the ISW, there was still some confusion about whether we had a prototype and the development that would happen during our time in Tanzania. Our team clarified that the purpose of our travel to Dar es Salaam was to work with communities to begin to develop some of this technology.

Our initial meeting with Capacity Project was the only meeting we had with them during our time in Tanzania. The Capacity Project advocates for the needs of MVC, but most of the Monitoring and Evaluation that they are doing is relatively new and is based on a PSW training that took place in the city of Dodoma in June (a few weeks after we arrived). We found out that they were working to develop a database of para-social workers as well as to improve the government structure for recruiting and dispersing social workers. We had to focus our time on connecting to the groups most relevant for the project.

7.1.5. WAMATA Initial Meeting

WAMATA is another organization that we met with on our second day in Tanzania. Dr. Theresa Kaijage founded WAMATA in 1989. When she started the organization, it was the first HIV/AIDS support organization of its kind. Dr. Kaijage told the team that the organization served as a model for the entire country. Some of the staff was conducting house visits, so we just met with the staff members that were available that day. We gave a brief introduction of our organization and, since we had been told that WAMATA's staff members face many challenges, we began to ask about their specific challenges. As far as data collection, the WAMATA staff members explained that a major issue that the organization faces is keeping records and tracking the whereabouts of the people that they take care of. Although we did not meet with WAMATA during the rest of our time in Tanzania, we may seek their involvement during the deployment phase of our projects because there may be one or two PSW involved with data collection for OVC in their Dar es Salaam office.

7.1.6. Department of Social Welfare Initial Meeting

The last initial meeting that our team conducted for the Social Worker Project was on May 30 with Sesil, the OVC/MVC Data Management Specialist at the Department of Social Welfare. Our meeting with him occurred at the end of our first week in Tanzania and by then we really had a handle on the questions we had as well as how to describe the work that we hoped to do. Our meeting with Sesil was insightful

because he gave us in-depth explanations about many U.S.-funded initiatives for OVC/MVC care in Tanzania, and the Capacity Project happens to be one of them. Since Sesil works at the national level, he was able to talk about the flow of data from the village level onward and what happens when he receives the data.

Sesil explained the major issues that the DSW was facing with the data collection for OVC. The biggest issue seemed to be incompleteness of and inaccuracies in the data. With a total of 132 districts, there are 81 districts that report to the national database and 51 do not report anything. Those that do report usually do not send complete information. Sesil told us that the process to verify the information happens twice a year and is very tedious because the national database goes back to the district to correct data entry errors and discrepancies. He said that if the national database received information every month, rather than every three months, the process would speed up rapidly. We explained that the mobile phone application may be able to provide summaries of data to the national database more often, but we were clear that we needed to consult with the PSW before we took the bold step to begin creating any type of technology.

7.1.7. Consultative, Collaborative, and Collegiate Mode

Although we spent the earlier portion of our time in Dar es Salaam, talking with various organizations associated with data collection for MVC/OVC, we were unable to begin needs assessment with the project until much later. Once we received approval from the IRB, we met with Mr. Bernard Sefu (on June 25), at the ISW, to clarify some points of confusion about whom we were to interview for the project. The new trainees had no prior experience working in the field, so they could not be of help to us because they lacked the field experience to understand what was currently happening on the ground.

We explained that we would rather speak with social workers who have had some experience in the field and who are in the Dar es Salaam region, for logistical purposes. Bernard agreed to arrange for at least five social workers or para-social workers who speak English, have experience with or knowledge of what goes on in the field, and know about some of the data issues to meet with us.

On July 1, we met with seven para-social workers (PSW) all from the Dar es Salaam region, which contains three districts – Kinondoni, Ilala, and Temeke. We were able to introduce ourselves and the project, as well as address their questions. In the end, we were also able to interview five of the seven PSW. The PSW enjoyed engaging in conversation with us. Not all of their comments were helpful for this specific project, but it was positive that they felt comfortable talking to us. It seemed that a lot of them have many things going on in their lives, with different groups they are a part of and other jobs they do. Most of them knew some English, which helped. Their input was not very helpful for designing the cell phone application, but many of them are involved with or are part of the village or ward committees that actually transfer data on OVC, so they will be the end users of the technology. In that sense, it was good to know a bit about our audience and listen to their concerns. They were all very friendly and welcomed us to come visit them to see what their work is like.

7.1.8. Key Findings from Interviews

During our interviews with the PSW, we quickly realized that motivation was a major issue for all of them. With insufficient funds and limited resources, the needs of the communities are almost always greater than the PSW can meet. Although the PSW received some training from the ISW, they are people with limited skill: most of them went to secondary school, but some of them that have been doing social work in their communities are not paid for the social work services they provide. They perform social work on a voluntary basis and maintain other jobs to earn a living. Some of our interviewees are schoolteachers, cooks, electricians, program coordinators at NGOs, and chairmen of their village committees.

The mobile phone project seemed like an opportunity to boost the social workers' morale, with the potential to ensure them that the work that they are doing is meaningful, and perhaps even provide them with the additional financial support that they desperately need. The financial support may come from organizations that we are trying to contact as potential partners for members of the PSW community. We were told that there are major issues with data collection. This was obviously something that we had heard before, but the PSW were able

to give us the community level perspective as to why the data does not get to the ward level as fast it should. For one, PSW are inundated with meeting the day to day needs of the OVC and other community members that they often times do not find the time to send reports. We were told that when they do send reports, the district takes no action and provides no response. The OVC need essential items such as food, health care, school supplies, and clothing, but the district does not give the village committees the necessary funding to meet such request.

Printing, photocopying, and travel expenses are costly, especially if there is no assurance that the district will provide workers with the support to meet the demands and challenges that they face in their communities. In a later interview, we were told that there is no official at the district level who advocates for providing funds and resources to social welfare-related work. This explained a possible source of some the challenges that the PSW said they were facing.

By the end of the consultative phase of the needs assessment process, it was clear that the PSW need a less complicated and less costly way to send data if they are expected to send the data more often and more completely. All of the PSW with whom we interacted own basic mobile phones (most of which are Nokia brand) and we were told that they use their phones on a regular basis, mostly every day. None of the social workers thought that making phone calls was cheap, but they said that SMS was much more affordable.

The PSW were not able to provide us with a list of data that should be sent more frequently, perhaps weekly, than the longer forms. Mr. Sefu at the ISW suggested the following pieces of information:

- Number of OVC
- Gender and age breakdown of OVC
- Location of OVC
- Needs of OVC and services provided to them (to match and figure out what needs are still unmet)

See appendix for the full version of interview questions.

7.1.9. Tandika Village Visit

We were able to visit a PSW that lives and works in Tandika, which is located in the Temeke District. The day that we spent at the Tandika village with the PSW and the rest of the MVC Committee was an eye-opening experience that allowed our team to get a firsthand view of the level of poverty that the village members, including the PSW and the OVC, are living on. The village committee warmly welcomed us into their community and asked us to help them in any way we could. We made sure that we talked to them about how the mobile phone application could assist them with reporting data, but it was very clear that they had many more needs apart from data collection.

7.1.10. Other Identified Needs

The following list includes needs that do not fall under the scope of work that TechBridgeWorld does in developing communities. Nevertheless, these are needs that were apparent during the interviews with the PSW, and they are crucial to the sustenance, survival, and success of the work that they do.

- Permanent donors that will assist local organizations that help OVC.
- Wages and salaries for the PSW.
- Financial support (from the local government and community organizations) for PSW.
- A stronger, more organized network of PSW that receive oversight and support from the Department of Social Welfare.
- Funds that will enable the ISW training process to be more thorough and sustainable with follow up training sessions and incentives for PSW to use their new skills in the field.
- Microfinance services to assist PSW that teach income-generating activities to OVC, widows, and families affected by HIV/AIDS, as well as PSW that are entrepreneurs and use the proceeds from their businesses to assist OVC, widows, and families that are affected by HIV/AIDS.

- Progress reports for the PSW, so that they are empowered by the impact of the work that they are doing.
- Emphasis on the importance of data collection from the village level to the district level.
- Ensuring that the data provided to the districts and eventually the national database is used to provide needed services and funds to OVC/MVC in Tanzania.
- Policy changes that bring OVC/MVC issues to the forefront of the district levels agenda.

7.2. Braille Writing Tutor Project

The needs assessment for the Uhuru Mchanganyiko Primary School was an enlightening and challenging process. We faced several challenges during the process, including a delay in the IRB approval process and the school's one-month vacation that started a few weeks after we arrived. While waiting for IRB approval, we worked to refine interview questions for the various communities and also made initial contact with the school. By the time the school resumed, we had very little time for needs assessment because we also needed to leave time to make necessary changes to the Braille Writing Tutor (BWT) software. Similar to the consultative portion of the Social Worker Project, we were only able to have one-on-one interviews with the schoolteachers; there was no time for a large group interview. The one-on-one interviews were extremely informative and allowed us to learn about the way visually impaired students are taught and the challenges that their instructors face in trying to provide them with the best education possible.

7.2.1. Contractual Mode

The initial meeting that we had with the Uhuru School was brief because we were unable to delve into in-depth conversations. The technical lead for the project, as well as another team member, went with our colleague, Eric Beda, from the UCC to see the headmaster, Mr. Mkwela, and the head teacher of the blind section, Mr. Noah. Eric introduced the team members and talked a bit about the work we were

hoping to do during our time in Tanzania. The two iSTEP team members introduced themselves and spoke in more detail about the project and the potential to work at the school. Mr. Noah seemed very interested in the project. We inquired about whether the school had a computer we could use, but we did not receive an answer at the time. We found out that there is a computer lab on the school premises, which made us feel as if the partnership has potential to be fruitful.

At the initial meeting, we found out some interesting facts about the school that encouraged us to think about how the BWT could meet some of the school's needs. We found out that there are about 900 students who have a range of abilities. Ninety are visually impaired, 12 are deaf and blind, 18 are mentally challenged, a few are physically challenged, and the others have no disabilities. There are 58 teachers, 14 of whom teach in the blind section, 16 of whom teach the deaf and blind children, and six teach the mentally challenged children. They teach the visually impaired students Kiswahili braille at the Blind Section.

7.2.2. Preparation for the Consultative Mode

After receiving IRB approval for the project on June 4 with the help of the TechBridgeWorld team, we began to compile the interview questions for the teachers in an attempt to refine and reword them. Due to the time constraints and school vacations, we ruled out the possibility of having two sets of interviews. We had to make sure that we maximized the time we had to have one-on-one conversations with the teachers. We also anticipated that we might have needed to have question and answer sessions with groups of teachers. A suggestion that came about during the revision process was to prioritize and categorize the questions in order to be able to use our time wisely.

As a result, we created letter categories for the questions (A-G). We started with questions that would make the teachers comfortable with talking to us, and then eased into questions about the needs of the school and students. Sections A, D, E, and F were the priority sections of the list of questions. See appendix for the full version of interview questions.

7.2.3. Consultative, Collaborative, and Collegiate Mode

On June 10, two iSTEP team members, along with Eric Beda and Mwangu, a University of Dar es Salaam student, went to the Uhuru School to meet the teachers of visually impaired students. Eric and Mwangu helped with translations so that we were able to clearly communicate what we were hoping to have happen in the next few days. Eleven teachers signed the consent forms and seemed interested in participating in the project. We began conducting interviews the next day.

Two team members worked with two UDSM students, Mwangu and Aloyce. The UDSM students were a huge help by assisting with translation. Our first interview took a lot longer than we anticipated, but after that, we were able to manage the translation and timing of the interviews. We intended on conducting individual interviews, but since the computer room was small, we decided to just interview two teachers at a time if they were scheduled at the same time. By the end of the day, we had interviewed seven teachers.

We had to make adjustments to the questions as the interviews progressed. For example, most teachers did not really understand when we asked them questions phrased like "what do you like most about…" or "what do you like least about…" So, we removed those or rephrased them as "what do you find difficult about…" and "what do you like about…"

The interviews with the schoolteachers and the head of the blind section were very informative. In particular, we learned that visually impaired students struggle with reading braille more than with writing braille. This is partly because they are taught writing before reading, using a slate and stylus, so when they begin to read, switching to the mirror image of what they wrote is difficult. Also, the students have trouble differentiating between different cells on the paper while reading. Their tactile senses are not as good when they first start to read and the dots are very small. Many teachers did say that while teaching students to write braille, they find it difficult to pin-point mistakes since they have to wait until the student is done and then turn the page over and read what they wrote. Also, one teacher pointed out that although he would like to teach them reading before writing, it was not as easy to

teach multiple students to read at the same time as it was to teach many students to write at the same time, since it is a matter of helping them memorize the character mapping. In addition, Mr. Noah mentioned that older students would benefit from a writing tutor for English braille.

7.2.4. Key Findings from the Needs Assessment Interviews

After interviewing seven teachers at the schools, it became clear that the school is understaffed. There is a great need for more specialist teachers that will be able to meet the individual needs of each student. The fact that the government requires classroom integration after Standard 3 makes it even more difficult for the teachers to properly instruct the visually impaired students because they become occupied with students with varying abilities and disabilities. Another major issue is the general shortage of teaching aids and supplies such as braille books, which makes it difficult for the teachers to instruct the students and for the students to get more practice reading and writing braille. The lack of braille books is one of the biggest problems facing the blind section because one of the greatest weaknesses for the students across the board is their reading skills. The students cannot read braille well, so they need additional practice. We later found out that there is a braille printing press located on the school property, but is owned by the government and not used for the school.

After the interviews, we realized that there was a possibility for the BWT to act as a teaching aid for the classroom. See appendix for the full version of interview questions.

7.2.5. Observing Classes

On July 14, we were welcomed to Mr. Noah's Standard 1 class. He was teaching the class to write numbers in braille. There were 12 students in the class – seven girls and five boys – all of whom are visually impaired. One boy was fast asleep during most of the class. Mr. Noah is visually impaired himself so it is difficult for him to know if someone is paying attention or not. He did, however, go around and ask each of them a question so that the sleeping student woke up to answer. They only had four A4-slates (plastic slate and stylus). While four students

were practicing their writing, the other eight were doing nothing, for the most part. As we had heard during the interviews, the students had no books or other teaching aids, only Mr. Noah's questions and jokes (to which they all responded well). The students would occasionally whisper a word or two to their neighbor, but for the most part they were quiet.

After that, we went to the Standard 5 class, where sighted students are mixed with visually impaired students. There were 32 students in the class, of whom four were visually impaired. The visually impaired students sit next to at least one sighted student who is supposed to help them with their assignments. Sighted students had textbooks, but visually impaired students did not, so the sighted students needed to read out questions that were assigned to the visually impaired students. The teacher also read out everything she wrote on the blackboard and asked the visually impaired students questions to make sure they understood. All four visually impaired students had A4-frames to write with. It wasn't clear to us how the teacher usually runs her class because she paid so much attention to us, but we did observe the sighted students' interactions with visually impaired students.

7.2.6. Other Identified Needs

The following list includes needs that can be addressed by other organizations that seek to help visually impaired students in developing countries.

- Braille books and games.
- Additional teaching aids for the teachers, such as maps, A4 frames (slate and styluses), and braille machines.
- More funds and services to assist students with disabilities.
    - Additional classes (outside of school) to help assist students with disabilities and provide a means for specialist teachers to earn a better living.
- More specialists to teach visually impaired students.

7.3. Literacy Tools Project

Figure 24: Interns Hatem and Rotimi with students at the Mlimani Primary School

The needs assessment process at the Mlimani Primary School was probably the smoothest and easiest of all three projects. We interviewed and interacted with three schoolteachers that teach English and their students. Although the school also went on a one-month vacation, we were able to interview the teachers during the vacation, and we established a relationship with them that allowed us to feel like members of the community.

7.3.1. Contractual Mode

At our initial meeting with the school, we met with Mr. Sipto, a mathematics, English, science, and geography teacher at the Milmani School. He said that it is common for teachers at the school to teach a variety of classes. Mr. Sipto was very excited about the research that we wanted to conduct with the school, although he was concerned because the school does not have electricity. We then explained that we would be doing our testing at the computer lab in the UCC. He said he would organize with the other teachers to set up interviews as soon as possible. He agreed that one-on-one interviews would be best because this is was very busy time for the teachers and they all had different exam times.

Mr. Sipto really wanted to cooperate with us, so he said that he would do everything he could to gather the children that live in the area and bring them to the school, as well as the teachers. We talked to Mr. Sipto about the specifics of the project. He had a lot of useful information and also made some interesting comments about the children's exposure to technology.

From this first interaction, we found out that the school does not have electricity or any technology at the school. Mr. Sipto also told us that the children have technology (cellphones, computers, etc) all around them once they leave school grounds. Additionally, the teachers teach

the students in Kiswahili – even their English courses are taught in Kiswahili. There are 1,500 students at the school, ranging from ages seven to 14. Each classroom typically has at least 60 students at a time.

7.3.2. Consultative, Collaborative, and Collegiate Mode

On June 5, we went to the Mlimani School to have our initial meeting with teachers. A colleague from the UCC accompanied us to the school. We spoke with five teachers who were interested in participating in the project. We explained the consent forms and they asked us questions about the technology and the process of our work while we are in Tanzania. We answered their questions to the best of our ability, with our colleague helping to translate and without promising things we had not started working on.

Later that week, our literacy project technical lead, the needs assessment lead, and the monitoring and evaluation lead spent some time with Mr. Sipto's Standard 5 Class. It was an opportunity to interact with the students and get to know the community a bit more. Mr. Sipto gave us the opportunity to teach the class an English lesson. The students were extremely bright and excited to participate.

Starting on June 11, the needs assessment lead and the monitoring and evaluation lead went to the Mlimani School on three separate occasions to interview three of the teachers. The interviewees answered many of the questions that we had been pondering since arriving to Dar es Salaam. We learned useful facts about the school, such as its history, the socio-economic background of the students, and the school's retention rate. We were told that the students primarily struggle with reading and speaking English, but do well with writing and dictation. One of the teachers provided us with an overview of the English syllabus for one of the classes. The syllabus seemed to be a bit random and less comprehensive than we expected. Another teacher gave us more specific details about the work that the students do, as well as extensive details about the challenges face when teaching the students English. All the teachers followed the English instructional book assigned by the government. They all face similar challenges, but a major issue was the lack of teaching aids. Most of the teachers were interested in having the students in their class as a part of the project.

7.3.3. Key Findings from Interviews

With a high teacher-to-student ratio and curriculum that is almost all Swahili, English is just one of nine subjects taught at the Mlimani School. From our interviews with the teachers, we could tell that they did not have too strong of a background in English literacy, which created an added challenge to teaching English to the students at the primary school. The limited numbers of books and lack of teaching aids at the school make it very difficult for the teachers to find the motivation to even try to have a serious English class. The students rarely practice their speaking skills in class and all of their tests are writing tests. During the interviews, we realized that there seemed to be a great need for help with English for Standard 7 students before they transition to an English medium secondary school. We were told that Standard 7 students have difficulty writing essays and letters in English. A mobile phone game would be a refreshing and educational experience for the students and teachers and would add something new to the old resources that the school has.

7.3.4. Observing English Classes at the Mlimani School

On July 20, some of our team members spent a day observing Standard 3, 4, and 5 classes at the Mlimani School. In each class, we noticed that students were sharing books and seating (five to six students per book/bench). The classes had a section where the teacher instructed the students, followed by a question and answer session, and then followed by an in-class assignment provided by the teacher. The teacher would then correct each student's work one-by-one. This observation day allowed our team to understand the little exposure that the students have to English, and the varying abilities among the students in each of the classes. The students were active and eager to learn, and we felt as if the mobile phone game would be ideal for them to expand their vocabulary and learn more grammar rather than just practical things.

7.3.5. Other Identified Needs

Although the TechBridgeWorld staff and the iSTEP interns have clearly communicated that our expertise centers around technology

solutions, we have started making efforts to try and connect the Mlimani School and associated organizations with other organizations that may be able to help by assisting in sponsoring some portion of the project, or meeting any of the aforementioned needs in order to provide the students with a greater chance to excel and succeed.

The school needs electricity. The teachers at the Mlimani School need advanced instructional English books. It would be beneficial for the teachers and students, if the teachers received some additional training that enhanced their ability to teach their students English. There is a need for financial support from non-governmental organizations and other donors to supply adequate financial support for the school.

- Provide more teaching aids, especially books.
- Improve condition of buildings, classrooms and furniture.

8. Social Worker Project

The Department of Social Welfare in Tanzania collects data from village, ward, and district committees and para-social workers. Currently, this data collection occurs via paper forms, and as such, it can take a long time – on the order of months – for the forms to reach their final destination, a national database. In order to help address this problem, TechBridgeWorld designed a solution to allow users, especially para-social workers, to submit data via SMS (also known as a "text message"). As a team, we decided on SMS because of its widespread availability (mobile phones are highly prevalent in Tanzania) and low cost. Users are given instructions on how to format a special SMS containing data they have collected in their work with orphans and vulnerable children (OVC). Due to the nature of mobile phones and SMS, the amount of data one is able to transmit is fairly small, on the order of 10 or 20 numerical values. Shortly after a user sends this SMS to the supplied number – a phone number owned that would be owned by the server operator – the server receives, parses, and automatically enters it into a database. The server is also able to determine, from the SMS, which user sent the data and where he or she works. Server administrators can export and analyze the submitted data as they choose.

8.1. Related Work

The problem of exchanging information without advanced infrastructure such as Internet access, stable mobile phone connections, or landline telephone service is a problem occurring throughout a variety of different projects. Due to the prevalence of this problem, a variety of research groups and organizations are working to make the exchange of information easier in rural areas.

Through Roni Rosenfeld, Jahanzeb Sherwani, and several other members of the Carnegie Mellon community, speech technologies are being developed for telephones. Their current project, HealthLine, implements a speech-based access system that allows users to access data from a

database.[62] Sherwani has helped pioneer a method for reusing existing speech processing systems for new languages (including languages which may have phonemes that are non-existent in English) with high accuracy and minimal work. There are several advantages to a speech-based solution. First, such systems do not require literacy, and only require a low level of technical literacy. Moreover, all data processing and custom software is server-side, eliminating the need for any installation on users' phones. Although Sherwani has already done some research tackling the problem of data access through speech technology, his work does not address data entry, which is an essential component of our project.[63]

Additionally, the OpenRosa consortium is a group of developers working to develop open-source protocols for data collection on mobile devices. Through projects such as JavaROSA, OpenRosa's standards have been used to develop mobile phone applications in developing communities.[64] Projects using the JavaROSA platform can be run on most Java-enabled phones, including the Nokia 3110c and 6085, which are readily available in low-income regions.[65] However, despite being available, Java compatibility is neither universal nor cheap. It is important for developers to pay special attention to the users. Since mobile phone customization is relatively uncommon in Tanzania, this may lead to a number of issues, especially concerning usability and trust, as the social workers may not know about or want Java applications.

Epihandy is a suite of tools constructed with OpenRosa for data aggregation on mobile phones. Epihandy has a wealth of already developed tools both user- and server-side to run on smart and Java-enabled phones that would minimize the need to re-implement basic data collection

---

[62] "HealthLine." SCHOOL OF COMPUTER SCIENCE, Carnegie Mellon. 31 July 2009 <http://www.cs.cmu.edu/~healthline/>.

[63] Rosenfeld, Roni. Personal Interview. 26 Mar. 2009.

[64] "JavaRosa." Technology for a Developing World. 1 Apr. 2009 <http://www.dimagi.com/content/javarosa.html>.

[65] Anokwa, Yaw, Carl Hartung, Adam Lerer, Brian DeRenzi, and Gaetano Borriello. A New Generation of Open Source Data Collection Tools. Tech. 3 Apr. 2009 <www.cs.washington.edu/homes/yanokwa/papers/anokwa_opendatacollection.pdf>.

functionality. Epihandy includes tools to design user interfaces that make data entry more user friendly.[66] Unfortunately, Epihandy also requires a consistent connection for data collection.[67] Additionally, the storage of data on memory cards raises the issue of the cost to ensure that data is not lost before it is transmitted, as well as privacy issues if the cell phone is lost or stolen. Further, Epihandy's server software was designed only to run on Windows 2000, making it difficult to maintain on newer machines.

