Assistive technology research as a mechanism to broaden the participation of women, underrepresented minorities, and persons with disabilities

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ABSTRACT

This paper examines the field of assistive technology and its potential as a "catalyst for change" for diversity in science and engineering. We will discuss programs in the Quality of Life Technology Center (QoLT) at the University of Pittsburgh and Carnegie Mellon University, and in the Department of Computer Science at the University of Puerto Rico Río Piedras that are using assistive technology to attract underrepresented students to Science, Technology, Engineering and Mathematics (STEM) fields. We will also discuss how collaboration with such programs can help introduce research in assistive technology at other schools by highlighting the collaboration between the University of Maryland Baltimore County and the QoLT. Underrepresented students in STEM include women, Hispanics, African Americans, Native Americans, Hawaiian Americans, Pacific Islanders, and students with disabilities. Involving students from these populations in assistive technology research can contribute to the students' sustained interest in STEM fields, and can lead to the development of a new generation of innovators who will contribute assisted and independent living solutions to problems that can enable people with disabilities to engage in society more completely, and for longer periods of time.

Keywords: assistive technology, Diversity, Broadening Participation, HFOSS

1. INTRODUCTION

The 2007 report by the National Academy of Sciences, *A Gathering Storm*, indicated the United States was not producing sufficient skilled labor in the areas of STEM to remain competitive with other nations. Since then, many efforts to increase the number of STEM professionals have focused on filling the gap by increasing the number of women and minorities in STEM (Langford 2014). The 2014 National Science Board's annual "Science and Engineering Indicators" report released earlier this year indicated that the number of women and underrepresented minorities in higher education in STEM had increased. However, the percentage of women and minorities in these fields had actually declined specifically in the fields of computer and mathematical sciences, physical sciences and engineers. Furthermore, the number of men and other racial and ethnic groups in STEM is increasing at a faster pace than women and underrepresented groups, explaining the decline in the percentage of underrepresented persons in STEM (NSB 14-01). Efforts in education led to a doubling of the national

fellowships offered in STEM by the National Science Foundation. Nevertheless, whereas the number of women and minorities enrolling in undergraduate education make up 70% of the undergraduate population, they represent only 45% of the people with an undergraduate degree in STEM (DOE 2014). This paper aims to discuss strategies to attract women and underrepresented minorities to higher education in STEM.

2. ASSISTIVE TECHNOLOGY AS A STRATEGIC SOLUTION FOR DIVERSIFYING STEM

Given the disparities in the numbers of underrepresented students in STEM fields, we began to look at fields that might be attractive to women, underrepresented minority students, and students with disabilities. Anecdotal data from students in these demographic groups who participate in the National Science Foundation's PROMISE: Maryland's Alliance for Graduate Education and the Professoriate (AGEP) show that many are attracted to research areas that "help people" or have direct benefit to society. In many cases, students think that they have abandoned their technological inclinations to pursue education, medicine, or law so that they can "make a difference" within their communities. However, we've been pleased to find that "assistive technology" is perceived to be at least one research area that bridges the "helping professions," medical professions, and technology, and we believe that it can be a discipline that could be marketed to further recruit diverse populations. With great success, we have introduced the concept of "assistive technology research" to underrepresented engineering graduate students, in the U.S., and in South America, at meetings such as the National Society of Black Engineers, the Society for Hispanic Professional Engineers, the Latin and Caribbean Consortium of Engineering Institutions (LACCEI) in Mexico, and the World Engineering Education Forum (WEEF) in Colombia. We've learned that students want to re-direct their talents so that people are the beneficiaries, and that they want to spend time on research that will not be considered to be "selfish," but rather helpful to a segment of society. Students with physical disabilities in particular, want to contribute to research that will either help people with their specific disability so that it can help them or their caregivers, or develop technologies that will assist people with disabilities that are different from their own. Assistive technology (AT) represents a cross-disciplinary approach to research that resonates with students, and can be shared widely among underrepresented populations. In particular, it is also important that students with disabilities, who may already be consumers of AT, have opportunities to extend beyond patients or clients, and now become contributors and innovators. Research in assistive technology can address number of existing challenges. Assistive technology is any item, piece of equipment, software, product, or system that is used to increase, maintain, or improve the functional capabilities of individuals with disabilities (ATIA 2013). As women, underrepresented minorities, and persons with disabilities participate in assistive technology research, they become a part of and involved in the participatory design process because they have the potential to be the designers, developers, and users of new and novel innovations.

