TECHNICAL RESEARCH REPORT

Universal Usability as a Stimulus to Advanced Interface Design () -0.018723

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Universal Usability as a Stimulus to Advanced Interface Design

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Abstract:

The desire to make computing available to broader populations has historically been a motivation for research and innovation that led to new breakthroughs in usability. Menus, graphical user interfaces, and the World-Wide Web, are examples of innovative technological solutions that have arisen out of the challenge of bringing larger and more diverse groups of users into the world of computing. Universal usability is the latest such challenge: In order to build systems that are universally usable, designers must account for technology variety, user diversity, and gaps in user knowledge. These issues are particularly challenging and important in the context of increasing the usability of the World-Wide-Web. To raise awareness, we urge web designers to provide universal usability statements, to provide users with useful information about the usability of their sites. These statements can inform users and thereby reduce frustration and confusion. Further steps toward universal usability might be achieved through research aimed at developing tools that would encourage or promote usability. We close with five proposals for future research.

Introduction

The goal of universal usability is to enable the widest possible range of users to benefit from information and communications services. This goal is stronger than merely providing access, which focuses on technology availability and is often tied to access for users with disabilities. Universal usability implies that diverse users with varying language skills, knowledge levels, motivation, and computer hardware/software can successfully apply technology to get what they need in life.

The challenge to designers is enormous and therefore the goal of universal usability is a powerful stimulus to developing advanced user interfaces. Similar challenges have accelerated development of advanced user interfaces in the past. The early movement from assembly language programming to high-level programming languages enabled more people to write programs. This first transformation made programming accessible to meteorologists, chemists, economists, and others.

The second transformation, from command line systems, such as UNIX or DOS, to graphical interfaces, such as the Macintosh and then Windows, further opened the way for hundreds of

millions of people to apply computing technology. Students could compose resumes that looked professional, small business managers could accommodate the special needs of more customers, and amateur genealogists could collect vast family histories.

A third transformation came from the World Wide Web's capacity to provide rapid searches, and then immediate access to billions of pages of information. The underlying infrastructure and interfaces also supported easy access to email, chat, or instant messages for communications. Now grandmothers can communicate more easily with distant grandchildren, shoppers can get detailed car buying information, and neighbors can conveniently organize community events.

Each of these transformations involved technological advances motivated by the desire to overcome constraints that limited the accessibility of computing. The developers of higher-level programming languages conducted extensive research to provide programmers with powerful tools for complex projects and high performance for intensive computation. Similarly, developers of GUIs reduced the complexity of command-line environments while preserving the power of sophisticated computing environments. Conflicts between the limited screen space of GUI environments and the desire to rapidly move between applications led to the development of overlapping windows, tiled windows, and other window management schemes. In each of these instances, challenging requirements led to important advances.

As a result of these transformations, more people could get what they needed. The designers who listened to and identified user needs could respond appropriately and produce technology breakthroughs. In short, recognition of user needs in challenging situations is a stimulus for innovation.

Unfortunately users rarely recognize their future technology needs on their own. It's not as easy as feeling hungry or getting tired. Only a few dreamers in 1975 said they needed a graphical user interface, and only a few visionaries in 1985 said that they needed the Web. However, when creative designers identified that users wanted to manage small businesses and communicate with distant customers, they were able to create electronic spreadsheets, email, and a broad range of online services. Other designers listened to users and developed search engines, digital libraries, instant messaging, online communities, and more. These services genuinely empower users to get more of what they want in life.

And now there is the potential to take the next step and create the fourth transformation that will include a still wider circle of people and offer them still more potent tools to accomplish their goals. This fourth transformation begins with the recognition of the large numbers of forgotten users – those who have not yet benefited from the World Wide Web. Geoffrey Moore paints a compelling picture of the adoption of new technologies in his books: *Crossing the Chasm* (1991) and *Inside the Tornado* (1995). He describes the familiar process of innovators getting excited about novel technologies and successfully selling the idea to a limited number of early adopters. The chasm is the difficulty in reaching the much larger group, which he calls the early majority (Figure 1). The early adopters are visionaries who love something new and want to try out all the features. The early majority are pragmatists who want something that is reliable, proven, and solves a real problem for them.