At the ITCD2009, the world-recognized ICTD conference hosted by TechBridgeWorld at Carnegie Mellon University in Qatar this past April, Somani Patanik, Emma Brunskill, and William Thies presented their paper on the accuracy rates of different data collection mechanisms using cell phones. Their study compared three different methods, utilizing a Java application to enter data into a form, sending a coded SMS message, and calling up a human operator and telling them the information. In comparing the three, the team tracked the mistakes that the workers made as well as the duration of the interaction. The results showed that the SMS and Java application had a comparable error rate hovering under five percent. The voice solution, however, produced errors less than 0.5 percent of the time.[68] The duration of the SMS and Java was also close, while interactions on the phone took almost one minute longer.

FrontlineSMS is a project that was developed to encourage stronger communication for NGOs and their workers. The system is a robust suite of tools that only requires a computer and a mobile phone. It can then arrange text messages efficiently such that messages can be sent either to individuals or to large groups, and conversations can be easily organized.[69]

---

[66] "EpiHandyMobile - EpiHandy." Main Page - EpiHandy. 2 Apr. 2009 <http://www.epihandy.com/index.php/EpiHandyMobile>.

[67] DeRenzi, Brian, Yaw Anokwa, Tapan Parikh, and Gaetano Borriello. Reliable data collection in highly disconnected environments using mobile phones. Tech. 3 Apr. 2009 <people.ischool.berkeley.edu/~parikh/papers/derenzi_nsdr07.pdf>.

[68] Patnaik, Somani, Emma Brunskill and William Thies Evaluating the Accuracy of Data Collection on Mobile Phones: A Study of Forms, SMS, and Voice. 10 July 2009. <http://research.microsoft.com/en-us/um/people/thies/patnaik-ictd09.pdf>.

[69] "FrontlineSMS: A free, large scale text messaging solution for NGOs and non-profit organizations." FrontlineSMS: A free, large scale text messaging solution for NGOs and non-profit organizations. 10 July 2009 <http://frontlinesms.com>.

It has been used in a variety of projects, including in a hospital in Malawai where it was able to track patients, respond to requests for care, and answer health worker's queries for dosage information.[70] However, FrontlineSMS is not open source and is better suited for conducting and tracking field workers. The goal of this project was to automate the process of data entry and while two-way communication would be useful, it was less of a concern. FrontlineSMS did not allow users to export and automate the processing of data and as such was not useful for this project.

Texas A&M University in Texas, U.S. set up the LINKS system in 2004 in Kenya and Ethiopia. LINKS, which stands for Livestock Information Network and Knowledge System, allows users to send coded SMS messages to a central server. These SMS messages contain data such as livestock type, age, and condition and the server will reply with an SMS message containing the prices a farmer could receive for such an animal in different nearby markets.[71] This facilitates the ability for farmers to maximize their profits and thereby improve their livelihood by increasing their profits. However, this system of communication between social workers was outside of the scope of the iSTEP project. With more time, the iSTEP team would have liked to develop a network between social workers, but this part of the project was infeasible and not a direct goal. Despite this issue, the LINKS study did further emphasize that using coded text messages is a feasible way of interacting with a system.

CAMBrowser is a project out of the University of Washington in Washington, U.S. hoping to restructure the way users interact with form-based data entry. Utilizing the mobile cameras that are becoming more prevalent in mobile phones, CAMBrowser's developers hope to make data entry more efficient. To enter data, users have a copy of a paper form listing all the fields and a corresponding bar code to each field. To enter data into a particular field, they take a picture of the bar code and CAMBrowser is able to decode the image by knowing what data the user is

[70] "jopsa.org » Mobiles in Malawi Pilot - Projects and perspectives on global health." jopsa.org - Projects and perspectives on global health. 10 July 2009 <http://www.jopsa.org/?page_id=125>.

[71] Kaitho, RJ, JW Stuth, and AA Jama. "Application of Information and Communication Technology in Livestock Marketing in the Pastoral Areas of Eastern Africa." The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences 34.XXX (2004): 1-2.

entering, thus ending the need to navigate through menus.[72] CAMBrowser offers an alternative to cumbersome navigation menus or text coding that was valuable for low-literacy users. However, for the social worker project, the users were determined to be literate and given the complexity of implementing CAMBrowser, the iSTEP team decided that the cost outweighed the benefits. Additionally, mobile phone cameras are not universal and for the iSTEP team to design an application that required a camera would narrow the number of users that could be served.

With a better understanding of projects that used mobile devices to exchange information over long distances, the iSTEP team developed an application that best suited the needs of this project. None of the projects surveyed uniquely addressed the need for automated processing of reports at the district level as well as the need for the application to be cheap and easily deployed on a variety of mobile devices. Thus the iSTEP team undertook the process to develop an application specifically for para-social workers in Tanzania.

8.2. Solution Overview

During needs assessment, the iSTEP team learned how social workers handled reports. Specifically, the team learned that reporting was a three-step process involving paper forms to the district where they were digitized as seen in **Figure 25**.

Figure 25: Flow of Reports to National Database

Para-social workers predominantly operate at the village level. Their efforts are concentrated on serving villages and the reports they construct are brought to a ward. A ward is a collection of about three villages, where the

[72] Parikh, Tapan S., and Edward D. Lazowska. Designing an Architecture for Delivering Mobile Information Services to the Rural Developing World. 10 July 2009. <http://glews.tamu.edu/africa/index.php?option=com_docman&task=doc_download&gid=187>.

social workers can meet and interact, as visits to the ward happen very frequently, if not daily. At the ward level, the paper form reports are coalesced and are then taken to the district level. This process is rare and expensive. The bus ride into the district can take hours and is often uncomfortable. Following the ride, the forms are delivered to the district level, where they are digitized and submitted to the national database once every three months. However, the many difficulties of ward-to-district transportation can cause the forms to be delayed anywhere from a couple months to a year in addition to some forms being lost entirely. This in turn leads to the national database containing out-of-date information.

Thus, entering the project, the iSTEP team targeted their efforts in streamlining the process of data out of the ward straight into the national database as seen in **Figure 26**:

Figure 26: Proposed Flow of Reports

The goal of the project was to digitize information at the ward level. In doing so, the lengthy and arduous task of dragging a large number of backlogged paper forms to the district level at uncertain intervals could be minimized and the national database could be updated directly from the ward level. Due to the limitations of volume of data that can be transferred over SMS, it is infeasible to digitize all data at the ward level and hence this system does not entirely eradicate the need for paper forms. However, it does allow the national database to be updated with key information at more frequent intervals. Additionally, by utilizing social workers mobile phones, the solution incorporates a technology that is already prevalent amongst Tanzania and with which the social workers are fluent. However, there are many avenues to be considered when discussing how to best digitize this information.

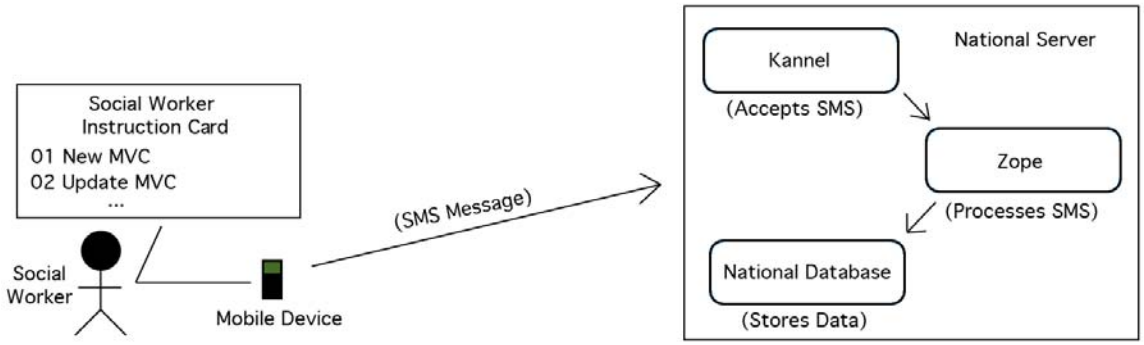

Figure 27: Detailed System Overview

After much discussion, the iSTEP team decided the most cost-effective way to digitize the information was with SMS messages. Voice calls were very expensive and, from earlier research, we believed that SMS and mobile phone applications have a negligible difference in error rates.[68] Thus it was decided to use a key code style format SMS message similar to the one being used by LINKS.[71] As seen in **Figure 27**, social workers would be given a small card, which contained all of the codes to be used in the SMS message. This SMS message would then be sent to a central server, which would take the information and process it into the national database.

The iSTEP team designed the system to receive text messages through the SMS gateway, Kannel.[73] By connecting a phone or GSM modem to a computer, Kannel receives SMS messages from the phone, processes the information into an XML file, and sends it to a Zope application. Zope is a content management system that has been in development since 1995. Using an array of Zope modules, an application was developed that stores the received SMS messages in SQL by parsing the XML file for the required fields.[74] If the Zope application finds the message to be improperly formatted or having strange values, Zope returns an error to Kannel, which replies to the user with the problem Zope encountered. Following this process, the information can be submitted into the national database.

---

[73] "Kannel: Open Source WAP and SMS Gateway." Kannel: Open Source WAP and SMS Gateway. 1 July 2009 <http://kannel.org>.

[74] "Zope.org." Zope.org. 1 July 2009 <http://zope.org>.

8.3. Implementation Details

In order to meet the needs of the community, TBW designed a system that would allow users - in particular, para-social workers - to submit data to a central database via SMS. SMS (Short Message Service) is a low-cost, low-bandwidth method of transmitting data that is supported by most mobile phones. In particular, we found an SMS-based solution very attractive because many users already own mobile phones, and the cost of an individual SMS is very low (presently somewhere between US$.03 and US$.05 in Tanzania). Additionally, owing to the fact that SMS is considerably less expensive than standard voice communication, many Tanzanian cell phone users are already familiar with SMS.

We initially explored several other options before ultimately settling on this solution. We considered a voice-based system, where users call in to a call center and speak to a live operator, who then enters the relevant data. This solution is highly robust since it avoids the possibility of mistyping data, and the operator can ask clarifying questions if he or she is unsure about the data. Unfortunately, the high cost of airtime as compared to SMS, as well as the additional cost imposed by training and employing the operators, prohibited us from pursuing this solution path. We also investigated the possibility of using a cell phone application to help users format their responses properly; our hope was that this would decrease error rates by making data entry more intuitive. Previous ICTD studies have shown that error rates were not significantly different between data entered with the aid of a Java application and hand-formatted SMS.[68] Additionally, each of the application formats we considered posed significant barriers to wide-spread deployment: Java applications tend to only run on high-end mobile phones, and SIM card applications require approval (which is virtually impossible to get) from network operators. This led us to design a system that uses hand-formatted SMS to transmit data.

Data flow begins with the users – in our case, para-social workers. Users are instructed via cue cards to submit data by sending a specially formatted SMS. This technique of using cue cards has been shown effective in other ICTD scenarios.[68] Despite its many advantages, SMS has its drawbacks. An SMS is limited to a mere 160 characters, and the lack of a proper keyboard on most phones makes typing large amounts of data cumbersome at best,

and error-prone at worst. Thus, it is reasonable to expect users to be able to accurately enter no more than a small amount of numerical data - a total of maybe 10 to 20 integer values. Based on discussions with employees of the DSW and the ISW, we determined that the most useful data would be summary data, such as the number of orphans and vulnerable children (OVC) identified in a village, their gender breakdown, their age range, as well as which services are being best provided and which services are most needed. Such data would hopefully allow an administrator to identify meaningful trends in social work across the nation and enhance the collection of data in the National Database.

Each SMS begins with a personal identification number (PIN) that uniquely identifies the user. Combined with user registrations in the database, the PIN also allows the server to identify where the data is coming from, as each PIN is tied to a village. Users can either register via SMS or can be manually entered into the database by an administrator.

Within minutes, if not seconds, of a user submitting an SMS, our server receives the message. This is accomplished using the excellent open source software Kannel in conjunction with a GSM modem. Since the format specified by the cue cards is machine-readable, as soon as the server receives an SMS, it is parsed and entered into the database. In the event that the server receives an incorrectly formatted message, or one with clearly incorrect data (such as a report of a thousand OVCs in a given village), instead of putting incorrect data into the database, we flag the message for review. In particular, messages that cannot be properly parsed are flagged, and depending on the data, we would like to implement range-validation as well, which will only allow certain, reasonable, ranges of values for different fields. This system combines the benefits of the robust human operator with those of crowd-sourced digitization.

We decided to implement the server using several open source technologies: Kannel, Python, and Zope. Kannel is an SMS gateway, which serves as the connection between the cell phone networks and the server, connecting one or more GSM modems to Zope. Zope is a web framework written primarily in Python. Our decision to use Zope was motivated by a need to design a simple and intuitive administrative interface as well as interface with Kannel and external databases. For database connectivity, we used SQL Alchemy, an object relational manager

for Python, which easily allows us to plug into various back-ends. Presently, our development version of the server runs using SQLite. However, in a production environment a better choice would be a production quality database, such as MySQL or PostgreSQL.

8.4. Initial Feedback

We conducted an initial evaluation to gauge the usability and feasibility of the proposed technology. This was done in two stages:

- Demo prototype of the mobile phone application to personnel at the ISW and the DSW to gather initial feedback.
- Assess effectiveness of cue card instructions with a village OVC committee to understand the degree to which they can follow the instructions to send an SMS in the required format.

We explore these two components in section 8.4.1 and 8.4.2.

8.4.1. Demos

The demos at ISW and DSW produced the following feedback about the technology:

- The design and functionality of the application is good.
- Highlighting data records with errors in red is a useful feature.
- The limitation on the amount of data that can be sent via SMS is a concern, since only 160 characters fit into one message. Currently, they use paper forms to send a lot more text-intensive data such as comments on particular children and other problems in the community. It is not feasible to send such data in one SMS.
- Training people to send data using this technology will be challenging because many people in villages and wards have limited exposure to technology and some do not even own or use mobile phones.
- Lack of mobile phone coverage (signal) in certain areas of the country will be an issue for an SMS-based solution.

- Since there are up to 12,000 villages in Tanzania, we need to make sure there are a corresponding number of unique PIN codes to assign to data senders at those different locations.

This feedback was useful in understanding some of the realities we would face when moving to the implementation phase of the project. Since the feedback about the technology itself (in terms of its capabilities and design) was positive, the demos did not lead to further modifications of the web application. However, it did help shape the instructional cue cards as well as the deployment strategy for this project.

8.4.2. PSW Feedback

The instructional cue cards designed for data senders were tested on five OVC committee members (one woman and four men) from Tandika, which is in the Temeke district of Dar es Salaam region. For this testing, we provided each of them with a cue card, which contained the following instructions translated into Kiswahili:

1. Begin a New SMS Message
    - Make sure the message is blank to begin with
2. Switch to Numeric Input Mode
    - On many phones:
        i. Press the menu button
        ii. Select "insert number"
3. Enter your PIN
    - Your PIN is: 1668
4. Enter a space, or a *
    - Press *
5. Enter the number of OVC in your village

6. Enter a space, or a *
    - Press *
7. Enter the number of male OVC in your village
8. Enter a space, or a *
9. Enter the number of female OVC in your village
10. Review the message
    - It should be formatted similarly to:

      1668 10 4 6

      - OR -

      1668*10*4*6
11. Send the message to 077XXXXXXX

We asked them to imagine they had 11 OVC in total, of which six were female and five were male. Equipped with this information and their mobile phones, we asked them to try to follow the instructions and transmit the data provided. The mobile on the receiving end of the SMS data was one of the researchers' personal phones. This allowed us to verify the accuracy with which the PSW formatted and submitted the given data.

There was a typo in the translated version of the cue card, so we needed to correct that at the beginning of the session. Apart from that, participants had a very difficult time understanding step #2 of the cue card instructions. They asked for some guidance for this, and were subsequently able to send the SMS in the required format. In order to address the issues they had with step #2 we may need to create phone brand-specific instructions, which will be easier to follow. None of them knew what "numerical input mode" meant, so we needed to show them where it was on their physical phone. It was clear that three of the five were quite proficient in sending SMS with their phone, and

mastered the instructions very quickly. The other two committee members had a difficult time getting past instruction #2, although one did not really make an effort. One of the members had little to no experience with SMS so we guided her through the entire process. Eventually, we received three correctly formatted messages. One of the members formatted it correctly, but didn't wish to send the SMS. The other did not successfully format or send a message. However, we noted that the committee members worked together to assist each other with the task, so with more time they would have been able to help each other send a correctly formatted SMS. The participants said that the instructions were not difficult to follow, except for step #2. They also mentioned that they think such an application will be useful to them in their work and that they would use it if it were available.

8.5. Challenges and Limitations

There are a number of challenges inherent to the problem of transmitting OVC data in Tanzania. Chief among these is costs – para-social workers (our target users) receive no compensation for their work, and as such do not generally have incentives to collect or submit high quality data to the DSW. No technology solution, no matter how fast and user friendly, will ever be able to solve that problem. That being said, once the server is set up, the cost per message is just the cost of one SMS, which at the time of this publication is roughly as expensive as making a photocopy, which is currently necessary to submit the paper-based forms.

Although we believe mobile phones can be an effective tool in a wide range of data transmission applications, including this one, there are a number of limitations to the platform worth noting. More remote areas in Tanzania, where data collection is already challenging, may have little or no reception. Our system is designed to complement rather than replace the existing system of paper form transmission, so while it may not improve the situation in these communities, it certainly will not negatively impact them. Furthermore, cell phones are not designed as general-purpose data entry devices, and so they run into usability issues. Entering data via the keypad, particularly alphanumeric data, can be difficult and error prone, and while an individual SMS is cheap, the data rate is still roughly US$200 per MB.

Identifying and registering users of the application is a challenging problem. Our current system allows distributed user registration, taking the burden off of the server administrators. However, it may not be the most user-friendly solution and is definitely an area of the application that would benefit greatly from testing and user feedback.

8.6. Future Work

There are a number of interesting areas where our work could be extended. Two interrelated ideas we would like to highlight are server-to-user communication and time-sensitive surveys. Server-to-user communication would allow server administrators to contact users via the same cell phones they use to submit data. There are some issues with this, including the bandwidth limits of a GSM modem, the possibility that such communication is unwanted by its recipients, and of course additional costs. That said, by initiating two-way communication, interesting new possibilities emerge. One such possibility is a method for collecting time-sensitive surveys. A survey could be distributed via SMS and then collected via SMS, with a response time that would theoretically be as short as minutes. Again, there are challenges involved in implementing this, particularly regarding usability, but it could prove a versatile and useful tool. Some possible uses could include tracking the spread of diseases or in disaster monitoring.

Another area we would like to explore is generalization. The project generally solves the problem of submitting data, especially location-tied data to a database. This has many possible applications beyond collecting data for social welfare in Tanzania. We hope that future work on the program would make it more useful for other developers.

8.7. Deployment Plan

We would like to begin deploying the application in a relatively small trial, probably limited to the Dar es Salaam region. Dar es Salaam is a large region with a population of approximately 2.5 million people according to a 2002 census. It is also the wealthiest of the regions in Tanzania and features excellent cell phone coverage. Due to its unique position, any

deployment in Dar es Salaam will not be typical of the rest of the country; however, since we expect it to be easier in Dar es Salaam than elsewhere, we hope to work out as many issues as possible before possibly expanding to other regions.

In order to accomplish this deployment, we would need the cooperation, or at least approval, of the DSW, which is officially in charge of social welfare programs within Tanzania. The deployment would also require people with a technical expertise to set up and maintain the servers, as well as explain the operation of the application. TechBridgeWorld, or possibly the UCC, would be best qualified to supply this technical expertise. A small amount of hardware is also necessary for deployment - a server (although a deployment of this scale would only need a small amount of computational power, and could certainly run alongside other applications on an existing server) and a GSM modem. Finally, a partnership with the ISW to engage and train users would be helpful.

During this trial, we would collect further data to identify which parts of the application work well and which parts could use improvement. Armed with this information, we would hope to iteratively improve and expand the program. We anticipate that the application could easily grow to cover the entire social welfare network of Tanzania.

8.8. Sustainability

During the last week of iSTEP 2009, we worked with our local partners to come to an agreement on what the next steps of this project would be.

8.8.1. DSW

Prior to the iSTEP team's departure from Tanzania, TechBridgeWorld (TBW) presented an official letter to the DSW requesting their partnership in pursuing this project. TBW agreed to stay in touch with the department via Sesil, their data management specialist. Thus, should the commissioner of the department have any changes or comments regarding the request letter, he will be able to communicate those thoughts with us through Mr. Charles and receive a timely response from TBW. Furthermore, TBW will work with DSW to come

to an agreement on ownership of the application and a plan for future piloting and deployment of the project.

8.8.2. ISW

The iSTEP team agreed that TBW will maintain communication with ISW to update them on progress of the project and future plans. In addition, TBW will work with ISW to create a contingency plan in the event that DSW does not wish to take ownership of the application. That is, we will look into other uses of the application that can be headed by the ISW rather than the DSW. A potential use could be assisting in the data collection process that ISW and Capacity Project set up to monitor the progress of the para-social worker training program in Tanzania.

8.8.3. PSW

Para-social workers were given the opportunity to learn about the technology and provide feedback on the instructional cue cards. Apart from this, we committed to keeping them apprised on the progress of the project via our local partner the ISW.

The sustainability of this project relies heavily on a local party taking ownership of the application and hosting it on their server. Ideally, the DSW will take on this role. Post-iSTEP 2009, TBW will work with the UCC and our contacts at the DSW to make this ownership official. As mentioned above, without DSW ownership or in addition to their participation, TBW will look to other local entities that may benefit from the technology; Capacity Project and ISW are potential candidates for this. Once ownership of the technology is undertaken by a local partner, we can work with that group to plan pilot testing as well as a long-term study to deploy, collect data, and evaluate the effectiveness of this SMS-based technology solution.

9. Literacy Tools Project

English literacy is one of the pressing problems in Tanzania's education system. Students are not instructed in English until they enroll in high school, and in primary school, English is allocated a single class. Teachers are typically expected to teach several subjects, some of which they might not be suitable for, especially English. English fluency is deemed very important in the Tanzanian job market, and increased competition in English from neighboring countries has forced Tanzanians to pay more attention to it.

The Literacy Tools project is aimed at developing a feasible solution to tackle the problem of English literacy among students in Tanzania. Children's engagement, learning, and easy deployment were the main concerns in the design and implementation of the solution, which consists of a culturally relevant game played on a mobile phone. The game simulates penalty kicks in football; the idea of using football as the theme was inspired by its popularity among both girls and boys in Tanzania. The game serves as a backdrop that provides incentives for students to answer questions relevant to English literacy. The questions are presented in a multiple-choice and fill-in-the-blank format. If the student answers correctly, he or she scores a goal; otherwise, the penalty kick is a miss and the student is encouraged to try again.

The choice of a mobile phone as the platform for the game is motivated by the lack of electricity in the school with which we worked. Although it was possible to transport students to a computer cluster at a nearby university, we opted instead to use a portable battery-powered device that is ubiquitous in Tanzania. This eliminates time for a commute to the computer lab and thereby provides a more sustainable solution. Furthermore, the game can be actively used in the classroom during a school day, instead of being an extra-curricular activity, which increases the game's potential impact.

Our solution is designed to assist teachers in the classroom, rather than to replace them. The game provides a more engaging experience for students, as well as feedback and personal attention that are not possible in crowded classrooms. However, the game's content depends highly on the teachers and their input.

Initial content for the game was selected from the Standard English curriculum in Tanzania for the classes Standard 3, Standard 4, and Standard

5 and from samples of student exams provided by our partner school. The multiple choice quiz format mimics the student exam format, thus increasing the familiarity of the game, and making it a useful practice tool for exams.