Expanding further, individuals with disabilities may have an increasingly strong interest in knowing about, actively pursuing, and being involved with AT because they have increased anticipation of emerging assistive technologies that can be be developed and brought to market to improve their lives. Students with disabilities can be active researchers (not just subject participants in an experiment), and can provide invaluable insight as designers at the very early stages of research and development of accessibility solutions. People with disabilities are an untapped resource because they can be experts in the field of assistive technology research due to their first-hand experience of the challenges faced by having the disability. In addition, they may be equipped with problem-solving solutions that can catapult theory and ideas to levels of technology readiness. Involvement of students with disabilities, and sharing information about their involvement, can contribute to increasing the rate of user acceptance and effective usability of the assistive technology devices. Assistive technology researchers with disabilities also have the motivation to advance the field and a means of progressing as a contributor in the profession. It is also important to note the role of caregivers of people with disabilities within the context of innovation. Since many students with disabilities have caregivers or family members who are very connected to their lives, the caregivers may contribute to the research because they may provide perspectives on usability, and can provide valuable insight into designs. If the researcher is designing a product that could be a personal

assistant, then family and caregivers' recommendations to the development of the product will be of value because caregivers often assist students with equipment.

Active participation of women, underrepresented minorities, and persons with disabilities in assistive technology research can facilitate a broader representation of innovators of assistive technology. In the next sections, we will introduce two exemplars for broadening participation in STEM in general, and assistive technology in particular. These examples focus on the computer science aspects of assistive technology. We will feature computer science projects from the University of Puerto Rico Río Piedras and the Quality of Life Technology (QoLT) Center in Pittsburgh.

2.1 BROADENING PARTICIPATION IN STEM THROUGH ASSISTIVE TECHNOLOGY RESEARCH AT THE UNIVERSITY OF PUERTO RICO RÍO PIEDRAS (UPRRP)

The UPRRP is a Hispanic-serving institution located in San Juan, Puerto Rico. It has an undergraduate computer science department that is approximately 10 years old. All the professors are PhDs, but there is no graduate program in computer science. Nevertheless, the University of Puerto Rico Río Piedras is the number one producer of Hispanics PhDs in STEM from 2008-2012 (302) ahead of the University of California Berkeley (260) , UC Los Angeles (219), UT Austin (172) and U. Southern CA (167) (NSF Science and Engineering Doctorates 2012). The majority of the students at the UPRRP campus are females, yet they comprise only 16% of the women in the undergraduate program in computer science. The term underrepresented minority in Puerto Rico does not apply to Hispanics because almost everyone is Hispanic and the racial diversity makes it difficult for many people to identify with either being Caucasian or African-American. Thus, for the purpose of this diverse population, the underrepresented populations that we are trying to attract to computer science are women and persons with disabilities; however, Hispanics are considered by NSF as an underrepresented population in STEM.