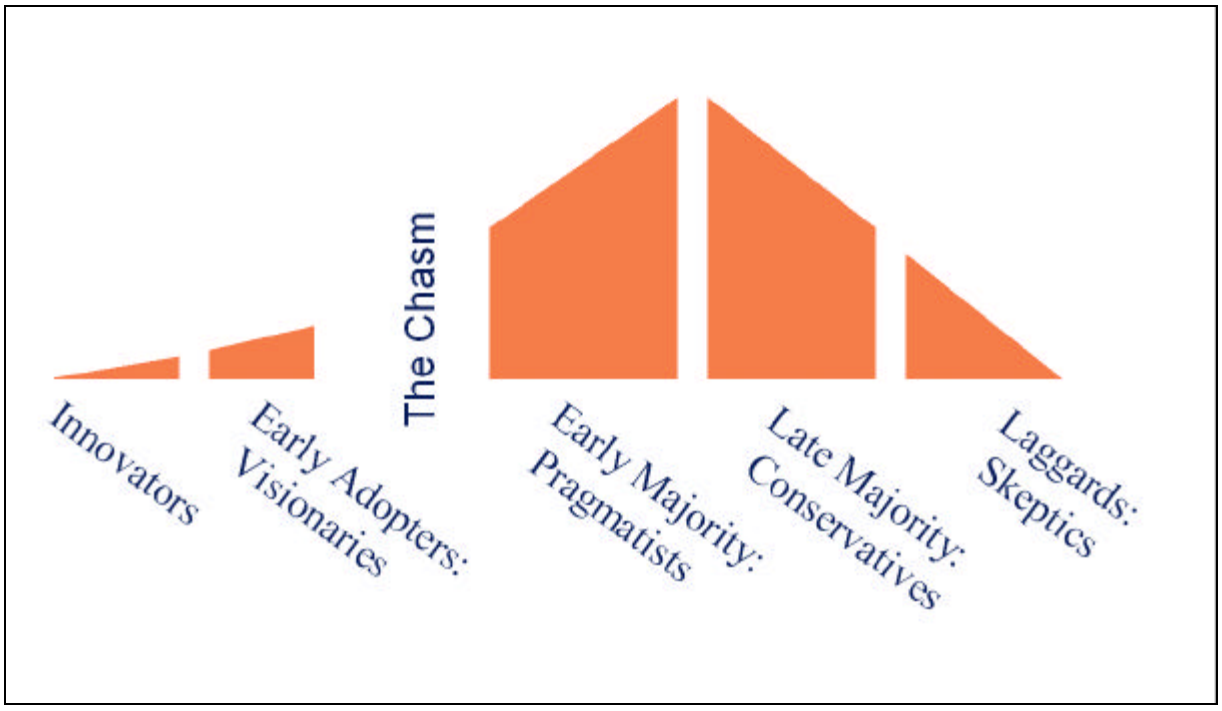

Figure 1: Geoffrey Moore's (1991) characterization of the technology adoption process.

Moore characterizes broadly used technologies as "Main Street" which is in harmony with the notions of universal usability serving the needs of every citizen. "Main Street" represents mature technologies that satisfy the needs of even the late majority. For products to be useful in Main Street they have to be reliable, easy to use, effective in diverse situations, and useful to a wide range of users. Moore reminds readers that "technology-based companies must make their peace with Main Street if they are ever to sustain prosperity."

In the computer world, the World Wide Web is today's "Main Street". As commercial, educational, entertainment, and government activities continue to shift towards the web, effective access to the web, and the skills and expertise necessary to feel comfortable using the web, will be prerequisites for full participation in modern society. Whatever the reason – lack of funds, inadequate education, or physical or psychological limitations, individuals who are not able to navigate through the tools and terminology needed to effectively use the Web will be "second-class" citizens.

The popularity of the web and computing has reached the early adopters and early majority, which makes up about half the population in the United States. Despite this impressive growth in computing use, people with low income and low education are less likely to be internet or computer users (National Telecommunications and Information Administration, 1999, 2000). In many other countries, internet and World Wide Web usage is much lower. Moore recognized two further communities of users: the late majority and the laggards. Technology innovators rarely think about the needs of these communities, but they now provide the largest opportunity

for growth in usage. The late majority are conservative users who are happy to continue in their current ways and do what they can to avoid using novel tools. The laggards are skeptics who are resistant to technology and often oppose its dissemination in organizations. They question the cost, the disruption, and the benefits. They often have excellent arguments with sound evidence, and serve a useful purpose by slowing implementation until technologies are refined enough for widespread dissemination.

Making peace with Main Street turns out to be a formidable technological challenge, as automobile manufacturers or phone companies discovered during the past century. Innovators created new materials with improved durability and performance, they improved designs to reduce learning time and error rates, and developed novel manufacturing techniques to kept costs low and quality high. Thousands of patents were issued to meet the rigorous demands for making peace with Main Street. One of the famous stories is the 30-year history of attempts to make an intermittent windshield wiper and Robert Kearn's battles over patent rights which led to a $10 million settlement with Ford.