Finally, since teacher input is vital to the game, we created an online Content Authoring Tool to assist teachers in creating custom questions and answers for their students. The teachers have access to this authoring tool via a computer lab at a nearby university.

9.1. Related Work

A multitude of technological approaches have been designed to address the problem of literacy. The Literacy Tools project began by exploring the various approaches adopted by other teams. Additionally, these projects provided insights on what techniques could be adopted for the work to be done in Tanzania.

An important literacy project developed at Carnegie Mellon is Project LISTEN, an inter-disciplinary research project aimed at improving children's reading skills through an automated Reading Tutor.[75] Children can choose stories they want to read and the Tutor "listens" and assists the child when he or she makes a mistake, gets stuck, or faces difficulty reading certain parts. Project LISTEN can highlight syllables and reiterate sections of a story that students find difficult, thereby highlighting areas on which the students need to focus.

Project LISTEN has met much success through multiple studies concerning the effectiveness of technology in improving child literacy. In 1996 to 1997, students working with the tutor gained two years of progress in eight months of work. In 2003 to 2004, English as a Second Language (ESL) students in Illinois, U.S. gained three times more fluency after working with the tutor than they received from silent reading.[76] In 2005, TechBridgeWorld used the Project LISTEN writing tutor in Project Kané,

[75] "Project LISTEN Summary." SCHOOL OF COMPUTER SCIENCE, Carnegie Mellon. 5 July 2009 <http://www.cs.cmu.edu/~listen/>.

[76] "Project LISTEN Progress." SCHOOL OF COMPUTER SCIENCE, Carnegie Mellon. 7 July 2009 <http://www.cs.cmu.edu/~listen/progress.html>.

a project that specifically targeted students in Ghana. Utilizing a nearby Internet café, researchers worked with students in grades 2-4 in a pilot study to determine the feasibility of using automated tutors to enhance literacy in the developing world.[77] This was followed up by a longer four-month controlled study in which students in low-income communities improved drastically from the usage of the tutor.[78]

However, Project LISTEN and Project Kané were developed to be used on computers with speech technologies. The resources at the Mlimani Primary School did not provide for desktop computers, microphones, or electricity that would be necessary to utilize this software.

In the area of mobile literacy tools, there is MILLEE. MILLEE, or Mobile and Immersive Learning for Literacy in Emerging Economies, is a research project started in 2004 at the University of California, Berkeley in California, U.S. to enhance access to literacy among children in developing regions.[79] Currently focusing on India, the project develops mobile games and applications for school-aged children to improve various literacy skills. The MILLEE team has created its own games and adapted popular games such as Frogger to introduce new English vocabulary and grammar to Indian children through a receptive-practice-activation cycle wherein students are taught new concepts, allowed to practice these concepts, and then tested on the material they were presented.[80] However, these games are not freely available to be used by communities that don't have access to many resources, and knowledgeable members of the community are not able to customize the educational content of these games. Due to the very limited resources available to our partner school in Tanzania, our solution needed to be more customizable by the teachers in

---

[77] "Project Kané." TechBridgeWorld. 7 July 2009 <http://www.techbridgeworld.org/kane/phase1.html>.

[78] Mills-Tettey, G. Ayorkor, Jack Mostow, M. Bernardine Dias, Tracy Morrison Sweet, Sarah M. Belousov, M. Frederick Dias, Haijun Gong. *Improving Child Literacy in Africa*: Experiments with an Automated Reading Tutor. 2007 <http://www.cs.cmu.edu/~listen/pdfs/Mills-Tettey_ICTD09_paper_FINAL_corrected.pdf>.

[14] "Mkombozi (Kilimanjaro and Arusha Regions, Tanzania, East Africa)." Mkombozi (Kilimanjaro and Arusha Regions, Tanzania, East Africa). 9 July 2009 <http://www.mkombozi.org/>.

[80] Kam, Matthew, Aishvarya Agarwal, Anuj Kumar, Siddhartha Lal, Akhil Mathur, Anuj Tewari, and John Canny. Designing E-Learning Games for Rural Children in India: A Format for Balancing Learning with Fun. 5 July 2009 <http://www.cs.berkeley.edu/~mattkam/publications/DIS2008.pdf>.

the school so that it was more useful to them in their teaching efforts. Additionally, MILLEE was based in India and therefore the content would not necessarily be customized to Tanzania.

Mkombozi is a child-focused agency in Tanzania aimed at improving Tanzanian children and youth in mind, body, and spirit through education, research and advocacy.[81] Mkombozi runs several projects that could effectively use technology to help improve child literacy in Tanzania. Their programs include improving computer and IT skills, psychosocial support, shelter, food, outreach, and street outreach. Most recently, in 2008, Mkombozi's Affordable Computers and Technology for Tanzania established an Internet café in their offices, allowing local community members access to technology that they previously would not be able to use. Mkombozi's work helps to broach the digital divide and provide access to IT, providing a resource and information if there is a need to develop the school's facilities to make the project feasible. However, given the time constraints of our internship, it was beyond the timeframe for the iSTEP interns to raise funds and acquire technology that may be useful in the classroom.

Knowledge Adventure is a firm that has been creating games for enhancing education among schoolchildren at all levels.[82] Although the games are aimed at children that will use them as a supplement to their already existing education at school, a lot can be learned from evaluating these games and possibly finding ways to customize them for Tanzanian children. Their JumpStart series is a specific example of this, which features Story Land and other virtual worlds to encourage students to read and improve their reading and spelling skills through engaging games.[83] However, the JumpStart series requires a stable Internet connection and access to computers that make it less feasible for the Mlimani School, as

---

[81] "MILLEE: Mobile and Immersive Learning for Literacy in Emerging Economies." Computer Science Division | EECS at UC Berkeley. 5 July 2009 <http://www.cs.berkeley.edu/~mattkam/millee/index.html>.

[82] "Educational Games – Free Kids Educational Games at Knowledge Adventure." Educational Games – Free Kids Educational Games at Knowledge Adventure. 7 July 2009 <http://www.knowledgeadventure.com>.

[83] "Reading Games – Free Kids Reading Games at Knowledge Adventure." Educational Games – Free Kids Educational Games at Knowledge Adventure. 7 July 2009 <http://www.knowledgeadventure.com/reading-games.htm>.

they do not have electricity, let alone a computer lab. Additionally, this is commercial software, which was outside of the budget for the iSTEP program.

The popular children's television series Sesame Street piloted a new study that utilized mobile technologies to improve children's literacy as well as get their parents engaged in the projects through a series of child-adult modules. Every week for eight weeks, families were sent audio and video clips on their cell-phones.[84] Adults received information about the clips that were provided to the children for that day as well as suggested activities to reinforce the content. Children received clips from characters such as Elmo teaching them about a letter of the alphabet and words beginning with that letter. By providing content for parents and children, Sesame Street provided educational content and encouraged parents to get involved in their child's learning. However, working on an individual level with the parents of all the students was outside the scope of the project. Due to the varying backgrounds of the students enrolled in the school, there was no guarantee the children would have access to cell phones at home, much less ones with video capabilities.

From these related projects, we garnered a better understanding of different approaches used to attempt to encourage English literacy. Additionally, Project Kané and MILLEE offered insights into working on literacy in developing communities. However, none of these projects uniquely addressed the Mlimani School, and as such, a new mobile game was developed to address its needs.

9.2. Solution Overview

The implemented solution consists of two parts: (1) a quiz-based educational game and (2) an online Content Authoring Tool. The game presents the student with questions from their textbooks targeting their vocabulary, grammar, spelling, and language use. Questions for the game are arranged in several categories based on teachers' input and the English curriculum. Students targeted by the game are from classes standard 3

[84] Revelle, Glenda, Emily Reardon, Mays, Jeanette Betancourt, and Jennifer Kotler. "The Use of Mobile Phones to Support Children's Literacy Learning." Persuasive Technology 4744/2007 (2007): 253-258.

(eight years old) to standard 5 (11 years old). Interviews with the teachers revealed several weaknesses in the students that the game tries to address:

- The students often find the use of "have" versus "has" confusing.
- Students find it hard to follow instructions in English.
- Students have a difficulty distinguishing between the English sounds of "R" and "L" because Swahili, their native language, makes little distinction between the two sounds.
- "Too" versus "two" versus "to" use is confusing.
- Question construction in English is difficult for students.
- Vocabulary is a major issue.

Based on these areas of weakness, we developed several question categories inspired by the Tanzanian English curriculum and samples of students' exams. Examples of categories include personal pronouns like "I", "you", and "he" as well as places such as "classroom" and "kitchen". Questions have different levels of difficulty - easy, medium, and hard – to accommodate student needs and account for differences among students. The difficulty level for a question is assigned during creation (via the Content Authoring Tool).

The Content Authoring Tool is an online tool that allows teachers to create a question, specify the correct answer for the question, and choose the category and difficulty level. The tool generates a game-content file that is uploaded to the mobile phone hosting the game.

In order to engage students, the game uses football penalty kicks in the form of a graphical animations (**Figure 28**) and appropriate sound effects. If the student answers a question correctly, he or she scores a goal and a cheering sound is played. Conversely, when the student answers incorrectly, a "goal-miss" animation and sound are played, and the student is encouraged to try again.

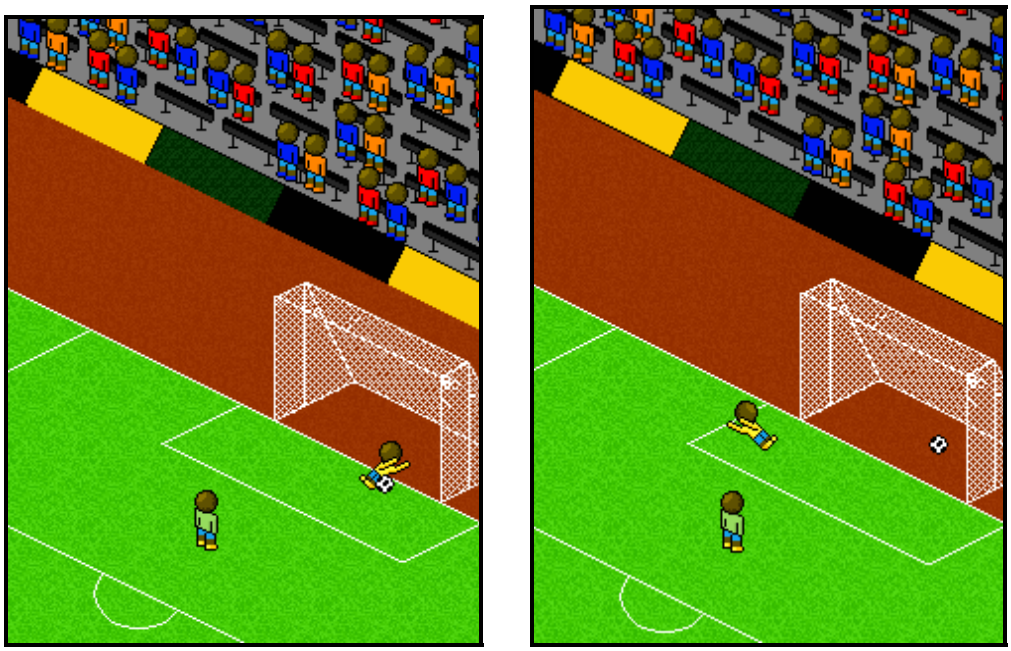

Figure 28: "Incentive" Images from the Football Game

Variations between students were an important consideration in designing the game. Advanced students should not feel that the game is too easy; otherwise, they will lose interest quickly. Similarly, the game should not be too difficult and should not frustrate students or make them afraid of using it. Hence, the game dynamically scales the difficulty level based on student performance. Starting with a medium-level question, the game adjusts the difficulty level based on the number of questions a student answers correctly and the number of mistakes they make.

Finally, competition and challenges are one of the things students seem to enjoy in Tanzania. Competition is added to the game by keeping track of high scores. The game tracks students' performance and records students' score based on the number of questions they answer correctly, the number of questions they miss, and the difficulty of the answered questions.

9.3. Implementation Details

Next we explore a detailed discussion of the solution components and their implementation. **Figure 29** illustrates the various modules and

components that form the literacy game. The description for these components is given in **Table 5**.

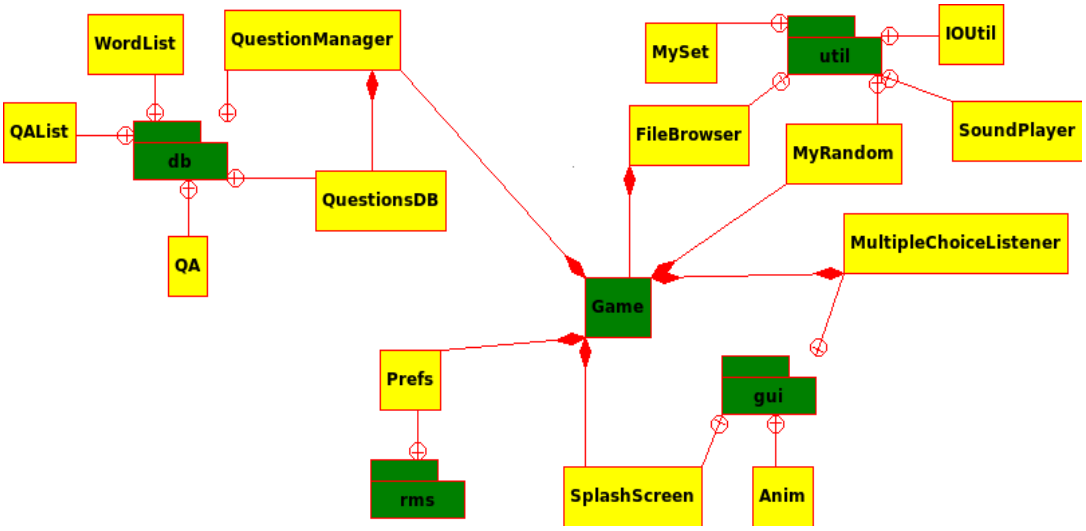

Figure 29: System Diagram for Football Game

Name	Description
`Game`	This core class represents the `Game` (i.e., the main `Midlet`) and essentially acts as a controller and dispatcher. It listens for events and takes the necessary actions (for example, switching screens, closing the application, playing a sound, etc)
`Prefs`	This class interfaces with the Record Management Store, and is responsible for storing/loading application specific data. At the moment, it stores the user's Sound preferences and the player's score.
`MySet`	A simple implementation of a `Set` to hold a unique set of elements.
`IOUtil`	A utility class for reading the various resources files bundled with the game.
`SoundPlayer`	A utility class for playing various sound files

	bundled with the game.
MyRandom	A utility class that provides random numbers between `0 < n < upperlimit`.
FileBrowser	A utility class that handles the traversing of directories and reading/listing files to load a user defined content file uploaded to the mobile phone
SplashScreen	The UI class that draws the Splash screen during application startup.
Anim	A simple form that handles the display of an animated image.
MultipleChoiceListener	A callback interface that determines whether a user chose the correct answer from the List of questions.
QuestionsDB	Handles parsing and loading all the questions from XML. Also acts as a provider of questions based on the difficulty requested.
QuestionManager	This class constructs the actual question that is eventually posed to the user.
QAList	This data class keeps track of all the possible answers to the question, and also the index of the right answer. The `QAList` objects are constructed by the `QuestionManager.`
QA	A class that logically represents a question. It holds the question and answer text, the category, as well as the difficulty of the question. `QA` objects are created by the `QuestionsDB.`
WordList	A data class that merely holds list of words that belong in a particular category. `WordLists` are used by the `QuestionManager` while reading the XML question/answers file.
Config	Contains any necessary parameters shared across

	all packages.
Debug	The debug package contains simple utilities for debugging.

Table 5: Component Overview for Football Game

9.3.1. The Football Game

Portability to different platforms is a major concern when developing for mobile phones. The lack of a specific set of mobile phones required the development of a game that could easily run on various mobile phones. For that reason, we chose to use Java Mobile Edition (Java ME)[85] as the main programming language. The game was developed using Java ME and the Light Weight User Interface Toolkit (LWUIT)[86] conforming to MIDP 2.0[87] and CLDC 1.1 specifications[88]. The game consists of the following main components, which we explore in detail in the following sections:

- Question selection
- Scoring scheme
- Adaptive difficulty
- Visuals and audio

9.3.2. Question Selection

The game stores a database of questions in XML files. In addition to questions and answers encoded in the XML file, the phone contains lists of words corresponding to the available categories to make the

[85] http://java.sun.com/javame/index.jsp

[86] https://lwuit.dev.java.net/

[87] http://java.sun.com/products/midp/

[88] http://java.sun.com/products/cldc/

choices in the multiple choice list more challenging and realistic. For example, **Figure 30** illustrates a "places" category question.

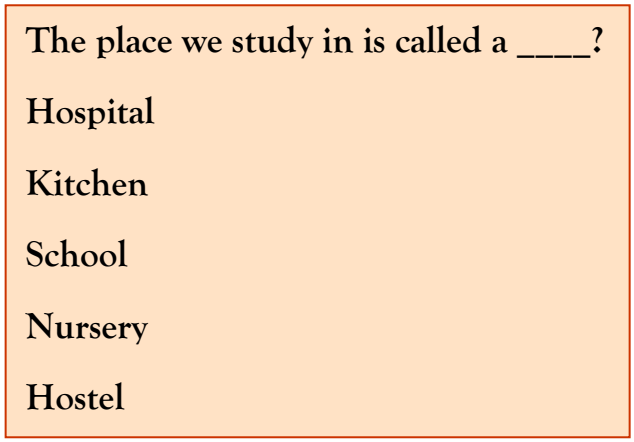

Figure 30: Example question in the "places" category

The multiple-choice answers provide sensible alternatives chosen from the "places" word list stored on the phone. The implementation selects possible answers randomly, although this random selection process is not always best. For example, a choice of "classroom" in the question in **Figure 30** makes the question confusing. However, the simplicity of the approach makes its use appealing on mobile phones due to their limited computational power. In addition to multiple-choice questions, the game features spelling practice questions. The format of spelling questions is identical to that of the multiple-choice questions, with the exception of displaying a text input field and asking the student to spill the word rather than a list of answers. **Figure 31** illustrates such a question.

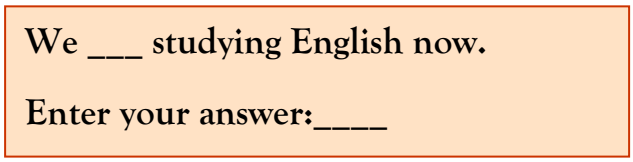

Figure 31: Ambiguous "spelling practice" question from the Football Game

The main challenge with this approach is dealing with open-ended questions for which several possibilities can be considered. For

example, a question of the form shown in **Figure 32** has several possible answers such as "clean" or "tidy".

Students should keep their school ____

Figure 32: Ambiguous "spelling question" from the Football Game

Therefore, it is better to associate spelling questions with new vocabulary to minimize ambiguity and provide some hints towards the right answer (as illustrated in **Figure 33**).

You carry your books to school in me. What am I? A bookcase or a cupboard?

Enter your answer:____

Figure 33: Unambiguous "spelling question" from the Football Game

9.3.3. Scoring Scheme

Students in Tanzania enjoy competition and challenges. Since the game is a single-player game, we have implemented a "high-score" based scoring system. The score is computed based on the number of questions answered correctly and their difficulty. The number of questions answered incorrectly adds to the computer score and avoids the problem of having a negative score. Questions are scored on a scale from one to four based on the difficulty of the question.

9.3.4. Adaptive Difficulty

Inspired by Computer Adaptive Testing (CAT),[89] our game adjusts the difficulty based on student performance. Questions start at the medium level and become easier or harder as the student progresses. In our

[89] Thissen, D., & Mislevy, R.J. (2000). Testing Algorithms. In Wainer, H. (Ed.) Computerized Adaptive Testing: A Primer. Mahwah, NJ: Lawrence Erlbaum Associates

implementation, a student has to answer five questions consecutively in order to move to the next level, and two incorrectly answered questions (not necessarily in a row) to go down one level.

9.3.5. Visuals and Audio

Visuals and audio are essential to capture children's attention and increase their interest in the game. However, care has been taken to reduce unnecessary distractions. If the student answers a question correctly, a goal animation will be displayed on the screen. The animation consists of a player shooting the ball; the goalkeeper tries to capture the ball and finally the ball enters the goal. As shown in **Figure 34**, upon scoring the goal, an animated "goal" text image is shown with cheers and applause sound. If the student answers the question incorrectly, a similar animation to the "goal" animation is displayed on the screen. In this case, if the ball misses the goal, an animated text of "pole" (Swahili word for sorry) is displayed on the screen accompanied by relevant sound effects to encourage the student to try again and select the right answer.

Figure 34: Images from the Football Game

9.3.6. The Content Authoring Tool

The Content Authoring Tool was designed for teachers to create content for students according to their lesson plans. Intuitiveness was the main consideration during the design and development of the tool, as teachers do not have lots of experience working with computers. **Figure 35** shows a screenshot of the web-based application. The application guides the teachers through the steps needed to create questions. First, the teacher needs to select a question category, used to generate a sensible multiple-choice list of answers. Next, the teacher selects the difficulty of the question, decides whether the question

should be a writing or a spelling question, writes the question, and finally supplies the right answer. Internally, the tool also spell checks the teacher's input and when the teacher selects "done" an XML content file is created and ready to be used on the mobile phone.

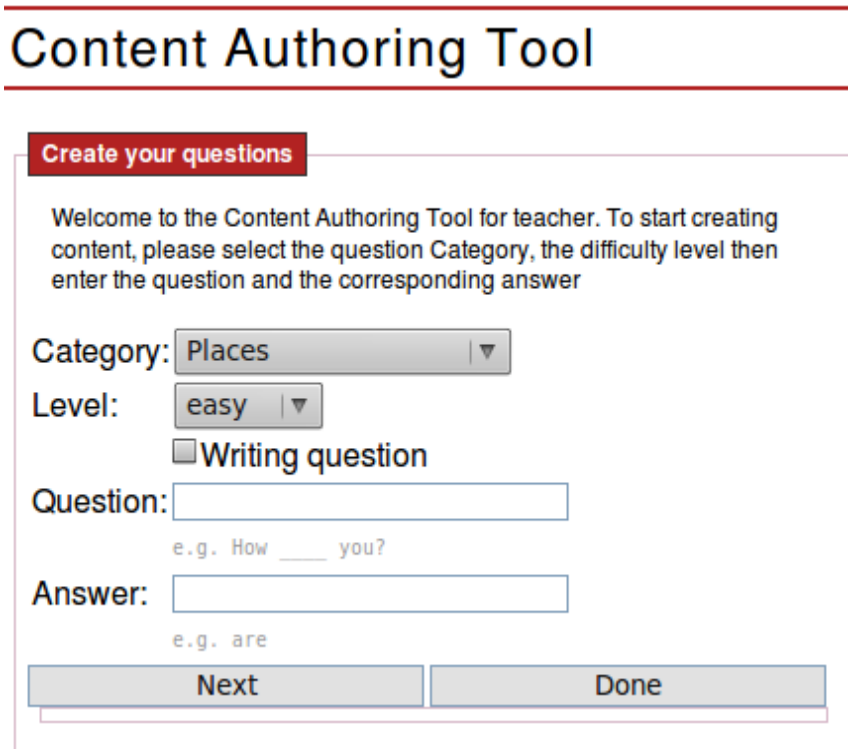

Figure 35: Authoring Tool Screen Shot

9.4. Initial Feedback

We conducted an initial evaluation to gauge the usability and feasibility of the proposed technology. This was done in the following three stages:

- Demonstrate a prototype of the literacy educational game to teachers at the Mlimani School to gather initial feedback.
- Assess usability by observing students at the Mlimani School interacting with the literacy tool (LT) and obtaining their feedback.
- Obtain feedback and record observations made during teacher training on the authoring tool for the game.

We explore these components in sections 9.4.1 through 9.4.3.