2.2 HUMANITARIAN FREE AND OPEN SOURCE SOFTWARE (HFOSS) AT UPRRP

Free and Open Source Software (FOSS) is software that is available for use by anyone so long as the code that is created from the base code acknowledges the writers of the original code. Humanitarian Free and Open Source Software is FOSS that aims to benefit society and that serve the realms of health care, disaster management, accessibility, and education to name a few. (http://foss2serve.org/index.php/POSSE_Overview) RedHat, Inc. began an initiative in higher education to educate instructors in Open Source Software so that they would incorporate them to their curriculum, the Professor's Open Source Summer Experience (POSSE). Later a coalition of university professors expanded the program to be a yearlong mentoring program for educators to help them develop curriculum that incorporated HFOSS and also to answer the research question "does HFOSS help to diversify the field of computing?" Since then, the POSSE acronym has been changed to signify the Professor's Open Source Software Experience. In the summer of 2013, the first author of this paper participated in POSSE and has had incredible success in using HFOSS to begin her research laboratory at the UPRRP.

The first author's lack of experience with FOSS led her to begin her experience in HFOSS through research. She found two students to work with on a project to help a former lab mate of hers in graduate school who is second author of this paper. The students were to build a program using HFOSS to help the people with limited mobility in their hands to program. In the POSSE workshop, the professor had been given the idea to use GNOME's accessible keyboard named Caribou and KDE's accessible voice recognition software named SIMON.

2.2.1 SKILLS APPLICABLE TO ASSISTIVE TECHNOLOGY ARE TAUGHT IN PUERTO RICO

During the first semester of the course, the students experienced all the frustrations in the use of open source software as they installed one virtual box after another and combined it with different flavors of Linux to find which they could use to install SIMON and Caribou. Each student worked on installing one of the two open source software. By the end of the semester, SIMON had been successfully installed, and we had started working

on using SIMON for voice recognition, but we had yet to get to the implementation. Nevertheless, word started spreading quickly about the project, and suddenly I had two more students interested in working on the project.

At the beginning of the second semester, one of the new recruits managed to make a break through and find the right virtual machine and version of Linux for SIMON. The students installed this version on all three machines in the laboratory gaining experience in installing an operating system. Whereas the keyboard and voice recognition work very well if users want to write e-mails, dictate letters, and surf the Internet, it is much more difficult if these users want to program. The students have learned about speech and language models and scenarios and have created their own scenarios for different programming languages. Two girls from the local high school have asked to do a one year project in voice recognition and assistive technology in the upcoming year after visiting the lab and hearing about the HFOSS project.

Besides learning about working collaboratively on a team, programming, installing Linux, working with HFOSS Software, resolving programs, they have also acquired invaluable lessons about proper communications with the programmer of SIMON. They have also experienced how important it is to persist in the face of adversity and look for other possible solutions.

2.2.2 AN INCREASING INTEREST IN ASSISTIVE TECHNOLOGY AMONG COMPUTER SCIENCE STUDENTS IN PUERTO RICO

After that success, one of the students has continued to play with assistive technology to create an interface for communicating between the hearing and the hearing impaired and has recruited another student. The remaining students continue to work with SIMON on creating a voice recognition interface for programing in Integrated Development Environments (IDEs). All the students must blog about their work at http://kavitaproject.blogspot.com/. They have communicated with the creator of SIMON via email and he is encouraging them to create a plug-in for SIMON. He is also encouraging them to communicate with him through the KDE assistive technology mailing list. Thus, in short in the time span of one year, the students have gone from being novices to developing a plug-in for a global open source project for voice recognition. They are learning to be a part of a global community of developers who are working to make the world a better place. The lab focused on HFOSS has gone from having only one student to having six enthusiastic students who are eager to make a difference in the world through the use of technology, two thirds of whom are women. Half of those women are in high school. While some may suggest that these results are based solely on the basis of providing the option for a humanitarian project, the director of the project believes that is the involvement in a humanitarian project composed of a distributed and international community with mentors that makes this research popular with the underrepresented in computing. The lead developer of SIMON is from Germany.