We can expect the similar patterns of innovations in configuring the internet, World Wide Web, search engines, email, and other services to meet the needs of the late majority who live on Main Street. Even more creative breakthroughs will be needed to serve the laggards who will only become users when their high expectations of reliability and utility are met at a still lower cost. Once realized, these breakthroughs may have serendipitous effects that benefit the innovators and visionaries: strategies for compressing web content for low-bandwidth connections may be transferable to the challenge of providing access on the small displays of web phones and small portable devices (and vice-versa). For recommendations, resources, and best practices related to implementing universally usability web sites see http://www.otal.umd.edu/UUPractice, or the U.S. National Cancer Institute's usability site at http://www.usability.gov.

Three challenges to stimulate innovation

The innovators and early adopters are relatively easy to please with an innovation, because their focus is on the technology and less on the utility. This technology-driven approach can yield novelty, but the user-needs approach is necessary to arrive on Main Street. The challenge of universal usability will press designers to listen carefully to the most angry and resistant users, and to cleverly anticipate what these users need. Emerging theories of human activities and relationships may provide insight for innovators of products and services. More immediately, designers can focus on three challenges (Shneiderman, 2000):

(1) Technology variety: Support broad range of hardware, software, and network access (Figure 2).

The goal of making web pages more plastic - flexible for use in a wide variety of contexts - has been identified by many but responded to by few (Thevenin and Coutaz, 1999). The benefits of being able to take web content and convert it into many forms will substantially enlarge markets and audiences. In an ideal world designers would create web content in a display-independent

manner that would enable rendering in many forms and media, even ones that have not yet been invented.

For example, converting web pages designed for the typical 768 x 1024 pixel display into something that would be useful on a small portable device with 240 x 320 pixel still takes costly human intervention and rarely produces an acceptable outcome. The useful innovation of web browsers that reflow text as window sizes change, might be refined to handle narrower as well as wider displays. Could new hierarchical browsing techniques, zooming user interfaces, or fisheye methods be applied for this problem? What form of filtering of secondary information might reduce the screen space needed? Can software tools help content designers to write in headline, abstract, and full-length genres?

Display size is one common constraint, but others might be low-bandwidth network connections that would favor automatic visual compaction of images or text-only devices that necessitate elimination of graphics. Even when bandwidth is plentiful, the utility of graphics, animation, and applets is constrained by the scarce resource of the user's attention. Features that distract users without providing value may be usability problems if they detract from their experience.

Idiosyncratic implementations of standards present further challenges to universal usability. Generation of HTML that will work across a variety of platforms requires careful attention to details and avoidance of non-standard idioms that only function on some browsers. Similarly, email programs that send embed HTML tags make difficulties for users with text-only email capabilities or slow connections.

Gary Perlman reports on his exemplary project to develop an English, French and Spanish website for Windows and Macintosh, using Microsoft Internet Explorer and Netscape Navigator (Perlman, 2000). He also accommodated a range of screen sizes, network bandwidths, and printer formats. His software architecture, based on display independence, also enabled cell phone access and user-controlled customization. But the punch line to his story was that the software architecture also facilitated rapid revisions when management presented new system requirements, thus saving substantial time and money.

Converting text into speech is another commonly stated goal that benefits blind users, and also greatly expands access by making every telephone a web browser. There are many benefits to speech output but there are also disadvantages. Simple approaches to conversion fail to provide an adequate interface for users because speech is too slow, consumes short-term and working memory, and is too hard to scan and replay. Breakthroughs in solving these problems would be eagerly applied.