9.4.1. Demonstration to Teachers

The demonstration to teachers at the Mlimani School produced the following feedback and observations about the technology:

- The font size on the mobile phone screen was too small.
- Teachers enjoyed the design of the game; in particular, the fact that it is a football (soccer) game was really appealing to them.
- They said that all students should enjoy playing the game as well.
- Teachers thought the application was easy to use.
- They commented that up to five students should be able to share one mobile phone simultaneously, with one person managing the keypad while others vocally participate in the game.
- The teachers liked the idea of students getting a second chance at a question they got wrong, and said it would be good if students are given the correct answer to questions they get stumped on.

Based on this feedback, we increased the font size before presenting the game to the students. Additionally, we expanded the repository of questions for the game by including questions from an actual Standard 5 examination and adding one writing question to the set of multiple-choice questions.

9.4.2. Student Feedback

To supplement feedback from teachers, we also tested the literacy tools with students from Standards 3, 4, and 5. The study was comprised of 15 students in total: seven from Standard 3 (three girls and four boys), four from Standard 4 (two girls and two boys), and four from Standard 5 (two girls and two boys). We explicitly selected a mix of girls and boys from each grade in order to obtain a more representative sample of the student population at the Mlimani School. Some students were faster learners than others. On average, this group scored 87 percent on their

last English exam[90], with grades ranging from 67 percent to 100 percent. Our goal was to involve a diverse group of students so that we could understand how different kinds of students reacted to the technology. We asked the students' class teachers to first introduce the game to them and explain a little bit about how it works. Then, we assisted the teacher in providing each student with a few minutes to interact with the technology and successfully answer one or two questions before passing the mobile phone to the next student. We observed students as they worked with the technology.

- About four to five students were able to share one phone screen, with one student selecting the answers using the phone's keypad and others observing.
- Some students did not have any experience using a phone so they took some time to get used to it; in particular, the continuously fading screen light seemed to stump many of them.
- Getting positive feedback for answering a question correctly really motivated the students to try hard.
- The "*boo*"ing sound that the game made for incorrect answers seemed to act as a disincentive to getting the answer wrong. However, it may also make weaker students self-conscious about playing the game, since other students laughed at students who repeatedly got booed. However, it did seem that the competitive and soccer-loving attitude among students would override any insecurities, and so the "*boo*"ing may actually serve well in encouraging students to learn enough English so that they do not get booed as much in front of their peers.
- The older students arrived at the correct answer at a faster rate than younger students, but no student gave up on a question, even after multiple boos.
- Standard 3 students gave eight correct answers and 15 incorrect ones. Standard 4 students gave 13 correct answers and 16 incorrect

[90] Note, this average is for 13 of the 15 students in this group. We were unable to obtain grades for the other two students.

ones. As would be expected, standard 5 students fared better than the younger students and answered all of the multiple-choice questions correctly. Standard 5 students also attempted the one writing question that was included in the game (other grades did not see this question), but it proved to be challenging even for those students. However, the teachers thought that having writing and spelling questions will be very useful to the students, and we believe that the student could be easily trained on how to use the phone's keypad to enter text.

After each student had a chance to try their hand at the game, we asked them a few questions about their experience.

- All of the students enjoyed using the mobile phone game.
- Students did not find the game difficult to play.
- Although students said they learned something new from the game, they could not recall what exactly they learned. However, some pointed out that they learned to use a mobile phone.
- Having a football-themed game was really popular among students.
- Students were enthusiastic about getting another try at playing the game and said they would play it at home as well, if they could.
- They enjoyed the sound effects of the game as well as the format of the questions (multiple-choice).
- Students were rather disappointed when they had to "try again" to get the correct answer.
- Sharing a phone with four other students did not seem to trouble any student.

9.4.3. Teacher Training

After collecting feedback from both teachers and students at the Mlimani School, we conducted a training session for teachers to instruct them on how to use the authoring tool. Training was conducted at one of the UCC computer labs, which are open to the public and function as Internet cafés. For this session, the UCC

provided us with access to these computers at no charge. The three teachers we interviewed joined us for the training and did not have any trouble uploading new questions for the game using the authoring tool. Editing questions that were already in the game's database was much more challenging for them since they needed to edit the xml code. Two of the three teachers eventually got better at editing, although the third teacher was not able to grasp the concept very well. Apart from editing, the teachers enjoyed using the authoring tool and creating content for the game. They all made several spelling and grammar errors while writing questions, but if they used questions from their teachers' guide texts they should be able to avoid most of these errors.

9.5. Challenges and Limitations

In addition to some of the limitations of the solution, several other technical and logistical challenges were identified. The main challenge in this project is acquiring enough mobile phones to accommodate at least 60 students per class. Additionally, the football game requires MIDP2.0 support on the phone, and these devices tend to cost more than US$50, which is rather expensive. The other challenge is making sure that teachers remain interested in supporting the application and use of technology if they find it useful. Teachers have very busy schedules and teach several subjects for different classes from 7:00 – 14:00 daily, which leaves little to no room for additional work. In terms of technology, the list of multiple-choice answers is generated randomly from a list of words that belong to a certain category. More guidance would provide better multiple-choice lists. However, given the limited computational power and space on cell phones, a more intelligent answer choices generation does not seem feasible. Another challenge is creating "writing/spelling" questions. Open-ended questions without guidance, such as "___ is our favorite school topic," is open to several answers. Creating appropriate questions in this category depends wholly on the teachers and the software does not provide any hints or tips on how to format such questions. Furthermore, text input using a cell phone keypad is a challenging and error-prone task for young children.

9.6. Future Work

Several possibilities for future work could be considered. One possible direction is the use of Text To Speech (TTS) engines that are built into a large number of smart phones in the market. An onboard TTS was not implemented in this project, as it requires device specific functionality and we did not have access to specific devices. However, TTS engines on mobile phones provide an accepted level of quality and clarity and could thus be useful in enhancing the students' listening skills.

Smart category detection is more immediately necessary future work. Currently, teachers are asked to provide a hint to what "category" the question is. Question categories are used to assist the program in creating a sensible list of answers for the student to choose from. However, it is possible to add smart category detection to the functionality of the game and ease the task of content creation even further.

The game framework is general enough to accommodate several other types of questions. For instance, listening skills could be improved by playing prerecorded voices and asking the students to identify the words they heard. Another category is reading exercises; a short paragraph of text could be shown to students and several questions relevant to the paragraph could follow. However, due to the limited screen size, reading questions are not easily implemented, unless paragraphs are very short.

Another direction for future work is the development of group challenges. Since students feel excited about competitions and challenges, mobile phones could be connected via Bluetooth and allow students, or groups of students, to compete against each other in an educational and fun setting.

Considering a more interactive game is another option. Although interactive games could be very distracting, they are more engaging. Care should be taken to balance the time spent on playing the game versus the time spent on learning new materials.

As for the game's content, an online community could be involved to create content and alleviate the load on the teachers. Furthermore, parents' involvement by having access to the game to create content and allow the student to practice at home is a promising idea.

9.7. Deployment Plan

Our deployment plan consists of several iterations of deployment and feedback. First of all, mobile phones need to be provided for the school with which we worked in collaboration with our partner. Once mobile phones are acquired, we envision teachers to use the game as a teaching aid used in class as often as possible. Prior to every class, teachers can create relevant content using the Content Authoring Tool, upload it to the phone, and allow students to practice the current lesson in small groups. This initial deployment step with our partner school is a long-term field study to assess the feasibility and sustainability of the game.

Cultivated by feedback from the initial deployment session, the second stage is to deploy the game in more schools. Schools vary according to the number of teachers, number of students, resources, teachers' qualifications, and many other factors. Results from a large-scale deployment will provide insight and feedback for a third stage of deployment.

The third stage of deployment will be geared toward larger community involvement. University students and students at Tanzanian teacher colleges are potential helpers, and parents can be valuable contributors. This can be accomplished through an online community to create content and themes to expand the influence and potential of the game.

9.8. Sustainability

During the last week of iSTEP 2009, we worked with the Mlimani School to come to an agreement on what the next steps of this project should be.

We agreed to install the game on the teachers' personal mobile phones at no cost to them, provided they use them and stay in communication with us either directly or via our partner, the UCC. An agreement between TechBridgeWorld and the Mlimani School is currently being negotiated for a long-term study of the LT at the school. This agreement will stipulate that the school agrees to be involved in a long-term study of the Literacy Tools project by working with us to improve the technology and also

monitoring its use so that we can collect data to measure its effectiveness as a teaching tool.

Apart from training teachers on how to use the Content Authoring Tool, we also left them with a set of instructions so that they can in turn train other teachers and also practice using the Literacy Tools on their own. TBW is also working with the UCC to come to an agreement on providing these teachers with access to the UCC's computer lab so that they can continue to interact with the technology.

Our objective post-iSTEP 2009 is to send a few TechBridgeWorld members back to Tanzania in a few months after having been in touch with the teachers at the Mlimani School and the UCC to present a modified version of the Literacy Tools project solution. The modifications will be based on the feedback we received from the teachers and students as well as our observations in the field. We also intend to involve English-as-a-foreign-language experts in order to provide teachers with more guidance while developing content for the game. Finally, we will work with the school to set up a data collection system so that we can monitor and evaluate the effectiveness of the Literacy Tools project solution.

The sustainability and long-term success of this project relies heavily upon the Mlimani School and its continued support. Furthermore, having the UCC on board with its technical support enhances the sustainability of the project initiated during iSTEP 2009. The UCC will be working with students from the UDSM to make improvements to the Literacy Tools and also provide technical support to the teachers at the Mlimani School. Furthermore, TechBridgeWorld will work with the UCC toward obtaining a donation of mobile phones from an outside organization, potentially the Mlimani Alumni Association, in order to deploy the technology in the classroom. We hope to have at least one phone per five students. Furthermore, we will also look into the status of obtaining electricity for the school so that the game can eventually move to a more powerful computer instead of a mobile phone.

Of course, maintaining communication with local partners is a key ingredient for a successful sustainability plan, so TechBridgeWorld will be making a concerted effort to ensure that the working relationships built during iSTEP 2009 are sustained post-internship.

10. Braille Writing Tutor Project

The Braille Writing Tutor (BWT) is an electronic device that teaches users how to write braille through a traditional slate and stylus. We field-tested the BWT at Uhuru Mchanganyiko Primary School after several updates based on conversations with teachers. We created a new mode-switching mechanism, translated all of the existing modes into Swahili, wrote a user manual for teachers and students, and created a new game called Music Maker. Music Maker is a way to turn stylus input into the BWT into music, and is an entertaining way to practice using a slate and stylus. We then tested these changes and received feedback from students and teachers. We have left a BWT at the school and two with the UCC for testing of the existing modes, as well as potential development of new modes.

10.1. Related Work

There are not many automated tutors that teach students to write braille in different braille languages – especially at a cost accessible to people in developing communities. Of the assistive technologies currently available, the Talking Braille Tutor by BrailleMaster™ and Speech Assisted Learning are most similar to the BWT.[91]

The Talking Braille Tutor (TBT) is an electronic learning aid that allows the user to learn and practice writing Braille.[92] The device has six enlarged buttons arranged as a braille cell and a seventh button that switches the device between Lesson Mode, Learn Mode, and Practice Mode. The seventh button also serves as a function key or space bar. As the buttons are pushed, a male voice identifies the letter. TBT comes with a cassette tape providing 19 lessons (each lesson is divided into three modes: learn,

[91] Nidhi Kalra, Tom Lauwers, and M. Bernardine Dias, "A Braille Writing Tutor to Combat Illiteracy in Developing Communities," accepted paper, Artificial Intelligence in Information Communication Technology for Development workshop at IJCAI 2007.

[92] http://www.abledata.com/abledata.cfm?pageid=19327&top=15422&productid=75982&trail=0&discontinued=0

practice, and quiz) for the English braille alphabet, numbers, punctuation, Level Two contractions, and 73 standard abbreviated words.[92]

At US$295, TBT is a stand-alone device and does not need to be connected to a computer and speakers. It operates on three AA batteries and has volume control. However, TBT does not offer the user an extensive curriculum for learning to write braille, and it cannot teach complex skills such as writing using a slate and stylus.[91] Furthermore, the braille dots follow the sequence of reading braille rather than written braille.[93] This feature may be beneficial to communities where people have access to the Next Generation™ Perkins Brailler® (US $650), a device in which the user types braille in the same sequence as reading braille, but for developing communities the Perkins Brailler less economically feasible. [94] [95]

Speech Assisted Learning (SAL) system is a stand–alone, interactive braille learning station that teaches the user fundamental skills in reading, writing, and arithmetic using a combination of synthesized speech, standard paper embossed sheets, and barcode identification technology.[96] At US$4,500, SAL is notebook–sized and is composed of a touch screen (which holds a bar-coded braille worksheet), a braille keyboard, and a floppy disk drive for loading lesson material.[96] With the bar-coded worksheet, SAL gives the user spoken instructions, which the user completes. Similar to the BWT, SAL gives encouraging comments when the user answers correctly and says "wrong answer" if the user responds incorrectly. SAL gives the user a score when the lesson is complete so that the user knows how well he or she has done.

SAL2, introduced in 2006, is an improved SAL system from designed to run on TouchGraphic's Talking Tactile Tablet (TTT).[97] TTT is a

[93] When writing Braille using the slate and stylus, the user writes from right to left so that the page can be flipped over and read from left to right. As a result, the Braille alphabet when writing is the mirror image of the alphabet when reading Braille.

[94] The Perkins Brailler is a braille typewriter with six keys corresponding to each of the six braille dots.

[95] http://www.perkins.org/nextgeneration

[96] http://www.nfb.org/Images/nfb/Publications/bm/bm03/bm0307/bm030707.htm

[97] http://www.nsf.gov/discoveries/disc_summ.jsp?cntn_id=105832&org=NSF&from=news

peripheral touch screen that is connected to the computer through a USB cable.[98] One main difference between the original SAL system and the TTT is that the tactile sheet is read with the TTT's touch-sensitive surface instead of a barcode scanner.[98] Another difference is that the TTT does not have a built-in braille keyboard.[96] As a result, users must purchase the Power Cord Braille Keyboard, an electronic braille keyboard, from TouchGraphics, to write using the TTT. Exceptional Teaching offers several reading, writing, and geography SAL2 programs that can be bought and used with the TTT.[99]

A major barrier of the SAL2 system is the steep retail prices associated with the SAL2 programs (US $49.95 - $349), the TTT system (US $699), and the Power Cord Braille Keyboard (US $219).[99] Furthermore, SAL2 does not help the user to learn how to write braille. The Power Cord Braille Keyboard is similar to the Perkins Brailler in that the user must type braille in the same sequence as reading braille.

10.2. Solution Overview

In order to meet the needs of the Uhuru School community during the given time frame, we created several new features for the BWT. We translated all existing functionality into Swahili using locally recorded voices, as well as added Swahili accented English sound files recorded by a native speaker. This was done to meet the curriculum of the Uhuru School and make the voice feedback more coherent to the local users.

To cater to the musical interests of the students and educate them on writing braille, we created the Music Maker game. This game allows users to interact with the BWT as if it were a drum machine.[100] The user can create music by inserting the stylus into different cells in any combination. The goal is to provide an incentive for users to practice using the stylus by turning it into a way to create music.

---

[98] http://www.touchgraphics.com/research/ttt.htm

[99] http://store.exceptionalteaching.net/isasy.html

[100] Inspired by http://lab.andre-michelle.com/tonematrix and http://www.onemotion.com/flash/drum-machine/

In order to ease the burden on teachers who are tasked with teaching sighted and visually impaired (VI) students, we created a graphical user interface (GUI) for the Music Maker game. This interface allows two users, one sighted and one visually impaired, to make music together. The visually impaired user creates music using the BWT as an input device and the sighted user simultaneously creates music on the GUI. The two users must work together to create music that sounds good to both of them. This is meant to encourage sighted and visually impaired students to cooperate and begin to envision each other as equals, rather than one having an advantage over the other.

Since the BWT is designed to be used by students with minimal supervision from teachers, we improved the mode-switching method by creating an audio menu that makes it easy to navigate the various mode. Originally, the mode-switching was done by inserting the stylus into a specific cell, which then activated a specific mode. Now, when the BWT starts, the user presses buttons 1 and 4 to scroll through the different modes, and then use button 0 to select one. During testing, our partners preferred this method to other methods since it is an intuitive system that works for both new and advanced users.

We also documented all of the functions currently available on the BWT as well as how to use the BWT in an easy to understand (and screen reader compatible) format. This was done to provide the Uhuru School with an easy reference for looking up how to work with the BWT and how to troubleshoot simple problems. For more advanced problems, UDSM students, lead by the UCC, will be able to assist in troubleshooting.

To ensure sustainability, we partnered with UDSM students on the Swahili translation. Three students, Mwangu Mwangu, Karaze Jonesmus, and Aloyce Melkiades, were closely involved in completing the Swahili translation for all of the modes of the BWT. The students also took part in working with the communities, acting as our liaisons and translators. We deliberately involved UDSM students in the development process so that they could create a relationship with the community as well as gain familiarity with the project.

10.3. Implementation Details

The BWT shown below consists of an electronic slate interface (E-slate) as well as eight programmable buttons.

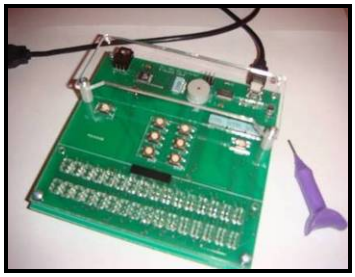

Figure 36: Braille Writing Tutor

The E-slate is made of two circuit boards separated by a small spacer. The user can connect the circuit between the two boards by using a regular metal tipped stylus, thus allowing the E-slate to detect where the stylus was entered. Six of the programmable buttons are grouped in a 2x3 cell that forms a "button cell" that can be used to teach basic braille concepts to younger students who aren't able to use the stylus. A number of curriculum modes had already been developed for the BWT prior to the iSTEP 2009 internship program.

The BWT's software components are modular and can be used as a reference for further additions. **Figure 37** gives an overview of the interaction between these components, and **Table 6** briefly describes them.

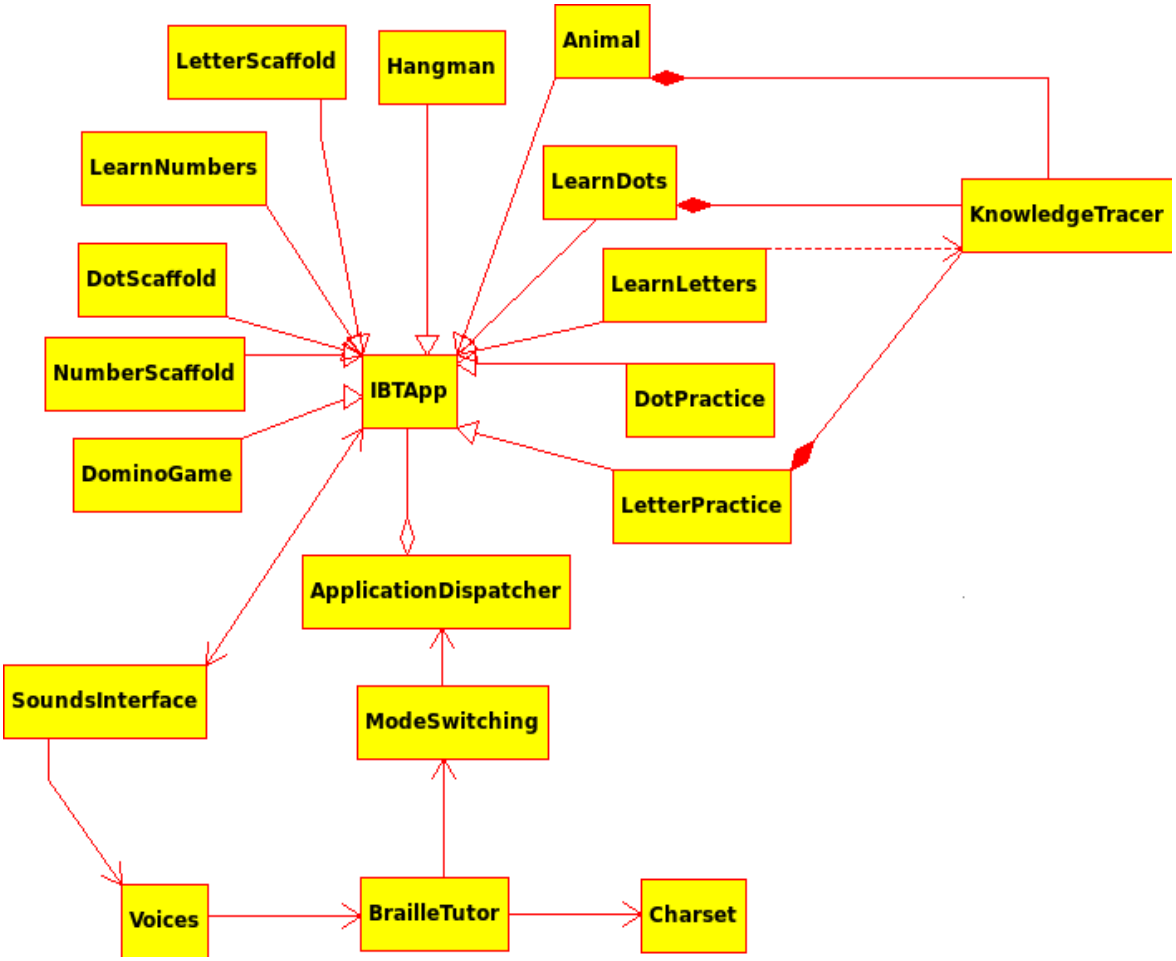

Figure 37: Overview of Components and their interactions

Name	Description
`IBTApp`	Represents the interface that all `BrailleTutor` applications inherit. This interface provides an abstraction that allows the `ApplicationDispatcher` to seamlessly invoke, control, and switch between different applications.
`NumberScaffold`	This mode allows the student to practice writing numbers in a free-form manner. Available in English, French, Arabic and Swahili.

DotScaffold	This mode allows the student to practice identifying dot locations in a free-form manner. That is, the user presses a button and the corresponding number is played back. Available in English, French, Arabic and Swahili.
LearnNumbers	This mode teaches the student the braille dot patterns of the numbers 0-9. Available in English, French, Arabic and Swahili.
LetterScaffold	This mode allows the student to practice writing the letters of the alphabet in a free-form manner. Available in English, French, Arabic and Swahili.
LearnDots	This mode teaches the student the location of the dots. The user is given a number (between 1-6), and he has to pierce/press the corresponding cell/button.
LearnLetters	This mode teaches the student the dot patterns of all the letters in the alphabet. Available in English, French, Arabic and Swahili.
Hangman	Implementation of the classic Hangman game played against the computer. Available in English, French, Arabic and Swahili.
Animal	This single player game plays various animal sounds, and the goal of the student is to guess the animal and write its name in braille. Available in English, French, Arabic

	and Swahili.
`DominoGame`	Implementation of the 2-player Dominos game[101]. Available in English, French and Arabic.
`ApplicationDispatcher`	This module processes the I/O events posted by the BWT, and switches to a different application depending on the mode setting and the type of I/O event.
`SoundsInterface`	This module/class provides a language agnostic interface to an `IBTApp` instance to invoke certain sounds, whilst allowing it to easily switch between the teacher's voice and the student's voice. These sounds include "dot sounds", "letter sounds", "dot sequence sounds", "letter sequence sounds" and "custom sounds." An `IBTApp` instance is composed of a `SoundsInterface` instance. For example, if an application wants to play the sound for the English letter "M" or the Arabic letter "ي", it only needs to call `sayLetter(teachervoice,"M")` or `sayLetter(teachervoice,"ي")`, and the `SoundsInterface` takes care of decoding the letter and playing the corresponding sound file, and notifying the user in case of an invalid letter.
`ModeSwitching`	Two forms of Mode switching techniques were implemented. One is a simple scroll menu where the user presses buttons 1-4 and it would say the name of the mode, and if the user wants that mode they would press button 0 to confirm. The second is a

[101] El-Moughny, Noura Mohammed, "Assistive Computing Technology for Learning to Write Braille," Undergraduate Senior Thesis, School of Computer Science, Carnegie Mellon University, April 24, 2008. Available at: http://www.cs.cmu.edu/afs/cs.cmu.edu/user/mjs/ftp/thesis-08/theses/el-moughny.pdf

	hierarchy style menu with the same scrolling mechanism but the user first chose a language, then a type of mode, and then an individual mode using the buttons?.
`Voices`	This low-level class is responsible for scanning/loading all the necessary sound files and making them available to the `SoundsInterface`.
`BrailleTutor`	This module directly interfaces with the hardware, and is responsible for converting hardware events into high-level I/O events which are then propagated through the rest of the system as either "Dot" or "Letter" events.
`Charset`	This class represents the current language that is being used by the `BrailleTutor` library. Based on the `Charset`, the `BrailleTutor` is able to construct the high-level "Dot" and "Letter" events.

