

# Assistive Technology in Computer Science

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## Abstract

The purpose of this paper is to demonstrate how assistive technology can be incorporated into computer science as a valid method of demonstrating basic computer science principles, human-computer interaction methods, and social, legal, and ethical issues in computing.

## 1.0 Introduction

One of the earliest depictions of “high-tech” assistive technology in popular entertainment is from the original pilot show for the TV series *Star Trek* (later incorporated into the episode “The Menagerie”). [18] In it the first captain of the Enterprise, Christopher Pike, has suffered an injury so crippling that he has no control of his body whatsoever, although his cognitive abilities are entirely intact. He can communicate solely through a combination light and tone signal, which he can flash on briefly. He is, for some unexplained reason, limited to only two responses: one flash for “yes”, two flashes for “no”. In 1964, when this show was written, even this much assistive technology was obviously considered science fiction.

We have clearly progressed well beyond such a simple output mechanism with techniques such as scanning – Captain Pike could certainly have communicated fully with a scanning alphabet, since clearly he could operate a single switch. However, from the input side it isn’t clear whether even at this point in time we match the depiction, since Pike had no control of voluntary muscles whatsoever. Apparently the device was controlled entirely mentally. While researchers have had some success with biofeedback-like techniques for doing exactly this, this method is still largely in the realm of science fiction nearly 40 years after the *Star Trek* depiction.

This paper describes a project to develop curriculum to introduce the intricacies of assistive technology to computer science majors. The purpose is to involve computer professionals as a vital element in the support of persons with disabilities.

## 2.0 Background

For the purposes of this paper, the term “assistive technology” (AT) will be limited to describing computer hardware and/or software that is used to increase, maintain, or improve the functional capabilities of individuals with disabilities. Although legally speaking AT typically has a much broader definition (that includes, for instance, mechanical devices such as standard wheelchairs or walkers, foam supports for arranging posture, etc.), the focus of this paper is clearly on the computerized aspects of the area.

Nearly 20% of the population of America is disabled, with half that number being classified as “severe.” [17] The main areas of disabilities are typically categorized to include vision impairments, mobility impairments, hearing impairments, speech impairments, and cognitive disabilities. Approximately 180,000 disabled students graduate from high school in America each year, with 10.5% of American college students being disabled. [6] As life expectancy continues to increase both for the disabled and for the population at large, all these numbers will continue to grow. Furthermore, laws such as the Americans with Disabilities Act of 1990 place significant requirements on employers, educators, and industry to provide reasonable accommodations to assist the disabled. [2]

Assistive technology is increasingly available to either help compensate for a disability or to provide accessibility to information and services, and to in general improve the quality of life of the disabled. Computer scientists, and specifically human-computer interaction (HCI) professionals, have an expertise in developing and evaluating devices from a usability perspective. However, currently this expertise is too seldom directed at the AT field. As a consequence, many AT devices are poorly designed from a usability perspective, resulting in extensive training needs, poor utilization by clients, and abandonment of the AT by the user. This is exacerbated by frequent poor matching of devices to persons with disabilities by well-meaning but poorly trained AT service providers. Finally, the complexity of many AT devices is often an impediment to potential users, requiring extensive computing experience to fully take advantage of features.

Those who are most often called upon to provide service for assistive technology are also typically not prepared for the complexities of the myriad of computerized devices. This lack of skill is due to a number of factors. To begin with, the degree programs for persons entering this field are by necessity general in their approach to the disabled population. For instance, occupational therapy programs (such as the Masters program at the University of Pittsburgh [16]) typically focus on the fundamentals of human anatomy, biomechanics, neurology, cognitive psychology, and working within the health care system – often without a single course on assistive technology. Even more specialized professional degree programs, such as in speech-language pathology or special education, have little room in their curricula for more than a cursory introduction to assistive technology. A number of certificate programs have been created in recent years to bridge this gap between formal education and real-world practice, for example California State University at Northridge Center on Disabilities’ Assistive Technology Applications Certificate Program [3] and the Certificate on Accessible Information Technology offered by Project EASI [8], but there are still far too few AT service professionals with a significant computing background.

Another issue is that understanding the intricacies of high-tech AT devices requires a level of computer sophistication that is much higher than what those who provide primary services to the disabled typically have. While many of the devices (e.g. a joystick) are simple to install and configure, the real difficulty with computer AT devices is often when something goes wrong. A recent email posted to an AT listserv from a desperate service provider illustrates: “I am looking for some help when backing up a [particular type of augmentative communication device] ... to Windows XP. I tried yesterday with no success. I spoke with Tech Support and they couldn’t figure it out either. I know that you have to uninstall the Palm software, but does anyone know any tricks/tips that may help me out?” [12] Unfortunately, this type of request for technical support is not the least bit uncommon.

### **3.0 The Role of Computer Professionals in AT**

In addition to potentially providing direct support to persons with disabilities, there is an increasing need for computer professionals who are familiar with assistive technology in at least two other domains: (1) in support of company employees who have a disability and require accommodation, and (2) in support of clients or customers of the employer who may require access to company information, services, and products by ensuring that company products meet requirements for accessibility. As more employees, clients, and consumers demand accommodations, the need to evaluate, recommend, install and configure, provide training for, and maintain (in addition to research and design) assistive devices will likewise increase. These tasks require support from persons highly skilled in computer technology. While not all assistive technology requires the skill of a computer science college degree, many of the devices do require extensive configuring and installation of companion computer systems. In some cases, such as with augmentative communication devices, the device itself is a special purpose computer with its own computer-oriented command structure, interface, and programming environment that requires extensive skill to set up, use, and maintain.