3. QOLT'S INVOLVEMENT OF WOMEN, UNDERREPRESENTED MINORITIES, AND PEOPLE WITH DISABILITIES AS RESEARCHERS

The Quality of Life Technology Center is a National Science Foundation (NSF) Engineering Research Center (ERC) and is a joint venture between Carnegie Mellon University (CMU) and the University of Pittsburgh. The QoLT develops technology solutions that can assist people who are aging and those who have disabilities. The center, at its core, is focused on engineering and technology projects in the following spaces: independent living, homecare, assisted living, rehabilitation, skilled nursing, and acute care. The QoLT's theme is "Transforming Lives Through Innovative Technology: Intelligent systems work symbiotically with humans to improve the quality of everyday living."

3.1 DEMOGRAPHIC DATA SHOWING DIVERSE POPULATIONS OF ASSISTIVE TECHNOLOGY RESEARCHERS

The QoLT Center's mission to broaden the participation in assistive technology is facilitated by the work of the QoLT Education and Outreach Team which has a project director, and coordinators, housed in the Human Engineering Research Laboratories in the University of Pittsburgh Department of Rehabilitation Science and Technology. The next four figures, Figures 1-4, show demographic data from the QoLT with respect to the participation of women, underrepresented minorities, and persons with disabilities.

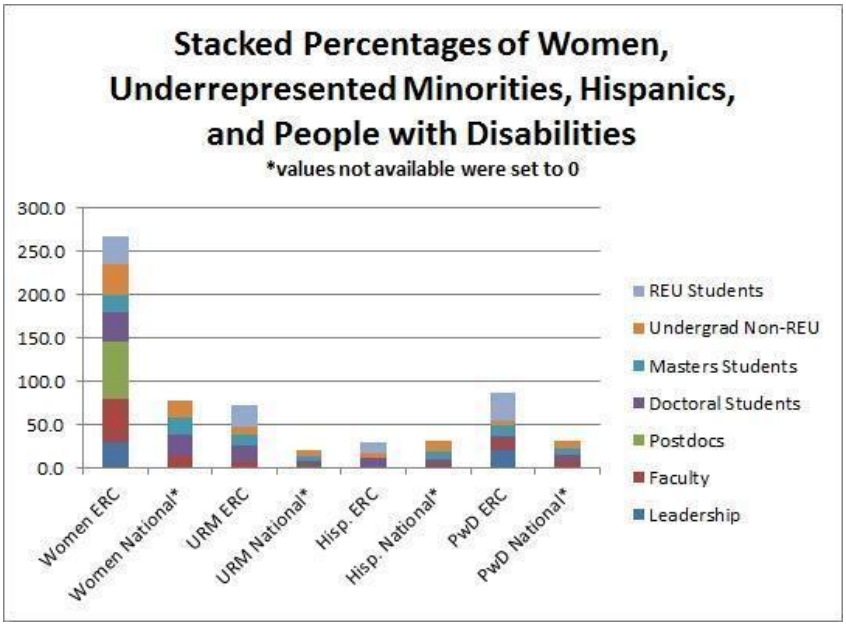

Figure 1: The QoLT's Percentages of People in Diverse Populations from 2006 to 2014

As depicted above, each column designated "ERC," displays the representation of women, URM, Hispanics, and people with disabilities within the QoLT ERC. The national figures that are displayed here are the from the National Science Foundation's 2013 report on Women, Minorities, and Persons with Disabilities in Science and Engineering. (NSF 2013) With the exception of Hispanic scientists and engineers , the QoLT ERC has a higher representation of each underrepresented group in comparison with the national average. Hispanics represent 2.3 percent of Pittsburgh's population, with modest increases in recent years. (Pittsburgh Post-Gazette 2011) Therefore, the city itself has not been a draw, and center personnel have made concerted efforts to attend conferences including LACCEI, SHPE, and SACNAS to increase the number the of Hispanics throughout its levels and programs. This effort has resulted in an increased number of REU students, raising our participation level to nearly equal that of the national level of Hispanics in science and engineering. Similarly, the graph below depicts the same values but organizes according to status (leadership, faculty, post-docs, doctoral students, masters students, undergraduate non-REU students, and REU students). The QoLT REU program stands out here, with a concerted effort to reach higher percentages of underrepresented groups than every other classification of personnel within the center (i.e. the REU has a higher percentage of underrepresented minorities, Hispanics, and people with disabilities than any other group in the center, and the national average), demonstrating the benefit of attending specific recruitment events.