Table 6: Description of Components and Modules in the BWT

Building on previous work done with the BWT, this project aimed to customize and improve these capabilities to suit the needs of the Uhuru School. The solution we implemented was primarily focused along five dimensions, detailed in sections 10.3.1 through 10.3.5.

10.3.1. Swahili-Adding Support for Swahili Braille

In order to support Swahili braille instructions, we had to create a new character map (a mapping between Swahili alphabets and their corresponding braille dot pattern) for the Swahili braille alphabet. Since this alphabet follows the same patterns as the English braille alphabet, this was a fairly simple process. Apart from the small changes in code to add support for Swahili in the basic curriculum modes (dot

scaffold, learn dots, dot practice, learn letters, letter practice, free spelling) we also recorded sound files for each letter in Swahili as well as phrases used for instruction and feedback ("find dot", "good", etc.).

10.3.2. Customizing for Local Accent

In addition to support for Swahili braille, it was also important to maintain support for learning English braille. We discovered that some students had trouble understanding the standard voices used for instructions in English braille so we re-recorded all English sounds using a local speaker with a Tanzanian accent. This change only involved replacing sound files following the appropriate naming conventions – no changes in code were required.

10.3.3. Implementing an Audio Scrolling Menu

With all of the different curriculum modes in English and Swahili as well as the gaming modes, the number of modes supported on the BWT grew to over 20. This forced us to spend some time figuring out an effective way to switch between all the different modes. After several brainstorming sessions in which we considered many different options, we finally decided to implement two different approaches. The first option was a hierarchical menu where the user was first presented with various categories of modes (English, Swahili, games, etc.) and once the user selected a category, they were presented with the options available within that category. All options were presented via audio. The second approach was a simple scrolling audio menu that allows the user to scroll through the available modes using two specific buttons on the BWT and then select the mode they want using a third button. After demonstrating both of these options to the head master at the Uhuru School, it was decided that the scrolling audio menu was the most user friendly so we used this method for mode switching in our solution.

10.3.4. Implementing a New Game: Music Maker

The Music Maker game is designed to provide a method for visually impaired to create music. The visually impaired user will make use of the dots on the E-slate, which also form a 6x32 matrix of dots. Each

row of dots on the E-slate corresponds to different musical notes and each column of dots represents a single time step or "beat". By inserting the stylus into a dot on the E-slate, the user can toggle on and off the musical note corresponding to row of the dot being played at the beat corresponding to column of the selected dot. The user can also use buttons on the BWT to control the tempo and to toggle all notes to the "off" position.

The implementation of this game involved creating a new thread of execution. The new thread simply loops through the 32 beats and at each beat it looks at the array of sounds and plays the correct combination of sounds for that beat. The current implementation of the game has a pre-recorded sound for every possible combination of the six musical notes (64 sound files) and so this step simply involves picking the correct sound file to play based on the notes that have been turned "on" for the current beat. The main thread handles input from the BWT E-slate and updates the array of sounds to be played based on which dot the stylus was inserted into. The array of sounds is accessible to both threads via a mutex lock to ensure that both threads will not try to access the array at the same time. The main thread also handles button events from the BWT, which allow the user to adjust the tempo (using buttons 2 and 5) as well as toggle off all notes (using buttons 3 and 6 together).

10.3.5. Creating Documentation

We identified the need for documentation and user manuals accessible to the visually impaired users in order to allow new users to easily teach themselves how to use the BWT, which will help with sustainability of the project. To this end, we wrote a detailed user manual in a format accessible by screen reader software.

10.4. Initial Feedback

We conducted an initial evaluation to gauge the usability and feasibility of the proposed technology. This was done in three stages:

- Demonstrate prototype of the BWT to teachers at the Uhuru School to gather initial feedback.
- Assess usability by observing students at the Uhuru School interacting with the BWT.
- Obtain more teacher feedback after training them on how to set up the BWT.

We explore these components in sections 10.4.1 through 10.4.3.

10.4.1. Teacher Feedback

We demonstrated the BWT to teachers at the Uhuru School by explaining how the tutor worked and showing them how to interact with it using the different modes of the tutor. Several teachers tried their hand at using the BWT, most of whom played the animal game, which seemed to be very popular. This demonstration produced the following feedback and observations about the technology:

- They suggested the implementation of braille contractions, math symbols (i.e. addition, subtraction, division, multiplication, etc.), and math/science learning modes. They found it a little difficult to navigate through the existing hierarchical scroll menu, and said they would prefer a simple or lateral scroll menu.
- It was difficult for the teachers to use the slate and stylus portion of the BWT because of a different tactile experience. Motor movements needed to utilize that section of the tutor are noticeably different from those used with the regular slate and stylus (A4 frame). The visually impaired teacher, in particular, struggled with this aspect of the BWT and resorted to using the buttons instead.
- The BWT software ran fine on the school's computers.
- Teachers had positive comments about the technology. They particularly enjoyed the animal game. All teachers present were attentive and interested in learning about how the BWT worked.

Based on this feedback we changed the scroll menu from hierarchical to a simple, lateral menu before presenting the BWT to students.

10.4.2. Student Feedback

To supplement feedback from teachers, we also tested the BWT with students at the Uhuru School. The study subjects comprised of 13 students in the visually impaired standards 1 and 2 classes. Of the 13 students, five were female and eight were male, with some students being faster learners than others. We purposefully included both boys and girls, as well as weak and strong students, in this sample to better represent the general student population at the Uhuru School. The head teacher of the visually impaired section of the school led the session by introducing the BWT to the students. We then assisted the teacher in providing each student with five to ten minutes of guided practice to interact with the technology. The teacher picked students one-by-one to work with the BWT. Each student came up to the teacher's desk and tried their hand at the tutor. Many used the dot-learning mode, while some used the letter-learning mode. The first few students spent a little time on letter learning and moved to learning dots if they struggled with letters. However, once the teacher better understood how to match a student's ability with the type of learning mode, he requested the mode type based on what he knew of the child's skill level. This approach seemed to work a lot better because students were more successful at completing tasks on the tutor afterwards. Other observations made during this session are listed below.

- Students appeared to have trouble with their tactile senses. One student even had difficulty writing using the buttons on the BWT. His hands kept wandering to the "enter" buttons on either side of the button braille cell, even though he was trying to locate a particular dot number. Additionally, many students had difficulty using the slate/stylus section of the BWT, but with some practice they were eventually able to "write" on it.

- It was difficult to explain to students that they needed to wait for the instructions to repeat before trying again. Some students kept trying to answer the question without pausing for the instructions to repeat, so the BWT took a little while to catch up. This was confusing to them because even if they were correct, they didn't hear positive feedback from the BWT.

- A lot of the students were slow in writing a letter or character, so they would take over five seconds to enter the next dot in a sequence. By then, the tutor would have already concluded that they got the question wrong and they'd need to start all over again. Of course, some students did not realize they needed to start again and simply continued completing the sequence of dots asked for; this resulted in repeated incorrect entries into the BWT and seemed to dishearten students.

- Weaker students performed a lot better using the buttons than the slate/stylus; this was expected.

- The teacher used the BWT as a teaching aid during this session. He provided guidance to each student while they were using the tutor. It seemed to function well as a teaching aid because the visually impaired teacher could hear what they were writing.

- We also realized that visually impaired students being attentive in class looks a lot different than sighted students being attentive. For example, there were several students with their heads on the table that would typically appear bored or asleep. However, when the student using the BWT made a mistake, they'd all react by giggling or shaking their heads, so they were clearly paying attention, just not in the way one would expect. Thus, all of the students were able to experience the BWT even though only one of them was physically interacting with it.

After each student had a turn at using the tutor, we asked them a few questions, which yielded the following responses:

- All of the students really enjoyed using the BWT. In particular, they liked the buttons and the audio feedback provided by the tutor.

- Students said they found it difficult to press down the stylus enough to write a dot (i.e. complete a circuit) on the BWT. Apart from that, they didn't find the tutor difficult to use, and found the buttons, in particular, very easy to use.

- None of the students had trouble understanding the local voice used for the BWT in Swahili mode.

- Some students claimed they learned to write characters (letters) using the BWT.
- All students said they would definitely use the BWT again if they could, and that the tutor was easier to use than the A4 frame they use in class.
- One student stated that it would be better if everyone possessed his or her own BWT.

After asking the students questions, we also asked the teacher about what he thought. He said:

- It was easy to teach students using the BWT
- If they practice using the BWT, it will make them "perfect"
- The tutor is very good for young students who are just learning braille

10.4.3. Teacher Training

After collecting feedback from both teachers and students at the Uhuru School, we conducted a training session for teachers to instruct them on how to set up the BWT. We went through each stage of the process with them, from attaching the USB cable to the tutor to quitting the application. The training involved two teachers, one that was visually impaired and one that was sighted. Therefore, we were able to identify specific difficulties in setting up the BWT for both sighted and visually impaired teachers at the school. Training itself lasted about 45 minutes, with each teacher taking turns to independently complete each step in the process of setting up the tutor. On the other hand, locating a functioning computer in the school's computer lab, which consisted of about 11 computers, was a much longer process. We unsuccessfully tried three other computers before discovering one that worked. Both teachers had some familiarity with computers so they were quick to learn what needed to be done. The visually impaired teacher, in particular, knew the computer keyboard well enough to locate the necessary keys to access the BWT application; he only struggled a little with connecting the USB cable to the BWT, but after a couple of tries

he mastered this task as well. After the training, both teachers said they could set up the tutor on their own, but took some notes because they may forget steps. We also provided them with a copy of the user manual for the BWT. The teachers said that they should be able to translate the manual into braille. However, we may need to first translate it from English to Swahili.

One aspect that changed significantly when the BWT ran on the school's computer was the audio instructions. Since the speed of that processor was slow, the voice of the BWT sounded a lot deeper, slower and a little slurred. Yet the teachers said they were still able to understand the instructions.

In addition to teacher training, we also demonstrated the Music Maker Game, which is a new feature of the tutor, to the teachers. The game was very popular with the two teachers that we trained. They each took turns playing music using the game and seemed to thoroughly enjoy the experience. There was some delay between "writing" a note (by pushing the stylus into one of the holes of the BWT slate) and hearing that note, but teachers simply continued writing while the Music Maker caught up. Teachers tried listening to how the letters of the alphabet and the letters that make up their names sounded on the Music Maker Game. It was evident that the music brought them a lot of joy and the game seemed to serve its primary purpose of acclimating users to the feel of the slate/stylus section of the BWT so that they would become more adept at using it.

10.5. Challenges and Limitations

There are many challenges and limitations within our developed solution. One distinct challenge is the implementation of the Music Maker game. Because it could not be completed as a mode within the BWT, it is included within the code as a separate executable. This means teachers have a different start up process to begin the Music Maker game, and it cannot be accessed through the scroll menu which has been developed.

The menu has many different components to scroll through, and it may take advanced users around a minute to reach their desired functionality. This is one of the downfalls of audio menus, particularly a scrolling audio

menu. One improvement that could mitigate this problem would be to interrupt the sound when the "next" button is pushed; however, this solution would be difficult to implement.

Translation from English to Swahili was also difficult due to the nature of Swahili as a language. In Tanzania, English is used as an instructional language for higher education, and literal Swahili translations for instructions or technical details can be difficult to obtain and are often incorrect. Because of this, the user manual will be difficult to translate into Swahili and may not be well understood. Also, some descriptions of the modes used in the scrolling menu have confounded meanings. For example, "free spelling" has been replaced with a phrase that literally means "free pronunciation" because there is little to no concept of spelling within Swahili, which is a phonetic language.

Another challenge is the Uhuru School's curriculum. Currently, the Uhuru School has computers, but only uses them in an extracurricular setting. Computers are used primarily by older students (both sighted and visually impaired) and teachers. The BWT is targeted primarily at younger students who are just learning braille. Also, the BWT in its current form requires a computer, which is not currently used in the daily curriculum. To implement the BWT on a larger scale, the Uhuru School would have to incorporate computer use as part of its curriculum for younger students. This represents a significant shift that would require time and money.

10.6. Future Work

There is much additional work that has been proposed based on conversations with the Uhuru School. The forefront of this future is the development of a braille reading tutor. This would be an automated device that could teach children to read braille through a changeable braille display. The tutor should be able to create a block of text in braille, take in some sort of input from the user, and then compare that input to an expected answer. It should then provide feedback to the user to let them know if they are correct or incorrect. An approximate solution would be a device where users can input text, and then move their finger over the text, and the tutor would say the letters out loud. This would double as a writing tutor of sorts, as it could provide feedback both about what was

written and what is being read. Important notes are that the tutor should be designed with similar principals as the BWT: low cost, durable, low-tech, and safe. There are many technological limitations that make the development of this device challenging: refreshable braille displays are complicated and costly and current speech recognition software is challenging for non-native English speakers.

Additional content that was requested by the Uhuru School is math symbols and contractions. This would entail creating a mode to teach users how to use math symbols (ex: '+' '=' '-') and contractions. Building on this, we can create math games to teach math skills and writing skills simultaneously. This new functionality would also benefit communities outside of Tanzania and could easily be translated into the other languages supported by the BWT.

Due to the wide-variety of modes, and considering that the primary users of the BWT are the visually impaired; creating an audio manual would be useful. This would also allow them to operate or learn on their own.

Another proposed enhancement to the BWT is a user login system. This would be a system where users login so that their progress and previous performances on the tutor could be tracked. It is important to design the login system in a manner where beginners can easily input their login characters. Also, previous performances should be stored so that users can start from where they last ended. From this tracked performance record, we could also provide user statistics and enhanced information about each student's performance to the teachers. Aggregated information about groups of users should also be presented to teachers in an easy to understand format. This information should include what modes are being used, general progress, types of mistakes made, and individual outlier performances.

Another area of future work is creating GUI output for the music maker game and for other modes. Other functions could involve GUI input/output to increase cooperation between sighted and visually impaired paired students. A good example of this functionality could be computer tutorials, science content, or hangman. A GUI would also be useful to give sighted teachers real time information about student's actions and performance, in addition to the aggregated information previously mentioned.

Finally, improving the "feel" of inserting the stylus into the holes would significantly improve the utility of the BWT. Currently the stylus has to be inserted through the first board, and then make contact with a second board. Users reported that this felt significantly different from using an A4 slate and stylus. In order to improve the fidelity of the BWT, we need to make the interaction feel more like using a slate and stylus.

10.7. Deployment Plan

The following is a possible deployment plan with we currently envision.

10.7.1. Stage 1: Modifications

Improve the Music Maker game to include more tempos, and switch the direction the music is read (should be read left to right, the same way braille is written). Create a GUI that can work with the Music Maker game. We should also consider creating a different version of the game where a tone is played as soon as you insert a stylus, and each dot is a different tone. This way, the BWT acts like a piano.

The user manual should be written in braille, and the BWT software should be installed on multiple computers. This should be done by the UCC, and also requires removing several viruses from the Uhuru School's computers that are currently infected.

10.7.2. Stage 2: Curriculum Creation

Create a curriculum that is supported by the BWT, and incorporate it into the Uhuru School's existing curriculum. This will require us to train the remaining teachers on the use of the BWT and their consent to use it regularly in the classroom. We should then create a rotation schedule for classes to come into the computer lab to use the BWT. This field-testing will provide valuable data to better adapt the BWT to the Uhuru School's needs.

10.7.3. Stage 3: Testing and Evaluation

Have a group of students regularly use the BWT in their classes, and track their progress on braille writing skills. Compare their performance on standard test against previous classes, or peers who have not used the BWT on a regular basis. This testing will serve as a means to evaluate the effectiveness of the BWT.

10.8. Sustainability

An agreement between TBW and the Uhuru School is currently being negotiated for a long-term study of the BWT at the school. In broad strokes, this agreement will state that the school agrees to be involved in a long-term study of the BWT by working with TechBridgeWorld to improve the technology and also monitor its use so that we can collect data to measure its effectiveness as a teaching tool. To enable this future work, we conducted teacher training, which is described in a prior section. We also left them with a manual detailing these instructions so that they can in turn train other teachers and also practice using the tutor without our intervention. Our objective post-iSTEP 2009 is to return in a few months, after having been in touch with the UCC and teachers at the Uhuru School, to present a modified version of the BWT. The modifications will be based on the feedback we received from the teachers and students. On our return trip we will work with the school to incorporate the tutor into their curriculum and set up a data collection system such that we will be able to monitor and evaluate the effectiveness of the BWT in their school.

The sustainability of this project relies heavily upon the Uhuru School agreeing to continue working with us so that this project extends to a long-term endeavor. TechBridgeWorld is also working on an agreement with the UCC to enable a longer-term collaboration between UCC staff members and students from the University of Dar es Salaam (UDSM) to make improvements to the BWT and also provide technical support to the teachers at the Uhuru School. Of course, maintaining communication with local partners is a key ingredient for a successful sustainability plan, so TBW will make a concerted effort to ensure that the working relationships built during iSTEP 2009 are sustained.

11. Dissemination

The iSTEP 2009 interns created a website (http://www.techbridgeworld.org/istep2009) where people can learn more about the internship, team, projects, and partners. Given the effectiveness and popularity of social media, the interns shared their experiences through Twitter (http://twitter.com/iSTEP_Tanzania), a blog (http://isteptanzania.wordpress.com/), and their own Facebook page (http://www.facebook.com/iSTEPTanzania). The iSTEP homepage also featured the latest 'tweets' from their Twitter feed and recent blog entries.

All interns had an account on WordPress.com and, as a whole, blogged regularly about their experiences, with each contributing a unique writing style and different perspective on the internship. The blog entries received 39 comments over the duration of the internship, mostly from family and friends. On Twitter, the team tweeted about their work and personal experiences from Dar es Salaam, Pittsburgh, and Doha. 61 Twitter accounts are currently following the team's feed, including Carnegie Mellon University, the Carnegie Institute of Technology, and iSTEP 2009 advisor Roni Rosenfeld. The interns' Facebook page gained considerable attention, as it currently has 237 fans ranging from Carnegie Mellon students to college deans. On the Facebook page, fans can expect to find updates as soon as a new blog entry is posted or a picture is uploaded.

Apart from updating the iSTEP 2009 website and various social media outlets, the interns sent e-mails to various faculty and staff members at Carnegie Mellon University in both Pittsburgh and Doha. E-mails were sent at the end of the fifth week announcing the halfway point of the internship. The e-mails were received enthusiastically by various Carnegie Mellon figures.

TechBridgeWorld staff aided the iSTEP interns in dissemination. Apart from occasional blog comments, tweets, and wall posts, bi-weekly e-mails were sent to iSTEP advisors, family, and friends. The e-mails included internship updates from the previous two weeks. The iSTEP 2009 website, along with iSTEP updates and testimonials, were featured on the TechBridgeWorld homepage and in the research group's Spring 2009 newsletter. iSTEP updates and announcements have also gone out through the various TechBridgeWorld e-mail lists and TechBridgeWorld Facebook group.

After the completion of the internship, TechBridgeWorld took over dissemination. A new individual intern experience was featured on the iSTEP 2009 blog every day. Internship completion e-mails were sent to family and friends, iSTEP 2009 advisors, and the TechBridgeWorld Advisory Board. Furthermore, TechBridgeWorld sent e-mails to Carnegie Mellon faculty and staff that received the halfway-point e-mails from the interns. This time, the e-mails announced the completion and success of the iSTEP 2009 internship and were also met with great enthusiasm.

Both the iSTEP 2009 and TechBridgeWorld teams strived to keep audiences updated with the internship's progress and were able to do so through various communication channels.

12. Team Experience

For TechBridgeWorld, it has truly been an awesome experience to watch the iSTEP internship grow from an idea into a highly qualified, multidisciplinary, and globally distributed team of Carnegie Mellon students and recent graduates that developed three technology development solutions specifically designed to benefit three communities in Tanzania.

iSTEP 2009 started in July 2008 when TechBridgeWorld faculty and staff members M. Bernardine Dias, Sarah Belousov, and Freddie Dias visited Dar es Salaam, Tanzania to explore new partnerships. There, they met with Dr. Theresa Kaijage, a faculty member at ISW, who helped make the trip possible. During their stay in Dar es Salaam, they also met with Professor Beda from the UCC to discuss potential projects. From those discussions, TechBridgeWorld and the UCC identified three projects for the iSTEP 2009 summer internship.

TechBridgeWorld officially announced the iSTEP internship in November 2008 and set the deadline for application submission to December 18. Information sessions were held in Pittsburgh and Doha. The audiences for these information sessions were undergraduate students from all disciplines in both Pittsburgh and Doha as well as graduate students in Pittsburgh. Ultimately, TechBridgeWorld received 50 applications for the iSTEP internship.

TechBridgeWorld, along with staff from Carnegie Mellon's Student Affairs in Qatar, interviewed applicants. Bernardine and Freddie interviewed applicants for the technical positions while Sarah, Ermine, Melissa, and Rachelle interviewed applicants for the non-technical positions. All applicants were notified by January 29, 2009 and the interns were finalized by February 5.

After the interns were finalized, the TechBridgeWorld team organized a mini course designed to prepare the students for their work during the summer. Taught by Bernardine, the mini course was held during the second mini of the Spring 2009 semester. Videoconferencing technology allowed the TechBridgeWorld and iSTEP teams in Pittsburgh and Doha to participate in the course sessions and guest presentations.

Throughout the mini course, TechBridgeWorld staff worked to finalize visas, research permits, and flight arrangements for the ground team's travel to and stay in Tanzania. Staff members also worked to gain Carnegie Mellon research approval for the three projects. Unfortunately, due to new procedures and requirements, approval for the third project was finalized four weeks into the internship.

During the internship, TechBridgeWorld provided support to the interns. More specifically, Bernardine took the lead on matters related to research and overall supervision for all three projects. Sarah took the lead on financial and legal matters pertaining to the internship, while Freddie took the lead on all technical issues regarding the internship. Ermine was the primary contact for any remaining issues. She was also responsible for ensuring the well being of the interns and communicating concerns to TechBridgeWorld and the UCC.

As a result, weekly meetings were held with the UCC and with the interns. The TechBridgeWorld team communicated with the interns primarily via Skype, mostly on a daily basis, throughout the work week. Doing this allowed TechBridgeWorld to stay connected and updated on both work and personal issues. When necessary, TechBridgeWorld intervened.

12.1. Meetings with the University Computing Centre

TechBridgeWorld staff met once a week with Eric Beda, the main contact from the UCC, to discuss administrative, legal, and financial issues of the iSTEP 2009 internship. The weekly meetings provided Eric with an opportunity to voice any concerns the UCC or the ground team had. The meetings also provided TechBridgeWorld with the opportunity to discuss with the UCC any safety and well-being concerns of the ground team.

For the first half of the internship, meetings with the UCC took place every Tuesday from 8:00 – 9:00 a.m. EST/3:00 – 4:00 p.m. GMT. Meetings were mostly held via Yahoo Chat or phone when Eric could not be reached via Yahoo Chat. For the second half of the internship, meetings were held on Tuesday but from 12:00 – 1:00 p.m. EST/7:00 – 8:00 p.m. GMT via Yahoo Chat or phone. The change in time was more convenient for Eric.