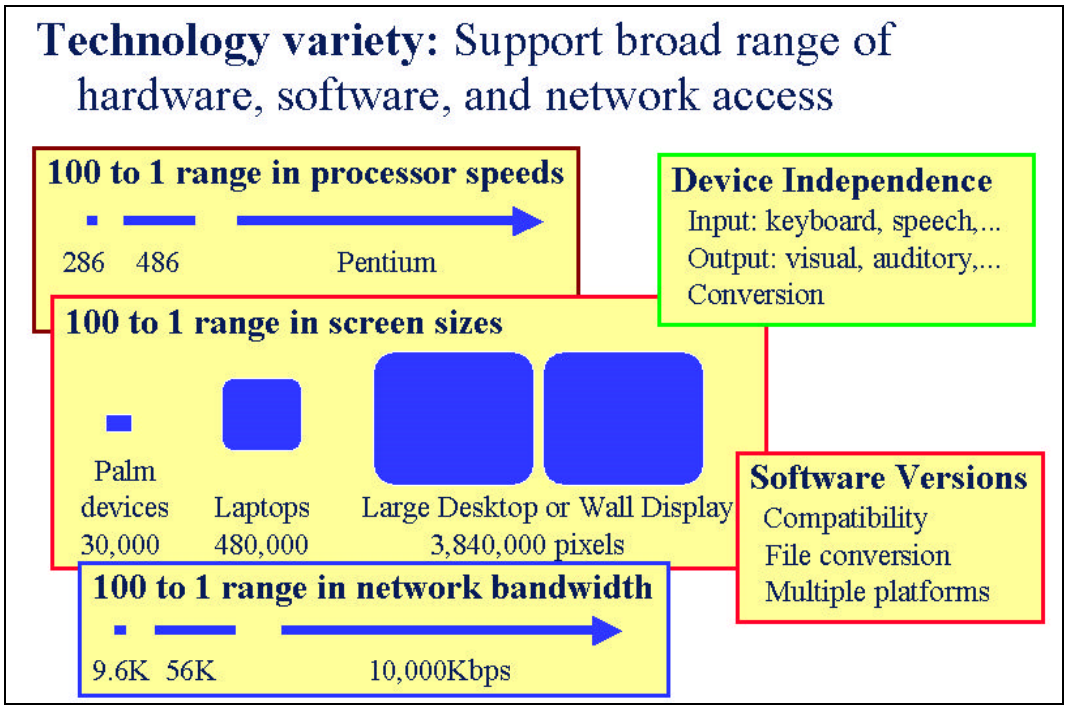

Figure 2: The first challenge is to cope with the technology variety by supporting the 100 to 1 range of hardware, software and network access speeds.

(2) User diversity: Accommodating users with different skills, knowledge, age, gender, disabilities, disabling conditions (mobility, sunlight, noise), literacy, culture, income, etc. (Figure 3).

Understanding the differences in users is another way that designers can get insights that lead to technology improvements and breakthroughs. Familiar examples are modifications to serve the needs of elderly users by increasing contrast, enlarging fonts, slowing dynamic displays, avoiding complex sets of simultaneous keypresses, and limiting short-term memory loads. Similarly the needs of young children who might be beginning readers, or have short attention spans can lead to innovations that benefit many users.

Ongoing efforts in the Web standards community illustrate some possible approaches to accommodating user diversity. The World Wide Web Consortium's (W3C) web accessibility guidelines (Chisholm, et al., 2000) can be used to build web sites that are accessible to users with varying abilities. The great interest in this theme stems from the legal mandate in the United States for government agencies to accommodate users with visual, auditory, and motor disabilities (Access Board, 2000).

Cascading Style Sheets (CSS) can be used to precisely specify layout, specify how documents will sound when rendered as speech, and otherwise increase the flexibility of web pages, while allowing users to override author style preferences (Jacobs and Brewer, 1999). In many ways, Cascading Style Sheets illustrate the challenges of achieving universal usability. This flexibility in layout and flexibility in customization provided by CSS hold great promise for users with poor

vision or color blindness, while offering web developers the alluring possibilities associated with greater control over layout. Unfortunately, CSS implementations that are not easy to use may be too hard for some users to customize, and standards that are only implemented in the latest browser releases may be inaccessible to users lacking the skills or computational resources to upgrade. Finally, browsers that do support CSS may vary in their adherence to the standard. Sites that use CSS will need careful testing to insure proper performance on different platforms.