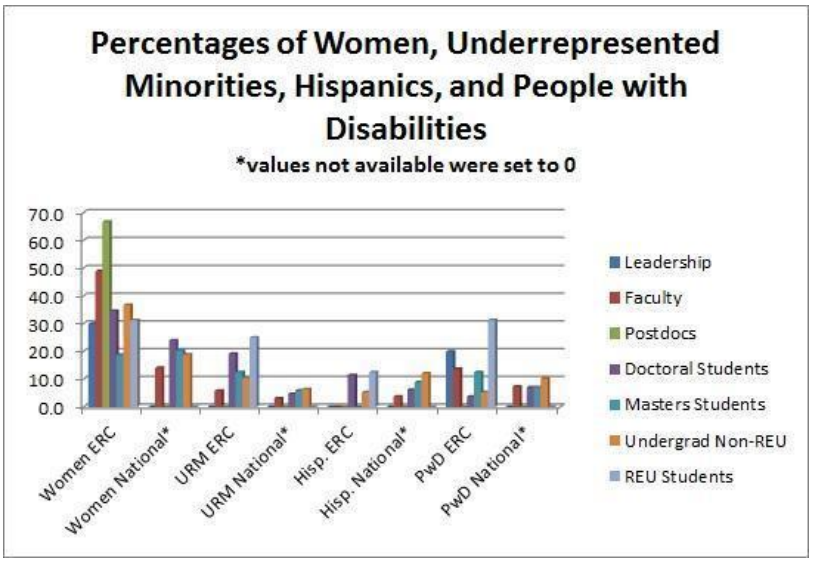

Figure 2: The QoLT ERC's numbers of diverse women, underrepresented minority (URM), and persons with disabilities (PwD) researchers, compared to national averages

The QoLT ERC has had representation of both domestic and foreign scientists and engineers with disabilities since the beginning of the center. The graph below displays the representation of this group since 2012 across undergraduate, graduate, faculty, and leadership levels. Compared to the national engineering averages of 2008, the QoLT ERC employed double the number of faculty with disabilities and enrolled more undergraduate students. (NSF 2014)

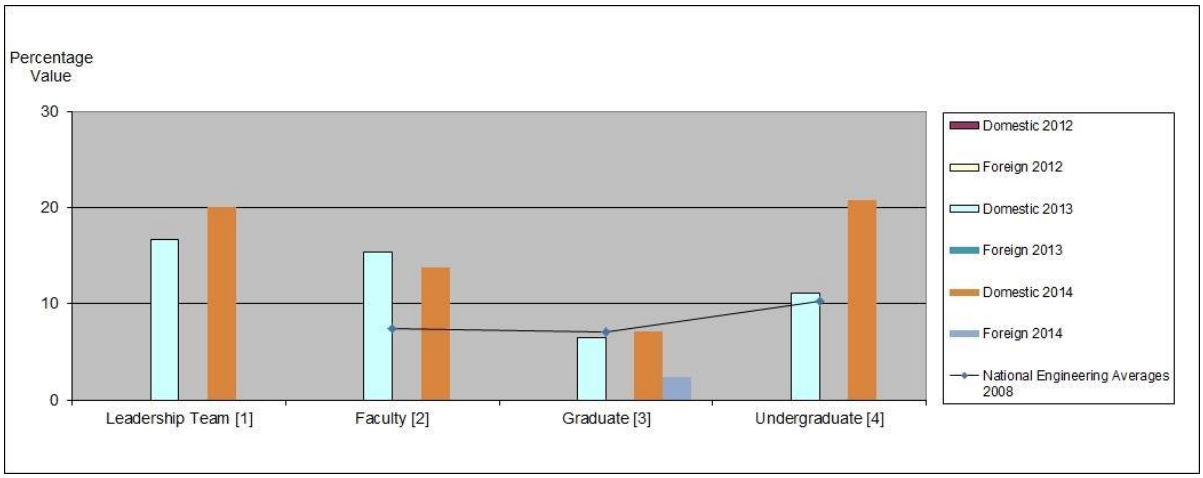

Figure 3: Persons with disabilities who have served as researcher at the QoLt ERC.