12.2. Meetings with iSTEP Interns

TechBridgeWorld staff member Ermine Teves met with the interns once a week to discuss any work updates from their week and to discuss any other concerns (work or personal). The weekly meetings were beneficial to interns as it was the only time during the week where all members were present to communicate with each other and to provide updates. The meetings were held on Mondays from 10:00 – 11:00 a.m. EST/5:00 – 6:00 p.m. GMT via Skype voice chat. From the updates, Ermine provided a logistics update to the TechBridgeWorld team during their weekly meetings on Tuesdays from 10:30 a.m. – 12:00 p.m. EST.

12.3. Tanzanian Housing

The interns in Tanzania resided in a hostel (dorm) at the UDSM, approximately two kilometers away from the UCC. This arrangement lasted eight weeks. The interns were provided with three rooms: two doubles and one single. They had a communal bathroom and the hostel had a kitchen where the interns could get their meals. The interns were provided with a maid for general cleaning. For the first half of the internship, the interns walked to the UCC and back. Due to safety concerns, the interns were provided with transportation to the UCC and back for the remainder of the internship.

As a result of the UCC's decision to rent an apartment for future guests, the interns moved to an apartment off of the UDSM campus three kilometers away from the UCC. The interns were also provided with transportation to the UCC and back. The apartment had five rooms, three of which were provided to the interns, and the other two were provided to UCC guests. The apartment had four bathrooms and a kitchen where a cook can come to cook meals. The interns were also provided with a maid for general cleaning.

TechBridgeWorld provided guidance and feedback for every stage of the project: needs assessment, solution development, solution demonstrations, project sustainability, and final presentation to the UCC. The team also helped the iSTEP 2009 team with writing and compiling the final report. During the last weeks, TechBridgeWorld aided interns in wrapping up the

internship. Letters were sent to community partners to thank them for their time, resources, and cooperation and to discuss sustainability of the projects.

After the completion of the internship, the TechBridgeWorld team communicated with internal and external media along with Carnegie Mellon figures to publicize iSTEP's success and impact. The team also helped facilitate interviews between interns and local media.

12.4. Overall Team Experience

The iSTEP internship was designed to give Carnegie Mellon students and recent graduates the opportunity to apply skills learned in the classroom to address real-world challenges. Furthermore, the multidisciplinary and globally distributed nature of the team allowed interns to draw on the different strengths of their teammates and take advantage of resources available in different geographic locations.

iSTEP also gave interns the opportunity to give back and positively impact three Tanzanian communities. Rotimi reflects, "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."

The iSTEP 2009 interns faced many challenges and frustrations at the start – partly because they were pioneers of a new internship program and partly because they were dealing with a new environment and culture. Brad affirms, "When I arrived in Tanzania, the pace surprised me. It's not that I worked too little – in fact, I probably worked more than normal. Rather, things just took a lot longer to get done. This is because there is less control over the environment and less understanding of the conditions."

Furthermore, for most of the interns, this was 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," states Beatrice.

Despite all of this, a valuable skill the interns acquired is to adapt to their surroundings. "The timeline I had originally created for myself changed as we started talking with the communities. I realized very quickly that I

needed to be more open to plans changing and not being able to predict my work timeline," adds Rotimi.

The interns also valued and appreciated the importance of working closely with the communities. Hatem advises, "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."

An important lesson learned was that everything cannot be solved in a 10-week internship, "This has been an ongoing theme, as repeatedly through the internship we have had to stop and take reality checks and pick out the things that we will not be able to accomplish before the term is over."

While the interns realized everything could not be accomplished in 10 weeks, they were optimistic about the future of the projects. Dan adds, "The fact that the project was too big for 10 weeks was not a bad thing – I enjoyed sinking my teeth into it, and I hope I have started work that others will continue."

Apart from work, the interns made good use of their free time. In Dar es Salaam, the ground team explored their surroundings and journeyed to Zanzibar and Mikumi National Park. They also observed a national holiday in Tanzania called "Saba Saba Day" which celebrates the founding of the Tanzanian political party.

12.5. Individual Intern Experiences

This section features the individual iSTEP 2009 intern experiences. Each intern expands on the challenges faced, successes encountered, lessons learned, and value received.

12.5.1. Anthony Velázquez

Throughout my time with the iSTEP program there were a few themes more prevalent to me than the need for organization. I have never felt like the most organized person in the world. For example, the desk I am working on right now is scattered with hundreds of research papers related to the program and a busted cell-phone with an American flag template. Despite this, the iSTEP program not only taught me how to be organized but just how much good organization can do for you.

Figure 38: Anthony's Work Station in the TechBridgeWorld Lab, Carnegie Mellon, Pittsburgh

Looking past the mess on my desk the technical leads have ensured that my work for the past 10 weeks has been organized and clean. Brad, Dan, and Hatem all have their own means of organizing their tasks to be done. Brad seems to be a big fan of Skype meetings and posting minutes to keep the agenda together. In addition to frequent IM chats, Dan keeps a running Google Doc where status on individual portions could be posted as they get completed. Hatem keeps long e-mail threads with embedded comments that everybody replies and gives feedback on. Despite the variations in these styles all three of them have ensured that not only am I never pressed for things to work on, but I also have an up-to-date understanding of the progress of all three projects. Additionally these formats have ensured that I can keep my own work organized when I am pulled in three directions on an everyday basis. I cannot inform which one is best but I can say the tech leads all did an admirable job in keeping their projects organized through the many setbacks we faced.

Putting it all together, it is difficult to give an accurate representation of how much I feel we accomplished. I look back at the start of the internship and I cannot believe how much we completed in such a

short amount of time. Conversely, as the projects wrap up, I can say how much we could have done with another 10 weeks. It is clear that there is so much more to do and I hope the people involved in Tanzania continue to develop these projects when we depart. But I do believe we have given them a considerable amount of work to get them started.

Consequently, I have learned to accept that there are things that you cannot accomplish. Ideally, I would like to work on these projects for months to come, but there is not enough time or resources to get them to the state I would like before the team leaves Tanzania. This has been an ongoing theme, as repeatedly through the internship we have had to stop and take reality checks and pick out the things that we will not be able to accomplish before the term is over. I have never been the type of person who likes to submit something partially finished. Despite this, I know we have done a lot of good work here and have an excellent start for future development. So we may not accomplish everything I wanted but I guess saving the world by solving world hunger, accomplishing universal peace, and building an In-N-Out Burger in Pittsburgh will have to occur during a different 10-week internship.

12.5.2. Beatrice Dias

Going into this internship, I had some idea of what to expect, but I do not think anything could have prepared me for the real-life situations and challenges in the field. 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. When starting the work, a lot of things seem to

Figure 39: Bea with members of Tandika Village

go wrong, because figuring out how to be less reliant on plans and more reliant on your resourcefulness comes with a steep learning curve.

There are many things that frustrated and overwhelmed me, mostly at the beginning and end of the internship. At the beginning everything is new and you are learning to roll with the punches, and at the end you are scrambling to finish things up so you can make a smooth exit. The middle bit is where I figured many things out and learned to revert to my laid back mode so I could take things in stride. I remember the first time I sat down with teachers at one of the primary schools we worked with. That moment reminded me of why I decided to embark on this journey in the first place.

I am a scientist and have been into mathematics and science most of my life, but post-college I realized that, although physically applicable sciences were interesting, I really wanted to see how science impacted people's lives. iSTEP afforded me the opportunity to do just that. I have seen how hypotheses developed in front of a computer in a remote location just do not make sense once you are on site. Ground-level realities are so important to consider if one wants to successfully implement a sustainable project. All in all, I would say iSTEP has given me my first glimpse into what field work is like; its challenges and also its victories. Based on this experience, I have affirmed my desire to be involved in ICTD (Information and Communication Technologies and Development) work.

12.5.3. Bradley Hall

When I came to this internship, I was looking for a couple of very specific things: I wanted to experience a developing country, while making an impact on improving that community. I also needed to work within my area of expertise, so that the work experience would be relevant toward my future career. In terms of what I wanted to experience, I wanted to see the culture while not being a tourist, and work towards improving living conditions.

When I arrived in Tanzania, the pace surprised me. It's not that I worked too little – in fact, I probably worked more than normal. Rather, things just took a lot longer to get done. This is because there is

less control over the environment and less understanding of the conditions. The other part that was difficult for me was developing new technology to meet the needs of a community that still had so many basic needs that have yet to be fulfilled. A direct example is that Uhuru Mchanganyiko Primary School desperately needed braille books. It was tough because while this internship did have a component where we tried to match community needs with providers who could meet those needs, my job was to focus on what I could do in the framework of the research. This limited me to doing work that I did not necessarily feel was the most effective at helping the community.

Figure 40: Brad Demonstrates the BWT to an Uhuru Teacher

I still think I am doing good work, and making useful improvements. What is also very comforting is that I can observe things will improve of their own accord. The people here are hard working and are driven towards improving the conditions in the country. They are invested in improving their lives, as well as the development on their country, just by living their daily lives. Many times we see the problems of the developing world and wrongly assume that without help from developed communities, they would crumble and fail. I think it is very much the opposite. If left to their own devices, these communities will improve, but they can improve faster with help. And I guess that is why I wanted to be here.

I have definitely learned a lot. I have seen the strengths and challenges of working in a different culture and community. I have been humbled by others hospitality and the warmth in helping a stranger, and I have been inspired by the work of Tanzanians. I have even advanced technically, getting my first real exposure to C++ and developing user documentation for people with limited technology experience. I have even learned how to work in a globally distributed team. I am confident that these skills will serve me well in the future.

Out of all the lessons learned, the biggest one I learned was to keep plugging. This means working through frustrations and limitations, and trying to find meaning even in small tasks. It means putting up with challenging conditions, and learning that what seems like a big problem in the United States is relatively minor here. It put things into perspective for me. And for that, I am grateful.

12.5.4. Daniel Nuffer

Figure 41: Dan Demonstrates the Mobile Phone Tool at ISW

How should I describe my time with iSTEP? Well, first of all, early. The pre-departure class was at 8:00 a.m. on Mondays and Wednesdays, and even when we were in Tanzania, a country that I have generally found to be very relaxed about time, we frequently left for work shortly after 8:00 a.m. I am normally a very late sleeper, and something really has to catch my interest for me to put in the effort to haul my body out of bed at that hour. iSTEP definitely caught my interest.

I am normally a technical guy. Throughout my time at Carnegie Mellon University in Pittsburgh, my primary interests were always the more theoretical, mathematical aspects of Computer Science, which are far removed from the realities of implementing software systems, let alone the social implications that software may have. Part of what attracted me to iSTEP – and kept me waking up at those early hours – was the opportunity to try something new. Here was a job where it was all about social implications. I had to think daily about not just creating a solution to the problem, but creating an inexpensive solution that could be used by community workers who may only have a primary education. And beyond that, it had to be an application that we could successfully pitch to government and other organizations. This was new, and it was exciting.

Of course, there was a great deal of novelty from just working in Tanzania. Communicating with people who spoke varying degrees of English – from flawless to nearly non-existent – oftentimes made me wish I were able to speak Swahili. Slow Internet connections and daily blackouts were a fact of life. And on the weekends, I was fortunate enough to get a chance to explore Dar es Salaam and its surroundings.

I do wish that we had more time. 10 weeks was just enough to do the first stage of needs assessment and build a prototypical solution; another 10 weeks and I think we could deploy that solution and get some useful data from it, and more. The fact that the project was too big for 10 weeks was not a bad thing – I enjoyed sinking my teeth into it, and I hope I have started work that others will continue.

12.5.5. Hatem Alismail

Figure 42: Hatem Demonstrates the Literacy Mobile Phone Game

iSTEP 2009 has been a remarkable experience technically and personally. On the technical side, the field experience was certainly different than any of my prior experiences. Working in the field requires being dynamic and ready to re-plan and adjust quickly. As a technical lead, my responsibility was to make sure the project succeeds within the 10 weeks timeframe. Beyond programming and Computer Science technical skills, time planning and project management skills were mandatory. This internship offered me the opportunity to solidify my project management and planning skills and put to test my Computer Science skills in a real world setting.

On the personal side, this experience has been truly influential. Living in a different country, meeting new people, getting accustomed to a new culture and managing a project all in 10 weeks had a significant impact on my personality. This internship helped me improve my

communication skills significantly. Communicating with our team, which is a very diverse and globally distributed team, has been a great exercise. Being able to communicate ideas to people from different backgrounds and collaborate in a project with them made our work experience significantly smoother and more enjoyable. Beyond day-to-day personal and work communication skills, this internship provided a great teamwork experience me.

In preparation for this internship, we enrolled in a six-week course to learn about Tanzania, its culture and how to live there. We tried to research the problems we were trying to tackle and gain a broad understanding of challenges we might face. We attempted to outline our work schedules and set up a work plan. However, once on the ground it seemed that everything – work plans, project goals, and even our understanding of the country and culture – were not as we had planned. Despite this fact, one of the important lessons learned in this internship is the importance of planning and preparation. Background knowledge about the country and its culture and people were very important for a smooth and enjoyable experience. Further, the mental exercise of trying to imagine the work and laying out a work plan was very useful and important. Although it seems that discarding the pre-work plan was inevitable, the importance of planning before field work should not be underestimated.

Another important lesson learned is to set realistic goals for a project. During the research phase, before the field work experience, it seemed that all challenges and problems were easily solvable within the 10-week framework. Unfortunately, this was not true and there were several challenges and obstacles that prevented us from solving "everything." Hence, it is important to stay focused, plan carefully, approach specific tasks and set specific and attainable goals within the timeframe.

The iSTEP 2009 internship has also shown to me the importance of people and 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. Therefore, community and people involvement is crucial and should not be underestimated. Furthermore,

having local partners is absolutely essential. Most of the work could not have been achieved without the support from our local partners. Local partners are part of the community and culture. Their support and knowledge are essential to achieve a relevant solution, especially within a limited timeframe.

Having firsthand experience of being on the ground cannot be replaced by any readings or online research. Living in a country and experiencing the daily interactions with people is the best way to truly understand the challenges a community faces and gain the necessary insight to contribute and help. Most of the work could have been done back at home, however our presence on the ground contributed significantly to the relevance and sustainability of our projects. All in all, this internship has been significantly influential, technically and personally. If I go back on time, I would certainly choose the iSTEP internship.

12.5.6. Rotimi Abimbola

From the first day of the iSTEP mini course until now, my experience as an intern on the iSTEP team has been an enlightening and powerful one. As a student with many ethnographic layers — my Nigerian heritage, British background, and American experience, as well as my prior work experience in other parts of Africa — I thought that my prior experiences would serve as a major advantage for me.

Figure 43: Rotimi Teaches an English Class at Mlimani Primary School

Before leaving, I was as prepared as I was going to get. I had the same feeling that I get before I run a 100 meter dash — whether or not I feel 100% that day, I know that I have been racing for years and that I have been working on my technique. And when the gun goes off, I use all I

know to get me through the race. In my book of life challenges, I would liken the iSTEP internship to an 800 meter dash, a race and adventure that I hadn't been coached for, but definitely knew I was capable of accomplishing. This internship challenged me in a new way, and required me to enhance the skills that I already had in order to excel in the role that I had been assigned.

Seldom does one find an internship experience that allows students to conduct research and find their own solutions to problems that are impacting developing communities in the world. Upon my arrival in Dar es Salaam, Tanzania, I was a bit intimidated by the goals that I had set for myself. I knew I wanted to explore the country, meet new people, and embrace the new culture but I was also aware that I had a lot of work to do. I also did not have much experience in needs assessment, so I wanted to make sure I was focused from the time we arrived. The timeline I had originally created for myself changed as we started talking with the communities. I realized very quickly that I needed to be more open to plans changing and not being able to predict my work timeline.

As the weeks passed, I became comfortable with my surroundings, familiar with the community members, and proactive with my work. I knew how to engage with the different communities, record data, and share it with the rest of the team. Nothing was spoon-fed to me. It was all about experiential learning and a full commitment to the success of the project in the community. I am going to walk away from this summer with a wealth of knowledge and understanding about the realities of ICTD, and the challenges facing the developing world. Africa is my homeland and the opportunity to travel and experience the cultures in Tanzania, and take a look at social justice and political issues that I really care about is something that I will always be grateful for. I cherish the experience that I have received this summer which has provided me with practical exposure outside of the classroom, outside my own ambit and back to the origin of life and commerce. I know this is just the beginning of my work in Africa, but it has created a strong foundation for me to be able to contribute to the development of my people.

Appendix I:
Legal and Financial Process

Several legal and financial matters were handled by TechBridgeWorld faculty and staff in collaboration with other Carnegie Mellon staff, our iSTEP interns, our partners in Tanzania and Tanzanian government officials.

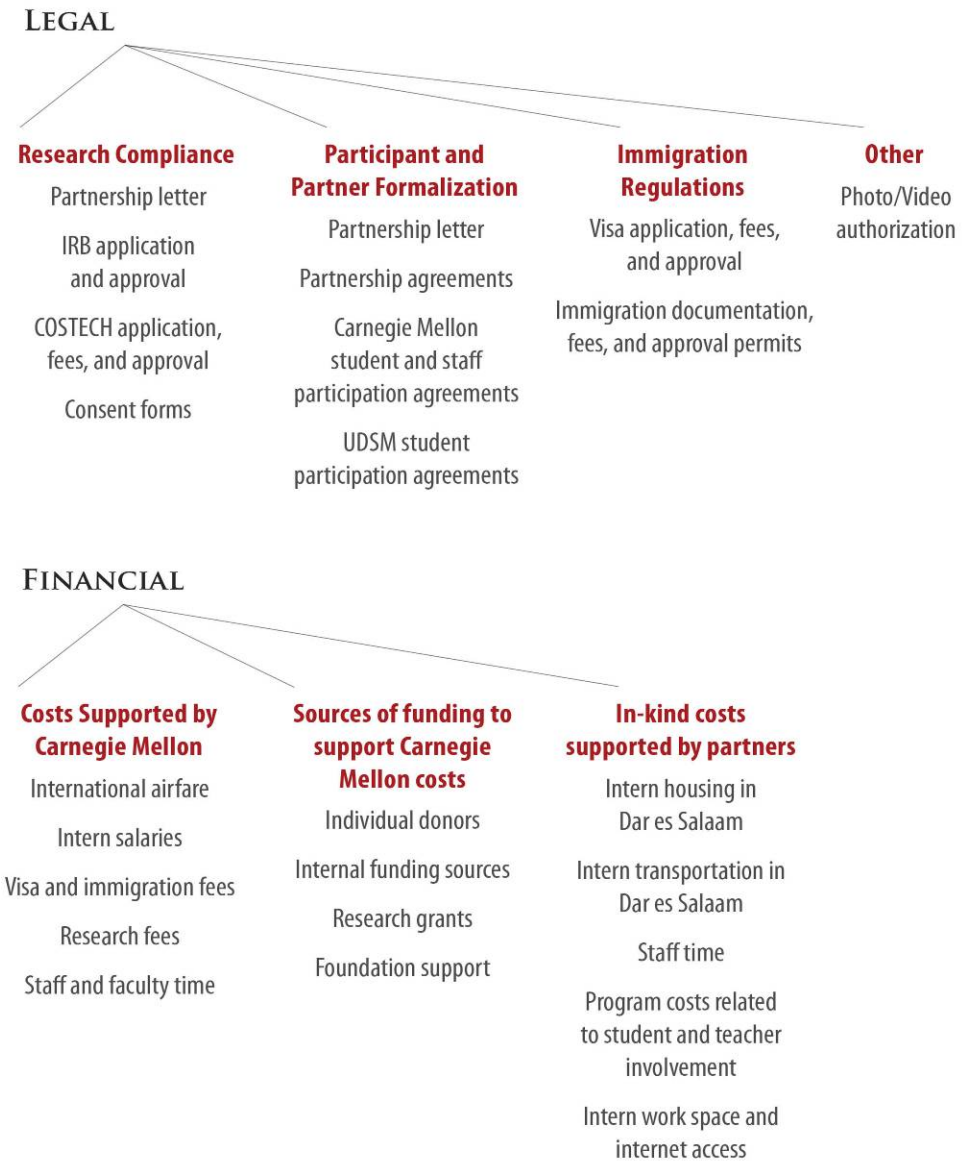

Figure 44: Financial and Legal Flow

Permits and Visas

In order to conduct research involving human subjects, all three projects had to receive research approval from Carnegie Mellon University (IRB) and from Tanzania (COSTECH). Prior to the start of the internship, the IRB updated its forms and procedures for research approval. Coupled with the IRB's many requirements, IRB approval for all three projects were delayed. Approval for the Literacy Tools and Braille Writing Tutor project were granted on June 3, 2009, approximately one and a half weeks into the internship. Approval for the Social Worker Applications project was granted on June 17, 2009, approximately three and a half weeks into the internship. Consequently, the interns were delayed in starting needs assessment for the projects. To adapt to the situation, the interns focused on needs assessment and technology development for the Literacy Tools and Braille Writing Tutor projects. For the Social Worker Applications project, technical lead Daniel Nuffer researched different technologies available to create a mobile phone application to track information on AIDS orphans and vulnerable children.

In order to conduct research in Tanzania, the ground team must receive a research permit from COSTECH. The interns received approval on May 20, 2009. TechBridgeWorld processed and paid for any required visas for traveling interns. This process was delayed since the application required COSTECH research approval. Visas were issued on May, 20, 2009.

Internship Salary and Travel and Housing Costs

Each of the interns is paid US$3,000 for their participation with the program. For the students traveling to Tanzania, they received free airfare, accommodation, and local transportation. Airfare was taken care of by TechBridgeWorld and accommodation and local transportation was taken care of by the UCC. Interns working in Pittsburgh and Doha were eligible to receive and additional US$1,000 (provided by TechBridgeWorld) to cover housing costs.

Appendix II:
Media Exposure

Throughout the summer internship experience, the iSTEP team focused on constantly expanding our media exposure through a variety of interfaces. The interns consistently updated the iSTEP 2009 webpage and blog, Twitter page, and Facebook page. In fact, more than 200 people became a fan of the Facebook page, and checked its updates regularly to keep in touch with and follow the interns' work in Dar es Salaam, Pittsburgh, and Doha.

The following are images of some of the aforementioned media outlets, in addition to those of a post about iSTEP 2009 on Carnegie Mellon University's Twitter page, as well as three articles – one by Carnegie Mellon's Inspire Innovation team, one from AME Info, and a third form Carnegie Mellon University's School of Computer Science's homepage.

Figure 45: The iSTEP 2009 Homepage
http://www.techbridgeworld.org/istep2009

Figure 46: The iSTEP 2009 Facebook Page
www.facebook.com/iSTEPTanzania?ref=ts

Figure 47: The iSTEP 2009 Twitter Page
http://twitter.com/iSTEP_Tanzania

Figure 48: The Carnegie Mellon University Twitter Page with a Shout Out to iSTEP 2009

Carnegie Mellon University's TechBridgeWorld launches iSTEP program

From AME Info

Qatar: Wednesday, July 22, 2009 at 09:50

The TechBridgeWorld research group recently launched a program titled iSTEP: innovative Student Technology ExPerience, an innovative internship for Carnegie Mellon students to conduct computing technology field research with impact in developing communities.

This program is a collaboration between colleagues from TechBridgeWorld and the Student Affairs team at Carnegie Mellon University in Qatar.

This summer, six Carnegie Mellon students and alumni are participating in the newly launched iSTEP internship program. Together with TechBridgeWorld faculty and staff, they are working on three technology research projects for communities in Tanzania. The teams are working collaboratively from bases in Dar es Salaam, Tanzania; Doha, Qatar; and Pittsburgh, U.S.

One of the team members from the Carnegie Mellon Doha campus is Hatem Alismail, a 2009 graduate with a major in Computer Science and a minor in Mathematics. Hatem is the technical lead for one of the three research projects and is based in Dar es Salaam.

