PRINCIPLES OF UNIVERSAL DESIGN FOR ENGINEERING STUDENTS

Suzanne Keilson
mailto: skeilson@loyola.edu
Loyola University Maryland 4501 North Charles Street, Baltimore, MD 21210

The language and principles of universal design and accessibility represent an important shift in emphasis in design and design education. This has initially been most important for those designing homes for independent living for the aged and disabled and has had a broad impact in home design fields. Another area where accessible and universal design has made inroads is in web design for the visually impaired. Limiting the notions of universal design to those areas is too narrow. The primary goal of universal design is that attention to good design should represent an enhancement of every user's experience and should not be viewed as an addition cost to be borne by the designer and manufacturer. This paper will present a brief primer on what the primary principles of accessible design should be for every engineering student with an emphasis on recent challenges posed for accessible consumer electronic products because of the move towards sleek membrane touch interfaces that have inadequate tactile, visual or auditory feedback.

Key Words: universal design, accessibility, design education

Background

The population in the developed world is aging with expectations of longer life, a desire for continued independent living, and reduced expectation for help from family and relatives. There is also an expectation that a growing portion of this population will both face an increased dependence on consumer electronics, computers, mobile devices and so on, as well as an increased likelihood of visual impairment of some kind as they age. Similarly and perhaps even more importantly in a larger context is the expectation of a similar trend in an aging population in countries in the developing world like China that are also shifting from a traditional dependence on large, extended families to one-child families. As longevity increases and a desire to stay independent increases and traditional dependencies on children and family for aged members necessarily decreases because of cultural shifts as well as the demographic changes, we can only expect that the need for thoughtfully designed products of all kinds that lead to an enhanced experience for all users and a continued safe and comfortable independent existence will drive a very large global market for those products that take care with accessibility early on in all of their product development and design phases. So expected increases in longevity, increased desires and needs for independent living will be complicated by increased reliance on visually focused consumer and home electronics and the concomitant increased impact of visual impairments, especially those associated with aging.

It is interesting to note that this entire area has not been aggressively addressed by researchers, thinkers, designers, manufacturers of consumer and home electronics and appliances. Two related areas that have received more attention are in the specific issues related to web-accessible design for those with visual impairment and in the area of building, construction, home architecture, where accessible design for various mobility issues such as ramps, low countertops, modified showers and the like have seen successful commercial implementation. The success of features such as "curb-cuts" in urban landscapes can serve as a model from which to learn. They were first seen as an unnecessary additional expense imposed upon municipalities and then finally not just accepted but embraced by the entire population, especially for those who use strollers, bicycles, carts and so on; a totally unintended user-group that greatly benefited from the investment.

The Principles of Universal Design

Take from the work of the Center for Universal Design [1], the following was developed in 1997 by a group of architects, product and environmental designers and engineers. These principles were intended to guide a wide range of design disciplines and to be applied to the evaluation of existing designs as well as guide the design process and education designers and consumers. Universal Design is defined as "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design." This general statement is followed by the seven principles of universal design which are stated as follows [2]:

- Principle One: Equitable Use
- Principle Two: Flexibility in Use
- Principle Three: Simple and Intuitive Use
- Principle Four: Perceptible Information
- Principle Five: Tolerance for Error
- Principle Six: Low Physical Effort
- Principle Seven: Size and Space for Approach and Use

These principles are further explicated in the Center's materials, including a poster guide that is quite useful for presentation and display for students and design working groups. A 1998 paper presents the work of the center and universal design guidelines and evaluation criteria. It describes the process of developing the principles and provides examples of designs that satisfy each [3]. In particular it is principles three and four that would have the most direct bearing on work in the consumer electronics arena, an area that has not developed a tradition of using these guidelines as fully as the building, construction, and architectural communities have been forced to address issues surrounding design and mobility. Simple and intuitive use aligns with ideas for user interface design, especially as explicated by Donald Norman [4,5,6].

The National Federation of the Blind (NFB) and accessibility

The website for the National Federation of the Blind reads in part, "with more than 50,000 members, the National Federation of the Blind is the largest and most influential membership organization of blind people in the United States. The NFB improves blind people's lives through advocacy, education, research, technology, and programs encouraging independence and self-confidence. It is the leading force in the blindness field today and the voice of the nation's blind. The NFB has affiliates in all fifty states plus Washington D.C. and Puerto Rico, and over seven hundred local chapters." [7]

An important component of the work of the NFB has been their engagement with technology. The have worked with many engineers, including the inventor and designer Raymond Kurzweil, on his breakthrough Braille readers and recently have engaged in work on web accessibility and consumer education around accessible design issues. The NFB houses the International Braille and Technology Center for the Blind (IBTC) which was opened in 1990. This is an evaluation and demonstration center of adaptive technology used by the blind. The center contains speech and Braille assistive devices for use with computers. They have been a pioneer in working in the area of accessible ATM and voting machines [8].