Figure 4 shows the number of underrepresented minorities who have participated in assistive technology research at the QoLT Center between 2012 and 2014. The number of U.S. citizen graduate students researchers has grown each year.

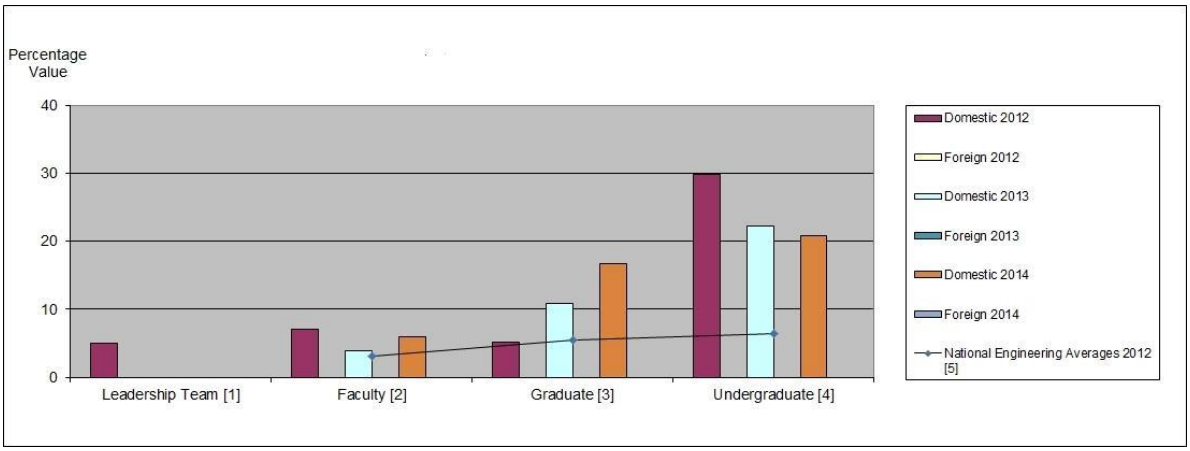

Figure 4: Underrepresented racial minorities who have served as researcher at the QoLt ERC.

In summary, the QoLT Center has increased the number of underrepresented minorities over time. Due to lower percentages of Hispanic students, a specific effort was made to recruit at targeted events which resulted in an increase of REU students who intend to ultimately fill the pipeline as graduate students, post-docs, and faculty. The nature of the science (assistive technology and quality of life technologies) may result in a larger representation of people with disabilities at the undergraduate and faculty levels, who through the QoLT center, have an opportunity to contribute to broadening participation and increasing independence of all people.

3.2 SAMPLE PROJECT FROM THE QOLT TEAM OF RESEARCHERS COMPRISED OF WOMEN, AND A WOMAN WITH SPINAL MUSCULAR ATROPHY:

The QoLT Center has a series of technology projects that are designed to assist people with their desires to live independently. A well-designed, functional kitchen with assisted technology built-ins is one such project. The kitchen of the future will include advanced robotics technologies to support people with disabilities and the elderly. Recently, the researchers at the QoLT designed the KitchenBot to provide an assistive robotic manipulator to access an entire kitchen workspace and to reduce caregiver needs in the kitchen [1]. The kitchen in the Human Engineering Research Laboratories (HERL) at the University of Pittsburgh is used for KitchenBot project aimed at improving the functional capabilities of people with varying disabilities. The KitchenBot consists of an overhead multi-degree track that is mounted with the Jaco robotic arm to aid individuals with physical limitations to be more independent by completing common kitchen tasks such as meal preparation or cleanup. The kitchen also recognizes its user's task activities from the sensors and is able to discern if (s)he is having difficulty with a task, and provides a helping hand with forms of prompting to assist with a task.