### **4.0 AT as HCI**

Assistive technology has obvious intersections with many issues that are classic human-computer interaction topics. Surprisingly, however, few HCI textbooks contain more than a cursory look at AT (e.g. [4, 7, 13, 14]). In a survey of 16 of the most widely used HCI textbooks, only two of those books contain sufficient mention of disabilities issues to warrant a reference in the book's index; total page coverage of the topic in all of these books combined is just 6 pages. [10]

The situation is better on the conference circuit, where conferences such as the Association for Computing Machinery's (ACM) Special Interest Group on Computer-Human Interaction's SIGCHI Conference regularly includes research papers dealing with assistive technology. There is also a relatively new conference devoted to accessibility issues, the International Conference on Universal Access in Human-Computer Interaction [9]. And the ACM's SIGCAPH group has been hosting the successful ASSETS conference for many years, although SIGCAPH itself is in danger of disbanding due to low membership. However, because of a lack of textbook support, few HCI courses cover assistive technology as a regular part of the content.

There are numerous ways that assistive technology could be used as examples and project topics within an HCI curriculum without sacrificing the core content of such a course. Some typical HCI topics and associated AT topics include:

- cognitive models (cognitive disabilities and the psychology of the disabled),
- human factors (range of motion, motor dysfunctions)
- interaction devices (alternate keyboard designs, pointing devices, and selection mechanisms)
- interaction methods (Morse code, voice recognition and generation, scanning techniques, word expansion, word prediction)
- modes of communication (single or multi-switch, audio and voice, alternative languages)
- web accessibility (web mechanisms that interfere with AT devices or techniques, dealing with graphics for the visually impaired, audio captioning)
- usability testing (as a means of user/device evaluation and product acceptance)

For example, in [11] I describe an experiment developed as a class project in a senior-level HCI course. While a large part of the goal of this assignment was to teach the students the difference between a scientific experiment and a usability study, a significant element of the project was to take into account factors related to a disability, in this case blindness – in fact, the intent of the experiment was to compare the performance of blind users to sighted users. As discussed in [11], one of the motivations of the described project was to create an assignment “outside of the students’ typical experience such that they could not anticipate the outcome.” It seems that too often students rely on assumptions based on their own skills when facing decisions about good and bad design, especially when evaluating how easy or hard an interface is to use. By incorporating examples and assignments related to assistive technology, this bias is largely removed.

## **5.0 AT as Computer Science**

AT can be used as applied examples in many other classic areas of computer science, including:

- architecture (designing new devices, hardware interfaces such as USB and wireless mechanisms, innovative devices such as tablet computers, special purpose computers)
- operating systems (accessibility of the overall system, development of device drivers)
- languages (artificial languages for interaction, voice generation, language expansion)
- algorithms and data structures (word prediction, macro expansions)
- artificial intelligence (voice recognition, intelligent agents)
- web development (general accessibility issues for the vision and motor impaired)
- networking (wireless interfaces for consumer products and interaction devices)

For example, a recent paper by Steriadis and Constantinou [15], while clearly aimed at the HCI segment of computer science, also contains elements that would be at home discussed in other CS courses. For instance, the authors use finite automata to describe the behavior of certain input devices, and state transition trees for describing an encoding of a particular method of interaction. These elements could provide powerful examples within a course where automata are introduced. In addition, since there is extensive discussion of the hardware elements of the input devices (e.g. a press-release button, simple bi-state switch, bi-state switch that automatically repeats a process), this paper could also be useful within an architecture course. Finally, the authors discuss the selection of a specific programming language for the development of their system, which would be useful in a comparative languages course.

## **6.0 Social, Legal, and Ethical Issues**

The study of AT as computer science could also be used to help satisfy recommendations and requirements by professional associations and accrediting agency curricula in the area of social, legal, and ethical issues in computing. Both the Association for Computing Machinery’s curriculum model [1] and the ABET Computing Accreditation Commission requirements [5] contain specifications for including topics in these areas. Discussions about the impact the introduction of AT devices have on the lives of the disabled, the difficulties of device acceptance, and the complexities of working within the health care system to secure funding for devices are excellent examples for incorporating social and ethical issues into the computer science curriculum. And in America, as elsewhere in the world, there are numerous

laws that require employers and service providers to provide accommodations to those with disabilities.

## **7.0 Conclusions**

It is easy to demonstrate that assistive technology is a subset of the HCI field. However, HCI has been slow to incorporate AT directly within its domain, at least from a curriculum perspective. As a result, few HCI textbooks or courses include anything more than a cursory mention of AT.

Within computer science as a whole, there is even less attention paid to AT issues. However, it can be demonstrated that discussions of AT devices and techniques can be used as valid examples in a number of curricular areas that are considered core to computer science. It is the intent of this project to develop specific curriculum that will make it possible for faculty to include AT topics within their courses as excellent application examples of computer science principles. The intent of this effort is to provide computer science majors with sufficient background to provide basic computer and AT support services to people with disabilities, and to encourage them as computer professionals to become involved in future research and development of innovative devices and techniques to further aid that population.

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