'TechBridgeWorld's iSTEP program redefines what an internship should be,' says Hatem. 'The unique and novel projects present interesting challenges that require innovation, flexibility and adaptability to unexpected situations. It is also a very unique opportunity to apply the skills I have learned throughout my education to enhance a life-impacting project. Those skills, without a doubt, are very important in shaping a successful future.'

This year's iSTEP partner is the University Computing Center (UCC) in Dar es Salaam. The UCC provides computing services and consultancy in information and communication technologies to the University of Dar es Salaam community, as well as the country of Tanzania. Together with the UCC, the iSTEP 2009 team is working on three unique research projects, each catered to individual communities for which specific needs have been identified. The projects include developing a mobile phone application for

use by social workers to track information on services provided to AIDS orphans and vulnerable children, creating and evaluating culturally-relevant educational technology and games for children's literacy and enhancing and evaluating a low-cost braille writing tutor for visually-impaired students.

The internship is a 10-week internship which began at the end of May and scheduled to complete at the end of July. Prior to the internship, the team completed a 6-week mini-course designed to prepare them for their work on the technology research projects this summer. The course was taught by Carnegie Mellon Qatar Professor M. Bernardine Dias during the Spring 2009 semester.

The project work from the iSTEP 2009 internship will result in papers co-authored by the participating interns to be submitted to upcoming ICTD (Information and Communication Technologies for Development) and other relevant conferences for publication.

Available at http://www.ameinfo.com/204470.html.

Real-world experience. In Tanzania.

From Inspire Innovation: The Campaign for Carnegie Mellon

July 24, 2009

Each year, hundreds of Carnegie Mellon students participate in summer internships around the globe. One striking example includes five Carnegie Mellon students and recent alumni from the university's Pittsburgh and Doha campuses. The group journeyed to Dar es Salaam, Tanzania this summer to take part in the innovative iSTEP internship program.

iSTEP – innovative Student Technology ExPerience – is a unique internship program launched this summer by Carnegie Mellon's TechBridgeWorld Research Group.

So what makes this program different from a traditional 9-5 office job?

For starters, the location puts true meaning in the phrase "real-world experience." These interns have to apply the knowledge and skills they acquired in the classroom in order to do some creative problem-solving in an unfamiliar setting.

The team is working closely with local partners in developing communities and contributed technical expertise by inventing new tools and customizing existing technology. Their three projects include literacy tools, social worker applications and Braille tutor.

To learn more about the interns' day-to-day experiences, follow them on Twitter, visit their Facebook page or read their blog.

POSTED BY INSPIRE INNOVATION TEAM AT 1:39 PM
LABELS: INTERNSHIP, ISTEP, TANZANIA, TECHBRIDGEWORLD

http://inspireinnovation.blogspot.com/2009/07/real-world-experience-in-tanzania.html

CS Interns Complete iSTEP Internship Tanzania Projects

July 31, 2009

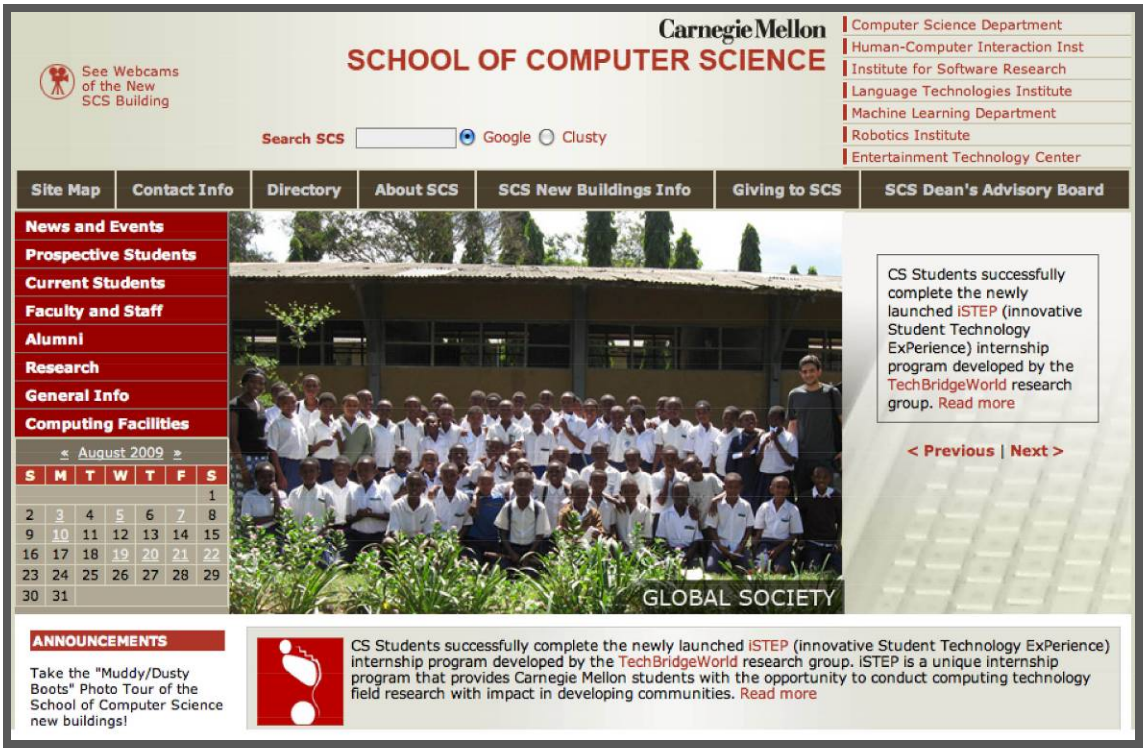

Figure 49: School of Computer Science Home Page

Carnegie Mellon University Computer Science students complete inaugural iSTEP internship program with three technology development projects

On July 31, 2009, six Carnegie Mellon students and recent alumni from the University's Pittsburgh and Doha campuses successfully completed the newly launched iSTEP (innovative Student Technology ExPerience) internship program. The TechBridgeWorld research group at Carnegie Mellon University introduced iSTEP this year as a unique internship program that provides Carnegie Mellon students with the opportunity to conduct computing technology field research with impact in developing communities. TechBridgeWorld is a research group at Carnegie Mellon University, based in the Robotics Institute, dedicated to innovating and implementing technology solutions to address sustainable development needs around the world.

iSTEP's goal is to provide Carnegie Mellon students with real-world experience in applying their knowledge and skills for creative problem-solving in unfamiliar settings. The internship is designed so that the team works closely with local partners in developing communities and contributes technical expertise by inventing new tools and customizing existing technology.

Together with TechBridgeWorld faculty and staff, the iSTEP 2009 team worked on three technology research projects for communities in Tanzania: (1) developing a mobile phone application for use by social workers to track information on services provided to AIDS orphans and vulnerable children; (2) creating and evaluating culturally-relevant educational technology and games for children's literacy; and (3) enhancing and evaluating a low-cost braille writing tutor for visually-impaired students.

In collaboration with this year's main community partner, the University Computing Centre (UCC) at the University of Dar es Salaam in Tanzania, along with primary school teachers, students, and social workers, the iSTEP 2009 team conducted a thorough needs assessment process to ensure that its research projects addressed the community's unique development challenges.

The multidisciplinary and globally distributed iSTEP 2009 team comprised of undergraduate and graduate students and recent alumni from the School of Computer Science, College of Engineering, and College of Humanities and Social Sciences. The iSTEP 2009 and TechBridgeWorld teams worked collaboratively from Dar es Salaam, Tanzania; Doha, Qatar; and Pittsburgh, United States.

Three Computer Science students and recent alumni were part of the inaugural iSTEP team. Anthony Velázquez, a rising senior in the Pittsburgh campus, was the team's technical floater. Stationed in Pittsburgh during the internship, Anthony provided technical support for all three projects. Daniel Nuffer graduated May 2008 from the Pittsburgh campus and was the team's technical lead for the social workers application project. Hatem Alismail graduated May 2008 from the Doha campus and was the team's technical lead for the literacy tools project. Both Daniel and Hatem were stationed in Dar es Salaam. Starting in the Fall, Daniel will be working for Jane Street Capital, a quantitative proprietary trading firm, in New York and Hatem will be returning to Carnegie Mellon as a Robotics Masters Student in Pittsburgh.

Project work from the internship will result in papers co-authored by the participating interns to be submitted to upcoming ICTD (Information and Communication Technologies for Development) and other relevant conferences for publication. The team blogged and tweeted about their exciting experiences during the internship and members of the team are available for interviews. For more information on iSTEP 2009 and TechBridgeWorld's work in Tanzania please visit www.techbridgeworld.org/istep2009/.

TechBridgeWorld iSTEP: Innovative Internship Experience

August 6, 2009

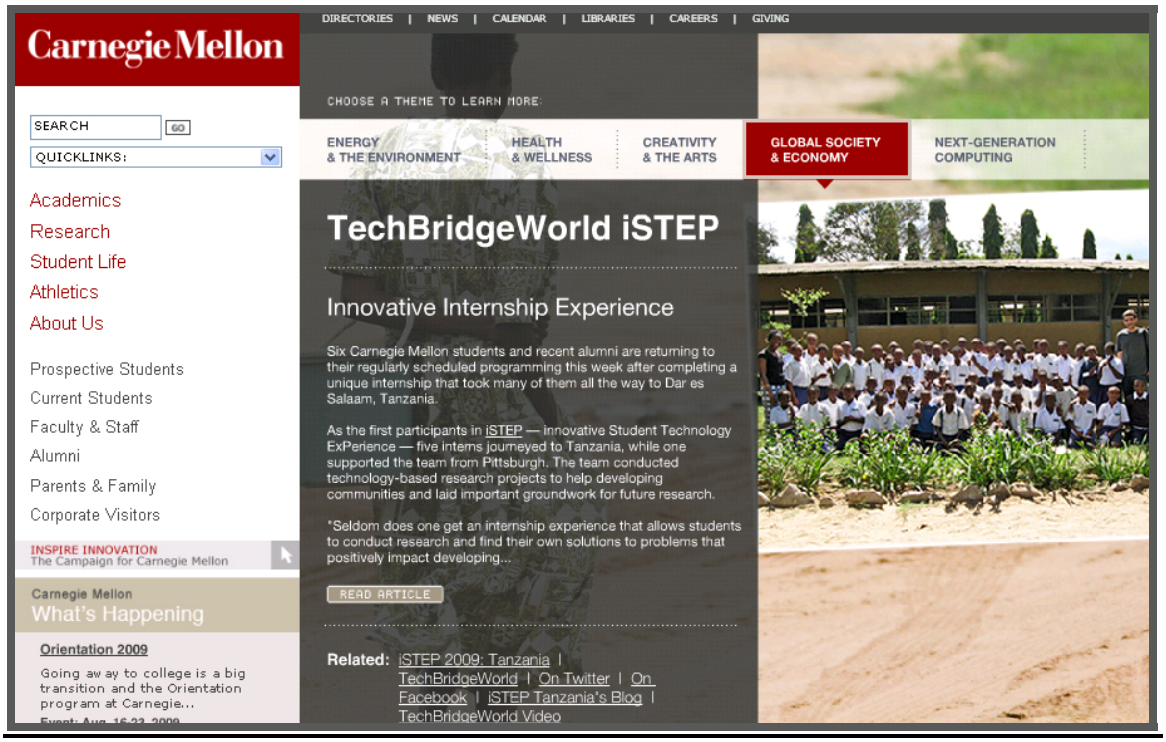

Figure 50: Carnegie Mellon University Home Page

Six Carnegie Mellon students and recent alumni are returning to their regularly scheduled programming this week after completing a unique internship that took many of them all the way to Dar es Salaam, Tanzania.

As the first participants in iSTEP — innovative Student Technology ExPerience — five interns journeyed to Tanzania, while one supported the team from Pittsburgh. The team conducted technology-based research projects to help developing communities and laid important groundwork for future research.

"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," said Rotimi Abimbola (HS '09), who called the experience "enlightening and powerful."

"The iSTEP 2009 internship has shown me the importance of people and communities," said Hatem Alismail, a 2009 computer science graduate of Carnegie Mellon in Qatar. "Regardless of how wonderful and powerful a technological solution is, community involvement is the most important."

Launched by Carnegie Mellon's TechBridgeWorld research group, iSTEP provides the interns with the opportunity to add real-world research experience to their resumes.

"TechBridgeWorld's iSTEP program redefines what an internship should be," said added Alismail. "The unique and novel projects present interesting challenges that require innovation, flexibility and adaptability to unexpected situations."

This summer, the interns used the knowledge and skills they acquired in the classroom to creatively solve problems in an unfamiliar setting.

Working closely with local partners in the communities, the team of interns contributed their technical expertise to invent new tools and customize existing technology. Their three projects and solutions include:

- creating a mobile phone-based literacy game for students at the Mlimani Primary School;
- working with the Institute of Social Work and the Department of Social Welfare to develop an information exchange protocol for social workers to report and receive information about AIDS orphans and vulnerable children using SMS on mobile phones; and
- enhancing and evaluating a low-cost Braille Writing Tutor with teachers and visually-impaired students at the Uhuru Mchanganyiko Primary School.

iSTEP provides interns from the university's Pittsburgh and Doha campuses the opportunity to tackle important world problems with the added benefit of witnessing firsthand the difference their work is making.

"With projects such as this and many others happening at Carnegie Mellon, I hope that awareness for issues can bring more attention and more opportunities in the future," concluded Anthony Velázquez, (CS'10).

Following their work in Tanzania, the interns plan to co-author papers about their project work and submit them for publication to upcoming conferences on Information and Communication Technologies for Development (ICTD) and other relevant conferences.

Related Links: iSTEP 2009: Tanzania | TechBridgeWorld | On Twitter | On Facebook | iSTEP Tanzania's Blog | TechBridgeWorld Video

Appendix III:
Social Worker Project Interview Questions

Shikamoo! Habari gani? (Hello, how are you?) My name is ____ and this is _____ and _____. Nashu kuru kuku faham (Grateful to meet you). We are with an organization called "TechBridgeWorld", which is based at a university in America. TechBridgeWorld works with different developing communities across the world to create new computing technology for them. We are interested in working with social workers in Tanzania to develop technology that will assist you in accessing information and recording data during your work with OVC. We want to serve YOU as best we can, but to do that we need you to let us know what you want to see improved here. So, we would like to ask you a few questions about your experience being a social worker or working with the ISW. Is that ok with you? You do not have to answer any questions you don't feel comfortable answering. Please feel free to interrupt me if you have questions or concerns. This interview will be kept confidential, so please speak freely – we really appreciate your honesty and your time. Do you mind if we take notes from this interview and write down your name? Please be assured that your name will not be associated with your answers in any research publications. Do you have any questions before we start?

A. Questions about Social Workers

- Can you please tell us how you became a social worker?
- Do you work (or have you worked) in the field making house visits and providing services to the community?
    - If you do not work (or have not worked) in the field, are you planning on doing so in the future?
- Can you please talk about what you do on a typical day at work?
- What are the challenges you face with the work you do?

- If you work (or have worked) in the field:
  - Do you have problems that specifically relate to filling forms and sending them to others?
  - Do you have other problems with accessing information or recording/reporting data during your field work?
  - Do you have to travel far to make home visits and to provide other services to the community?
- Have you interacted with OVC? Can you please describe this experience?
  - What are some of the services you offer these children?
- Do you train or supervise para-social workers?
  - If so, can you please talk about the work you do as a trainer or supervisor?
  - What are some of the challenges you face when training/supervising them?
- Do you work closely with the Committees at the village, ward, and district levels?

B. Questions about Technology Experience

- Have you had any experience using a mobile phone?
  - If not, would you like to learn how to use a mobile phone?
- If you use a mobile phone:
  - How often do you use it?
  - Do you use your mobile phone a lot to coordinate with other social workers (either in the field or not)?
  - Do you have any problems sending SMS messages?
  - Do you find it expensive to use your mobile phone?

- Do you lose signal on your mobile phone many times during your field work?

C. Questions about Social Workers' Thoughts on Project in General

- What do you think about using your mobile phone to fill out information on OVC, instead of using paper forms all the time?
- If technology is used to help with sending data to the district, what do you hope will be the result: Do you hope it will make your work a little easier, improve the efficiency in data transfer, or something else?
- We would really appreciate any help you can give us in designing the technology and with this project in general. Would you liked to be involved in helping us to create technology to help with OVC data transfer?
- Is there anything else you would like to talk to us about or would you like to ask us any questions?

D. Questions about Para-Social Workers (PSW) – Questions for ISW & Capacity Project

- How are people selected to work as PSW?
- How long is their training, and what do they learn?
- Are you aware of the educational backgrounds of or literacy rates among PSW?
- Do you know if PSW use or own mobile phones?
- How many PSW currently work in Tanzania?
- Do PSW work closely with the Committees at the village, ward, and district levels?

E. Questions about Social Work and OVC in Tanzania – Questions for Sesil & ISW

- How many social workers are there in the country and in Dar es Salaam?

- Are all social workers in the country trained at the ISW?
- How many OVC have been identified so far and is there an estimate for how many OVC are unaccounted for in Tanzania?
- How do social workers currently collect data, while they are in the field working with OVC?
    - Do social workers send data to the district?
    - Do you think it is important to collect any additional data compared to what is now collected?
    - Which data do you think is most important to collect frequently, i.e. at least once a week? Can you also tell us why you think frequently collecting this data is important?
- How do you think the current system for data collection can be improved to make the data collection process easier?
    - Can you give us specific examples of some of the problems you've identified with the current data collection process?
- Is there anything else you would like to talk to us about or would you like to ask us any questions?

Appendix IV:
Literacy Tools Project Interview Questions

Shikamoo! Habari gani? My name is ____ and this is _____ and _____. It is very nice to meet you (Nashu kuru kuku faham). We are with an organization called "TechBridgeWorld", which is based at a university in America. TechBridgeWorld does work with different developing communities across the world to create new technology for them. We are interested in working with your school to build technology that will assist you in teaching students English. We want to serve YOU as best we can, but to do that we need you to let us know what you want to see improved here. So, we would like to ask you a few questions about your experience teaching at this school. Is that ok with you? You do not have to answer any questions you don't feel comfortable answering. Please feel free to interrupt me if you have questions or concerns. This interview will be kept confidential, so please speak freely – we really appreciate your honesty and your time. Do you mind if we take notes from this interview and write down your name? Do you have any questions before we start?

A. Questions about Teachers

- Can you please tell us the story of how you became a teacher? When did you decide to teach at this school? What inspired you to work here?
- What do you like most about being a teacher here? What do you like the least?
- What is most challenging about teaching in this school?
- What do you teach here? Do you teach English?
- Can you please talk about a typical day at work for you?

B. Questions about the School

- Can you please talk to us about this school and its students?
  - How many students are there in the school? How many students do you teach?
  - What are the ages of students in this school?
  - What grade levels does the school offer? Which grades do you teach?
  - Are there a lot of teachers here?
  - How long is the school term? How often are exams given?
  - Do student pay to go to school here? Can they all afford the cost of school and books? Does the school help with some expenses?
- What are the usual daily activities in the school? Can you please talk a little bit about the curriculum here?

C. Questions about the Students

- Can you describe a typical student here?
  - Where do they usually come from? Far from the city?
  - How many female students do you have compared to male students?
  - Are there many children from poor families?
- Do you think students enjoy coming to school? Why or why not? Do many students drop out? If so, do you know why and which age group of students generally drops out of school?

D. Questions about the English Literacy

- How well do you think students are learning English?
  - At what grade level/age do they start learning English?
  - Do they enjoy learning English? What do they like most or least about the subject?

- What are they best at in English class? Is there anything in particular they struggle with and does this vary with each age group? If so, how?
- How do you evaluate their progress? Do you assign regular exams and homework? How do they usually fare on the exams?

- How do you teach beginning students to read and write in English?
  - What type of teaching tools do you use? What methods work best? What methods are least effective? Are you looking for new ways to teach English?
  - To what extent is it easy or difficult to teach English to these students?
  - What is most challenging about teaching English to these students?

E. Questions about the Technology

- Have you had any experience working on the computer or a mobile phone?
  - If not, would you like to learn how to use a computer or a mobile phone?
  - If you used a computer before, can you please talk a bit about your experience? What did you use the computer for? How long ago and where was this?
  - If you used either a computer or mobile phone before, did/do you enjoy using these devices, and would you like to have more interaction them?

- Do you know if your students use computers or mobile phones in school or outside of school?
  - Do you think they would enjoy using the computer or mobile phone for school work?
  - Which grade levels do you think would benefit most from some technology to help with learning English?

F. Questions about Teachers' thoughts on Project in General

- Do you think using educational games on a computer or mobile phone will be a good way to help students learn English?
    - If so, what type of games do students enjoy – what games are popular in Dar es Salaam or Tanzania in general?
    - If not, why don't you think so?
- Would you liked to be involved in helping us to create technology to help your students learn English? We would really appreciate any help you can give us in designing the technology and with this project in general.
- What would you hope to be the result of this technology project? Higher exam scores? More students speaking English?
- Do you want to talk about anything else?

G. Additional question for principal or one of the head teachers:

- Are there any other assessments or projects going on in your school currently? Can you please explain?
- Does the Mlimani School benefit from being so close to the University of Dar es Salaam campus? If yes, how?

Appendix V:
Braille Writing Tutor Project Interview Questions

Shikamoo! Habari gani? My name is ____ and this is _____ and _____. It is very nice to meet you (Nashu kuru kuku faham). We are with an organization called "TechBridgeWorld", which is based at a university in America. TechBridgeWorld does work with different developing communities across the world to create new technology for them. We are interested in working with your school to build technology that will assist you in teaching students braille. We want to serve YOU as best we can, but to do that we need you to let us know what you want to see improved here. So, we would like to ask you a few questions about your experience teaching at this school. Is that ok with you? You do not have to answer any questions you don't feel comfortable answering. Please feel free to interrupt me if you have questions or concerns. This interview will be kept confidential, so please speak freely – we really appreciate your honesty and your time. Do you mind if we take notes from this interview and write down your name? Do you have any questions before we start?

A. Questions about Teachers

- Can you please tell us the story of how you became a teacher? When did you decide to teach at this school? What inspired you to work here?
- What do you like most about being a teacher here? What do you like the least?
- What is most challenging about teaching in this school?
- What do you teach here?
- Can you please talk about a typical day at work for you?

B. Questions about the School

- Can you please talk to us about this school and its students?
  - How many students are there in the school? How many students do you teach?
  - What are the ages of students in this school?
  - What grade levels does the school offer? Which grades do you teach?
  - Are there a lot of teachers here?
  - How long is the school term? How often are exams given?
  - Do student pay to go to school here? Can they all afford the cost of school and supplies? Does the school help with some expenses?
- What are the usual daily activities in the school? Can you please talk a little bit about the curriculum here?

C. Questions about the Students

- Can you describe a typical student here?
  - Where do they usually come from? Far from the city?
  - How many female students do you have compared to male students?
  - Are there many children from poor families?
- Do you think students enjoy coming to school? Why or why not? Do many students drop out? If so, do you know why and which age group of students generally drops out of school?

D. Questions about the Braille Literacy

- How well do you think students are learning braille?
  - At what grade level/age do they start learning to write and read in braille?
  - What aspects of braille writing and/or reading does your school focus on at each grade?

- Do they learn the Kiswahili alphabet, the English alphabet, both, or something else?
- Do they enjoy learning braille? What do they like most or least about it?
- What are they best at in terms of learning braille – reading or writing? Is there anything in particular they struggle with and does this vary with each age group? If so, how?
- How do you evaluate their progress? Do you assign regular exams and homework? How do they usually perform on the exams?

♦ How do you teach beginning students to read and write in braille?

- What type of teaching tools do you use? What methods work best? What methods are least effective? Are you looking for new ways to teach braille?
- To what extent is it easy or difficult to teach braille to these students?
- What is most challenging about teaching braille to these students?