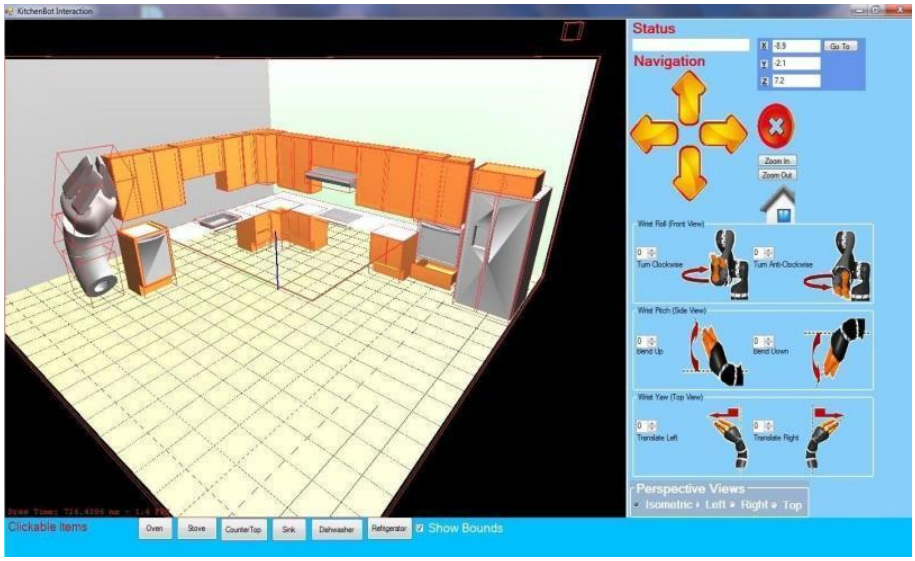

Figure 5: Tablet controlled interface for the KitchenBot

A tablet control interface was designed and developed to show different perspective views of the kitchen, allow user to select a cabinet and either confirm or reject the clicked cabinet, issue commands to the Arduino board for the track system to go to the clicked cabinet, and send commands to the Jaco robotic arm for opening/closing the clicked cabinet. For example, the interface in the figure to the right allowed to manipulate the JACO arm to virtually move it to perform tasks in a kitchen, such as, open cabinet doors and turn on the sink faucet. Also, the interface was clickable with a 3D model of the kitchen for intuitive interaction of cabinet selection using C# and the SharpGL library.

The interface was designed and developed by the second author of this paper, who was born with the severe physical disability Spinal Muscular Atrophy and is only able move the index finger of her right hand. She is working in the area of assistive robotics as part of her Ph.D. thesis research. By allowing participation of people with disabilities in assistive technology research, more awareness of personal experiences can be brought out and shared with people from the industry, academia, and various professionals to evaluate the effectiveness of existing assistive technologies to improve independence for many individuals with disabilities and the elderly.

Studies with eleven subjects in focus groups from the potential user population indicated that positive perceptions, opinions, and attitudes were experienced by the subjects and that provided them the increased ability to perform tasks independently. In the future, the KitchenBot may perform routine tasks autonomously and support people with and without disabilities for expanded consumer marketability as a product for everyone. A future study may also examine the KitchenBot preparing a simple meal and feeding it to the user while (s)he is independently controlling the interface.