Web Accessibility

Web accessibility has been an area that has been explored more robustly than other areas in the electronics and user design fields. There have been a number of legislative initiatives in the United States, Europe and Australia, including Section 508 of the Americans with Disabilities Act (ADA), which have both responded to the recognized need for persons with visual impairments to have ready access to information and commerce via the Internet. These initiatives, as is often the case with legislative fiat, have driven the work of companies and designers. Businesses have arisen to provide companies, schools and other organizations with the needed certification and more importantly with a meaningful evaluation of their website for accessibility. Tools have been developed for automatic Web accessibility analysis [9]. Some tools assist in a review of guidelines, a kind of check of whether or not the site complies with various aspects of the guidelines. The most relevant guidelines are the Web Accessibility Initiative developed by the World Wide Web Consortium (W3C-WAI) [10]. Automating that process is an ongoing and interesting challenge in software engineering. Other tools might assist in the analysis and critique of the overall structure of the website, a kind of "cognitive walkthrough" of its organization. No comparable push has really entered the more general consumer electronics market yet.

Project Outline

The project being developed at _____ consists of the following elements:

1. Engineering Education and Design Education. How can our undergraduates be best educated in considering issues of accessibility as they are learning the elements of engineering design?

2. Partnership with Manufacturers. How can manufacturers be best educated in considering issues of accessibility in their product design and development?
3. Prototyping a voice interface for a home consumer device (microwave oven). This will demonstrate to manufacturers and students elements of design and user interface as well as be a proof of concept for the economic viability of such devices.
4. Exploration of other user interface designs and modalities. A voice driven interface is not necessarily the only or best solution to the variety of interface design challenges faced by those concerned with making accessible products. This is especially true for the Deaf-Blind community. A rich area to explore is that of tactile interfaces and the general area of haptic interfaces.

This is still in its beginning phases, but we hope that it will provide a rich platform for on-going collaboration with a community partner and for student and faculty research and experience in current problems in user interface design and consumer electronics accessibility as a window onto the more general principles that need to be more fully articulated for a universal design for electronic devices. Materials might be developed to be used in undergraduate and graduate courses in computer engineering, software engineering, user interface design, and product development out of engineering, computer science and business departments.

The wide-spread acceptance of the IPod in the marketplace is an excellent case study of the challenges facing accessible design [11] when it becomes an afterthought and will require re-engineering of the product or after market add-ons. It has taken legal efforts to force even the beginnings of such change on the part of the manufacturer. Both for the Deaf and hard-of-hearing communities and the visually impaired the IPod can present severe usability problems and as that product is being adopted more and more in school and business settings as a way to communicate and deliver important information those organizations have to look at their overall compliance with ADA guidelines and perhaps put pressure on the manufacturer to reconsider design issues for the product. What adds to the challenge is the praise that a device like the IPod receives from experienced designers especially those who are visually oriented and like its large landscape and clean graphics. That is all good, but the touch interface is fundamentally flawed for the visually impaired and it would have taken little initially to consider implementing an auditory interface as well. There are problems with establishing hierarchies in audio interfaces, as anyone who has struggled with telephone menu options has experienced. The temporal realms and physical space require two different approaches to layout.

All of this can be extremely instructive for engineering and business students and represents unsolved challenges for the future. Part of the open and new challenge for the educator is how to introduce these concepts, projects, and even simulated experiences into the current design curriculum.

Alternate Interactive Modalities

A few words should be said about the challenges of various modes of input and interaction for electronic devices with their users. We have relied primarily on visual techniques and have developed some good design principles about feedback, mapping, color, contrast, affordances, sight and sound as ways to effectively communicate with a user about both the tasks that can be done, how the interactive environment of the device is can be explored, and feedback that a, presumably desired, action has taken place [4]. Sight and sound have been used for a number of years, but newer ideas around gesture and body movement capture, voice control, tactile control the two-way interplay of speech-to-text/text-to-speech, and more sophisticated forms of tactile feedback are just developing [12].

References

1. http://www.design.ncsu.edu/cud/

2. http://www.design.ncsu.edu/cud/about_ud/udprinciplestext.htm

3. Story MF. *"Maximizing usability: the principles of universal design", Assist Technol.* 1998;10(1):4-12.

4. Norman D., *The Design of Everyday Things*, 2002, Basic Books.

5. Norman D., *Emotional Design*, 2005, Basic Books.

6. Norman D., *The Design of Future Things*, 2009, Basic Books.

7. http://www.nfb.org/

8. http://www.nfb.org/nfb/Technology_Center.asp?SnID=52602704

9. J Abascal, M Arrue, I Fajardo, N Garay, J Tomás, *"The use of guidelines to automatically verify Web accessibility", Universal Access in the Information Society (UAIS),* 2004 3:71-79

10. www.w3.org/WAI/Policy/

11. http://www.pcmag.com/article2/0,2817,2338723,00.asp

12.Baumann K., and Thomas B., *User Interface Design for Electronic Appliances*, 2001 CRC Press.