E. Questions about the Technology

♦ Have you had any experience working on a computer?

- If not, do you think you would like to learn how to use a computer?
- If yes, did/do you enjoy using the computer, and would you like to have more interaction with it?
- If you used a computer before, can you please talk a bit about your experience? What did you use the computer for? How long ago and where was this?

♦ Do you know if your students use computers in school or outside of school?

- Do you think they would enjoy using the computer for school work?
- Which grade levels do you think would benefit most from some technology to help with learning braille?

F. Questions about Teachers' thoughts on Project in General

- Do you think games will be a good way to help students learn braille?
  - If so, what type of games do the students usually enjoy?
  - Do the students enjoy music or other things that you think we can use to motivate them more?
  - If not, why don't you think so?
- Would you liked to be involved in helping us to create technology to help your students learn braille? We would really appreciate any help you can give us in designing the technology and with this project in general.
- What would you hope to be the result of this technology project? Higher exam scores? More students reading or writing fluently in braille?
- Do you want to talk about anything else?

G. Additional question for principal or one of the head teachers:

- Are there any other assessments or projects going on in your school currently? Can you please explain?

Appendix VI:
Braille Writing Tutor Project User Manual

TechBridgeWorld

The Automated Braille Writing Tutor

User Manual – For Uhuru Mchanganyiko Primary School

iSTEP Internship Program
Bradley Hall, CIT '10
info@techbridgeworld.org
7/29/2009

Table of Contents

1. Terminology

The Braille Writing Tutor is a square shaped electronic device with 8 small legs, 8 buttons, and 32 Braille cells. It should come with one mini USB cable and one stylus with a metal tip. The program used to start the Braille Writing Tutor is called `btbt.exe`. The buttons are square extrusions with small circles on top of them. The cells are located at the bottom of the Braille Writing Tutor and should have two rows of 16 cells each, which are shaped like the cells in an A4 frame. Each cell has 6 holes in it, spaced the same way as a Braille cell. The mini USB cable plugs into the back of the Braille Writing Tutor, and then into an available USB slot on a computer which has the proper drivers installed, as well as the btbt.exe file.

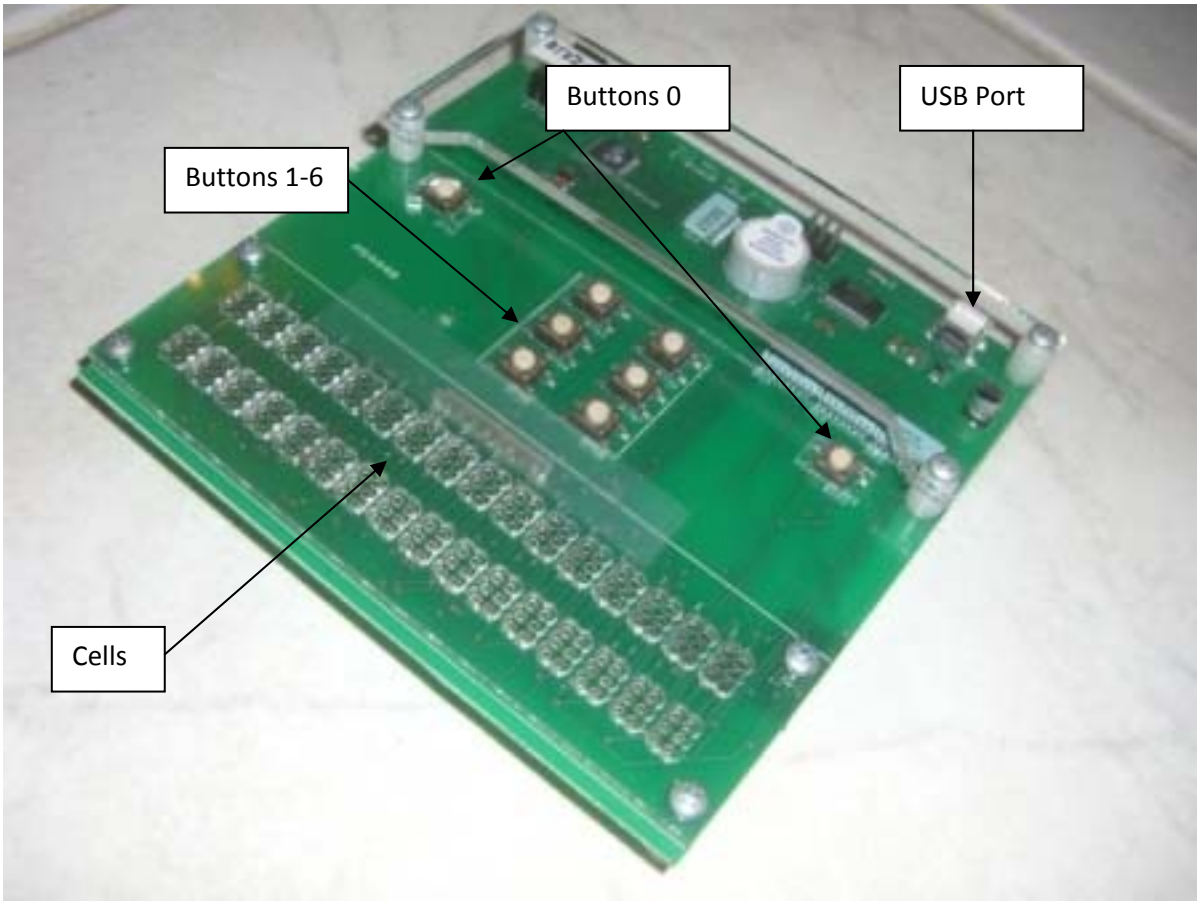

Figure 1: Braille Writing Tutor

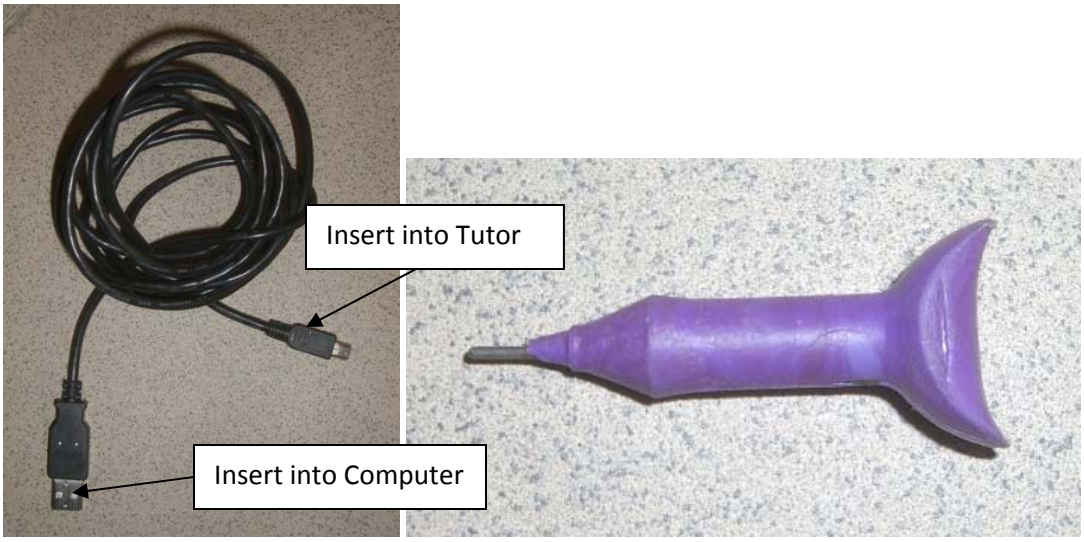

Figure 2: mini USB Cable and Stylus

2. Starting the Braille Writing Tutor

Your Windows system may require a driver to use the Braille Writing Tutor. In many cases, plugging the Braille Writing Tutor into your USB port will cause the operating system to download the appropriate driver if your computer is connected to the Internet. If this is not the case for you, run the provided driver installer program distributed with the software:

Driver Installer (CDM 2.02.04).exe

which supports Windows Vista, XP, 2000, and Windows Server 2003. Alternately, you may download the driver from the company that makes the Braille Writing Tutor's USB interface chip. The webpage is here:

http://www.ftdichip.com/Drivers/VCP.htm

Be sure to select a driver that supports the "FT232R" chip.

Once the appropriate driver is ready, the Braille Writing Tutor is a "plug-and-play" USB device. No additional steps are required beyond plugging the Braille Writing Tutor into your USB port.

To start the Braille Writing Tutor program, open the command prompt. This is done by:

Press the start menu > All programs > Accessories > Command Prompt

Now the command prompt should be open. Now you need to change the directory. There should be a folder on your desktop labeled "BWT" – that is the directory we are changing to.

You should now type "cd", insert a space by pressing the spacebar, and now type in the location of the directory

For example: `C:\Documents and Settings\TechBridgeWorld>cd C:\Documents and Settings\TechBridgeWorld\Desktop\BWT`

Then press enter. This should respond with:

(location of the directory)>

Now type "`btbt`" and press enter. This starts the Braille Writing Tutor software. You should now be on the main menu of the Braille Writing Tutor software. Test this by pressing button 1 or 4 – the tutor should say the name of a mode aloud. If you do not hear a voice, check to make sure the speakers and sound on your computer is on, and then try again. If this still does not work, follow please retrace these steps or refer to the **Troubleshooting** section of this document.

3. Interacting with the Braille Writing Tutor

a. Button Layout

The buttons are arranged in the following manner:

```
0       4 1     0
        5 2
        6 3
```

When pressing a button, it should respond with a "click" sound. If you do not hear that sound, try pressing harder, if no "click" sound is made, you may not be pressing a button.

b. Inserting the Stylus into the Cells

The cells are numbered right to left. The first cell (cell 1) is located in the top row, far right. The last cell (cell 32) is the located in the bottom row, far left. A stylus should be provided with the tutor for inserting into the cells.

There is some difference between an A4 frame and the Braille Writing Tutor cells. It is important to fully insert the stylus into the holes in the cells. The stylus should be inserted vertically (not at an angle) down into the holes to ensure proper detection of the stylus. The stylus passes through the first board, down onto the second board, and it should feel as though you are pushing a pin through a cylinder onto a depression.

Sometimes users have the stylus pressed directly against the side wall of the frame, and cannot insert the stylus because of this. If the stylus is pressed against the frame, move the tip slightly in from the wall of the frame towards the center of the cell to locate the hole.

c. Listening to the Instructions

The user should listen to the instructions fully before inserting a stylus or pushing a button. If the Braille Writing Tutor is speaking instructions and the user either presses buttons or inserts a stylus before the Braille Writing Tutor finishes, it may cause an error.

d. Selecting a Mode

When you start the Braille Writing Tutor software, you start on the menu. By pressing buttons 1 and 4, you scroll through the different modes that are available to you. Pressing button 1 scrolls right and pressing button 4 scrolls left.

As you scroll onto each mode, the tutor says the name of the mode. To select that mode, press button 0. The Braille Writing Tutor will then enter that mode.

e. Exiting a Mode

To exit a mode, hold down button 0, and then press button 3, 6, or 1. This will exit the mode and the Braille Writing Tutor will restart on the main menu. You can do this at any time. The Braille Writing Tutor will not store your progress on any mode.

f. Entering a Single dot

To enter a dot, the user should press any of the 6 middle buttons or insert a stylus into any of the dots within the cells on the bottom of the Braille Writing Tutor.

g. Entering a Series of Dots

To enter a series of dots, either press any combination of the 6 middle buttons or insert the stylus into any combination of dots within a single cell on the bottom of the Braille Writing Tutor. The user may press a button or insert the stylus into the same dot more than once without causing an error.

h. Entering a Series of Characters

There are three different ways to enter a series of characters:

1. The user can input a series of dots(using any of the means described by **Entering a Series of Dots**) and then press either of the carriage return buttons (button 0)
2. The user can input a series of dots into a cell, and then start inputting another letter into a new cell.
3. The user can input a series of dots, and then wait for 5 seconds.

4. Learning Modes

a. Free Play

The Braille Writing Tutor says aloud a dot's number when the stylus is inserted into that dot. This mode is meant for users to explore the relationship between dot location and dot number.

Interaction: Buttons 1-6, Empty Braille Cell

Recommended Skill Level: Any

b. Learn Dots

The Braille Writing Tutor instructs the user to find a specific dot. It will ask the user to locate a dot, and then wait for the user to either insert a stylus into that dot, or push the appropriate button. If the user indicates the correct dot, the tutor will respond with “good!” and ask the next question. If the user indicated the incorrect dot, the tutor will respond with “no” and ask for that dot again. This continues until the user indicates the correct dot. This mode is meant to practice the relationship between the dot location and the dot number.

Interaction: Buttons 1-6, Empty Braille Cell

Recommended Skill Level: Beginner

c. Dot Practice

The Braille Writing Tutor asks for a series of dots, and then waits for the user to correctly input that series of dots using either the stylus or the buttons. For example, the Braille Writing Tutor will say “please press 1, 2” and wait for the user to press 1 and 2. These can be input in any order (for example, 1 then 2 or 2 then 1 both are correct answers). If the user inputs the correct answer, the tutor will respond with “good!” and ask a different series of dots. If the user inputs the incorrect answer, the tutor will respond with “no” and wait for the correct answer.

As the user answers correctly, the series of dots the tutor asks for will become increasingly longer (for example, first it will ask for 1 dot, then a 2 dot sequence, then a 3 dot sequence). As the user answers incorrectly, the series of dots the tutor asks for will become shorter.

This mode is meant to get users to practice inputting a series of dots. Because most letters are represented by more than a single dot, this mode gets users to input a series of dots to build up to representing letters as a series of dots. The dot sequences that a user is asked to input actually represent the alphabets (but the user is not aware of this). That is, the user is not randomly pressing dot sequences but implicitly also learning the letters.

Interaction: Buttons 1-6, Empty Braille Cell

Recommended Skill Level: Beginner

d. Learn Letters

This mode is meant to teach the user the mapping between letters and dot sequences. The tutor internally divides the alphabet into subsets, and focuses on teaching the student one subset at a time. The tutor starts by instructing the user how to write a letter. For example, the tutor will say, “to write the letter A, press dot 1.” The tutor then waits for the user to correctly input the sequence. If the user inputs a correct answer, the tutor will respond “good” and move on to the next letter. If the user enters an incorrect answer, the tutor says “no” and repeats the instructions.

The tutor tests a subset of five to six letters at a time. When the tutor has reached the end of the subset it administers a test. The tutor will ask the user to write one of the letters within the subset. For

example, the tutor will say, “write the letter A” and then wait for the user to input the correct sequence that represents A. If the user inputs the correct answer, the tutor tests another letter at random until it has tested all of the letters within the subset. If the user inputs an incorrect answer, the tutor asks for the letter again. If the user again inputs an incorrect answer, the tutor will instruct the user of the proper sequence, and then ask the user to enter that sequence. After this has been correctly completed, the tutor will continue with the testing.

Once one subset is finished, the tutor moves on to another subset of letters until it has taught and tested the entire alphabet.

Interaction: Buttons 1-6, Empty Braille Cell

Recommended Skill Level: Intermediate

e. Letter Practice

In this mode the Braille Writing Tutor will prompt the user to input a series of letters which compose words in the given language. The tutor will say, “Please write A, T.” The tutor then waits for the user to input the proper characters. After a letter is input into the tutor the tutor will say the name of the letter the user has input.

Once the user inputs the correct series of letters, the tutor will say “good!” and move on to another series of letters. As the user continues to get answers correct the series of letters increases in length. If the user inputs the incorrect answer, the tutor says “no” and waits for the user to input the correct answer. If the user does not input the correct answer after three tries, the tutor instructs the user on the correct sequence of dots which represents the letter it has requested. The sequence of letters decreases in length as the user answers incorrectly.

The goal of this mode is to allow the user to practice writing sequences of letters, which represent words.

Interaction: Buttons 0-6, Empty Braille Cell

Recommended Skill Level: Intermediate

f. Free Spelling

In this mode, the user can explore the alphabet. As the user presses a button or inserts the stylus into a dot, the tutor says the number of that dot aloud. The user can input a series of dots, and then employ any of the three methods described in **Entering a Series of Characters** to make the tutor say the name of the corresponding letter aloud.

If the user inputs a series of dots which does not have a corresponding letter, no sound is played. The goal of this mode is to allow users to freely explore the relationship between dot sequences and characters. It is particularly targeted at users who learn better through exploration than instruction.

Interaction: Buttons 0-6, Empty Braille Cell

Recommended Skill Level: Any

g. Learn Numbers

This mode behaves similarly to **Learn Letters**, but instead of teaching the mapping between letters and dot sequences, the tutor instructs on the mapping between numbers and dot sequences. It does this by randomly selecting a number between zero and nine, and stating the name of the number, and then the series of dots which represent that number. It then asks the user to input that series of dots. If the user inputs the correct answer, the tutor says “good!” and moves on to another number. If the user inputs the incorrect answer the tutor says “no” and instructs the user again on the proper sequence of dots which represents that number.

The goal of this mode is to teach the user the mapping between numbers and their corresponding dot sequences.

Interaction: Buttons 1-6, Empty Braille Cell

Recommended Skill Level: Intermediate

h. Free Number Practice

This mode behaves similarly to **Free Spelling**, but instead of allowing users to explore the relationship between letters and their corresponding dot sequences, it allows users to explore the relationship between numbers and their corresponding dot sequences.

Interaction: Buttons 0-6, Empty Braille Cell

Recommended Skill Level: Any

5. Game Modes

a. Hangman

In this game, the computer chooses a word, and the user is supposed to guess what the word is. The tutor will start by saying the word, with dashes where the letters are to obscure the answer (for example, the tutor says, “dash dash dash dash” which means the word is 4 letters and the user has not guessed any letters correctly yet).

The user guesses a letter which they think is in the word by inputting that letter into the Braille Writing Tutor. If the letter is in the word, the tutor tells them the word constructed only with letters they have correctly guessed (for example if the word is “b-a-c-k” and the user guessed the letter A, the tutor would say “dash A dash dash”). If the user guesses a letter that is not in the word, they have made one mistake. The tutor will record and inform the user how many mistakes they have made - the user can only make 7 mistakes until the game is over.

The goal of this game is to give the user practice writing individual letters and spelling words.

Interaction: Buttons 0-6, Empty Braille Cell

Recommended Skill Level: Advanced

b. Animal Game

This game engages students by asking them to spell the name of the animal when presented with the sound the animal makes.

The tutor asks the user to "write the name of the animal that makes the sound" and then plays an animal noise. These noises include those of a bee, horse, cat, dog, hyena, and a few others. The name (and thus the answer to the command) is dependent upon the language.

To input the name of the animal, follow the instructions described in **Entering a Series of Characters**. The goal of this game is to give the user a fun way to practice inputting letters to spell words.

Interaction: Buttons 0-6, Empty Braille Cell

Recommended Skill Level: Intermediate

c. Music Maker

Music Maker is a game where the Braille Writing Tutor can be used to make music. The goal of this game is to get users to learn how to use the slate and stylus in a fun and interactive way. This game uses all of the 32 braille cells.

Each column represents a single beat. At every beat, there are six different tones, one for each dot in a column. All the tones are silent, until you insert a stylus into the hole to turn it on. Every beat (column) plays sequentially, and when it reaches the last row, the program loops back to the beginning.

The music loops constantly, so the user makes their music by deciding what notes should be on and what should be off. It is an exploratory way to make music, as well as practice inserting the stylus into the cells. The idea is that the user writes words and letters, and the Braille Writing Tutor reads it back to them as music.

There is a separate executable to run this game. To start the game, follow the same instructions as **Starting the Braille Writing Tutor** program, except instead of typing `"btbt"` type `"musicmakergame"`. This will start a separate game. The game starts reading what you write instantly. The more you write, the more complex the melody. If you want to end the game, hold control and press `"C"`.

Interaction: All Braille Cells

Recommended Skill Level: Any

6. Language Switching

The languages included on the Braille Writing Tutor are Swahili and English. On the main menu, scrolling right will go through the Swahili modes, scrolling left will go through the English modes. All modes are included in both languages.

Other languages are available (for example, French and Arabic) but are not currently included.

7. Turning Off the Braille Writing Tutor

To turn off the Braille Tutor, go back to the command prompt you opened to start the "`btbt`" program. Now hold the control key, and press "C". This will end the program. You may now unplug the Braille Writing Tutor and safely store it. Please store the Braille Writing Tutor in a clean dry place, well away from contaminants such as dirt, dust, or excessive moisture.

8. Troubleshooting

a. "Nothing is happening!"

When you finish using a Braille Writing Tutor program on your computer, you must unplug your Braille Writing Tutor and plug it back in again before you can run another Braille Writing Tutor program. The current hardware has an "autodetect" mode that only runs when the Braille Writing Tutor is plugged in; once a program cancels "autodetect" mode, the Braille Writing Tutor will not return to that mode until it has been unplugged and plugged back in.

If nothing is happening, unplug the USB cable from the Braille Writing Tutor, plug it back in. Hold control and press "C" to end the `btbt.exe` program. Then restart the program by typing "`btbt`" into the command prompt.

b. "The Braille Writing Tutor is talking on its own!"

The Braille Writing Tutor operates at a certain pace. If you enter information too quickly, the sound files will build up and you will not be able to enter information in the correct time. If you are hearing one sound file after another without entering information, pause for a minute and let the Braille Writing Tutor catch up to you. However, if you enter information too slowly you may not be able to enter the full character before it tries to recognize the series of dots as a character. Best practice is to listen fully to the instructions, and then respond quickly. Do not try to input characters while the Braille Writing Tutor is speaking.

The other possibility is that Braille tutor is registering false input. When using the Braille tutor, make sure it lies flat on a table, and that you are not inadvertently pressing undesired buttons. Also, do not pinch the top and bottom board together near the Braille cells. This will register as input.

c. "I can't insert the stylus!"

Please refer to the **Inserting the Stylus** section. Inserting the stylus properly can be tricky, but can be mastered with practice. Try moving the tip of the stylus in small circles. Gradually increase the radius of the circle you are making until you find a hole to insert the stylus into. You can also use the frame of the cells to understand what hole you have found.

Another possibility is that you have found a hole, but the stylus is stuck in the first board and will not pass through to the second board. Make sure the stylus is vertical, and push with slightly more force. This should make the stylus pass through the first board.

9. Contact Information and Credits

This Braille Writing Tutor is based on an initial version that was co-invented by Nidhi Kalra and Tom Lauwers of Carnegie Mellon University, as a project in the TechBridgeWorld (www.techbridgeworld.org) group. The first version of the Braille Writing Tutor was field tested at the Mathru School for the Blind near Bangalore, India, and subsequent developments reflect this applied experience.

The current (second) version of this tutor hardware was designed by Tom Lauwers with consultation from Nidhi Kalra, Tom Stepleton, and Daniel Dewey. The accompanying software development library was developed by Tom Stepleton and the BT_Curriculum application was developed by Daniel Dewey. All of this work was coordinated through Carnegie Mellon University's TechBridgeWorld group.

The first and second versions of this tutor are in the process of being released under an Open Source license.

The Braille Writing Tutor was first tested in Tanzania in 2009 by the iSTEP internship program through TechBridgeWorld. This code, as well as this manual, was compiled by the iSTEP team: Bradley Hall, Anthony Velázquez, Imran Fanaswala, Freddie Dias, Daniel Nuffer, Hatem Alismail, Beatrice Dias, Rotimi Abimbola, Sarah Belousov, Ermine Teves, and M. Bernardine Dias. This team worked in cooperation with the University Computing Centre at the University of Dar es Salaam. Special thanks to Mwangu Mwangu as the Swahili voice of the Braille Writing Tutor.

Please send direct inquiries about the Braille Writing Tutor included in this package to:

info@techbridgeworld.org

Please send direct inquiries about TechBridgeWorld to:

Ermine Teves (eteves@cs.cmu.edu)

Please send direct inquiries about the University Computing Centre to:

Eric Beda (ericbeda@yahoo.com)