4. ENGAGING FUTURE DIVERSE RESEARCHERS IN ASSISTIVE TECHNOLOGY

Tess Almendarez Lojacono, President and CEO of Fine Art Miracles, Inc., part of the QoLT consortium of non-profit and industry partners and thought leaders, is contributing to the process of broadening participation in assistive technology by introducing robots to children from underrepresented and underserved backgrounds as early as elementary school. Lojacono says that introducing robots to children at very early ages, and providing consistent exposure within classrooms, can later lead to children's desires to program the robot. She is focused on elementary grades and schools that have populations of underrepresented minority children because she wants to be sure that children from the underserved backgrounds receive exposure to technology. She notes that by 4th and

5th grade, the children want to learn how to modify the robot's functions, which opens the opportunity for STEM learning. Lojacono is also working with Carnegie Mellon University's Robotics Department so that Fine Art Miracles can use robots in therapy sessions with clients on the autism spectrum. Fine Arts Miracles provides one example of ways to engage both young children from underrepresented backgrounds, and children with disabilities. Lojacono's work also supports a study from SRI International which found that college students with autism spectrum disorders who go to college, tend to major in STEM fields, and were more likely than the general population to choose science and computer science majors (SRI, 2012).

At the university level, programs like the QoLT are training new researchers in rehabilitation engineering and assistive technology through their research experiences for undergraduate summer programs, graduate programs, and collaborative relationships. Two women who received PhDs from Carnegie Mellon and were part of the QoLT as graduate students, now teach in the Department of Information Systems (IS) at the University of Maryland Baltimore County (UMBC). One QoLT alumna serves as a tenure-track member of the faculty and has a laboratory with diverse students that is part of the Human-Centered Computing Program, within the IS Department. The other woman teaches computer science as an IS adjunct assistant professor, and conducts research in technology for the elderly while continuing to lead mentoring activities for undergraduate women in computer science in Pittsburgh. The QoLT also has a collaborative relationship with PROMISE: Maryland's Alliance for Graduate Education and the Professoriate (AGEP) at UMBC, which led to the development of the "QoLT Bridge Program" for underrepresented graduate students, most from the NSF Louis Stokes Alliance for Minority Participation (LSAMP) Bridge to the Doctorate Program, who connect with QoLT's researchers in Pittsburgh to have research experiences in assistive technology development. The PROMISE - QoLT collaboration has introduced 7 new graduate student researchers from UMBC to assistive technology experiences. These graduate students include a woman with a degenerative disability, 4 African-American males (one with a mild disability), 1 Hispanic Male, and 1 Hispanic female. In addition, another African-American male from the QoLT's undergraduate summer research program came to UMBC to pursue his master's degree in Human-Centered Computing, and an African-American female graduate student received an offer to conduct summer research at the QoLT. All of these students will be on the radar for postdoctoral opportunities with QoLT researchers once they complete their doctoral degrees. This collaboration worked well for UMBC, because a few years ago, the university did not have a research program that centered on assistive technology. At present, UMBC's Human-Centered Computing program is growing, and information about the program and research is widely requested by undergraduate students who learn about UMBC from conferences and initiatives such as the National Society of Black Engineers (NSBE), the Society of Professional Engineers (SHPE), and the LSAMP program. This kind of collaboration can be a model for other schools who don't have research programs in assistive technology, who want to partner with programs that have research resources in this area.

5. CONCLUSION AND FUTURE WORK

The assistive technology projects at the University of Puerto Rico Río Piedras and the QoLT demonstrate that women, people with disabilities, and people from underrepresented groups, can lead and participate in computer, engineering, and technology research that will bridge STEM and the "Health and Helping" professions. In addition, the presence of persons from these groups within the STEM enterprise, attracts others from those demographics to consider those fields where they see successful role models. The presence of a female computer science professor in Puerto Rico has led to an increase in the numbers of young women who are taking computer science at UPPRP, and subsequently have a chance to learn about assistive technology as a special area of research. Similarly, the presence of several underrepresented graduate student researchers in UMBC's Human-Centered Computing program has attracted additional URM students to consider master's thesis and doctoral dissertation research in assistive technology.

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