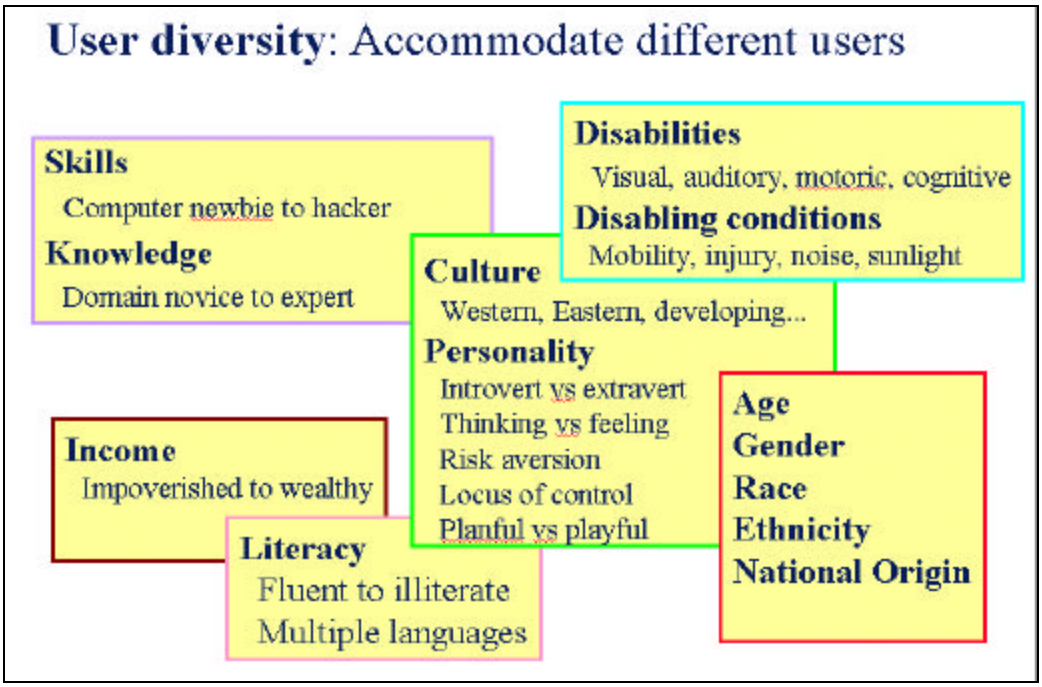

Figure 3: The second challenge is to accommodate the enormous diversity of users.

The central recurring problem of interface design is coping with first-time and frequent users in the same interface. First-time users need step-by-step guidance, meaningful labels, fewer choices, low short-term memory load, informative feedback, and meaningful metaphors. However, expert users want shortcuts, feedback on errors only, compact displays, more choices, and the capacity to create their own macros (Shneiderman, 1998).

Accommodating users from different cultures, who speak different languages, or have different social expectations, will also push the technology envelope. Expectations about turn taking, speaking publicly in angry ways, or the respect for privacy will dramatically influence participation in online communities, and eventually the design of the interfaces (Preece, 2000).

A difficult challenge is accommodating the needs of users with low self-confidence, low motivation, or hostility to technology. Making them comfortable in using email or search engines that still have incomprehensible error messages ('illegal data'), harsh metaphors ('process aborted'), or chaotic layouts won't be easy. These designs will have to be redone with controls to ensure that user experiences are empathic, supportive, and positive.

(3) Gaps in user knowledge: Bridge the gap between what users know and what they need to know (Figure 4).

No matter how knowledgeable you are about computers, the first time you use a new interface, you must bridge the gap between what you know and what you need to know. Sometimes the bridge is built with familiar metaphors and standard terminology, but often novel actions or objects require some learning. While email users may understand 'Reply' and 'Forward', they might be uncertain about the metaphoric distinctions between 'Certified Reply' and 'Registered Reply'. Another problem is inadequate knowledge of the problem domain such as the online stock trader who is confused by a 'Stop Loss Limit Order' or a 'Zero-Coupon Bond'. Other problems include complex sequences of actions, which are hard for novices to anticipate, and hostile or incomprehensible error messages, which appear when problems arise.

While progress in usability has been substantial in the past few decades, user expectations have grown faster. One survey of six thousand users by a California-based computer services company found that on average users spend 5.1 hours per week trying to figure out how to opearte their computers. Research progress in tutorial methods and online help has slowed in recent years, but the need to understand zero-trial learning design strategies is still great. Individual applications such as bank transaction machines have progressed and most users do succeed quite regularly, but frustration with many e-commerce websites and technology platforms is still great.

A level-structured approach in which users can set the level of complexity of the interface and the breadth of features is potentially helpful. Users could begin with level zero in which there are few menu choices, few error messages (preferably none), and clear guidance using a restricted vocabulary. Users would feel safe to explore and become experts at level zero before choosing to move on to levels 1, 2, 3.... The level-structured approaches have been successful when implemented, but designers are reluctant to pursue and refine these approaches (Carroll and Carrithers, 1984; Baecker et al., 2000). Could user interface building environments be more supportive of level-structured design?

In addition to trying to bridge the gap on their own, there is increasing attention to online services such as email or chat rooms for customer service help desks and listservs for discussion groups among users. Another effective but expensive approach is video/audio conferencing with shared workspaces for synchronous consultations (e.g. NetMeeting).

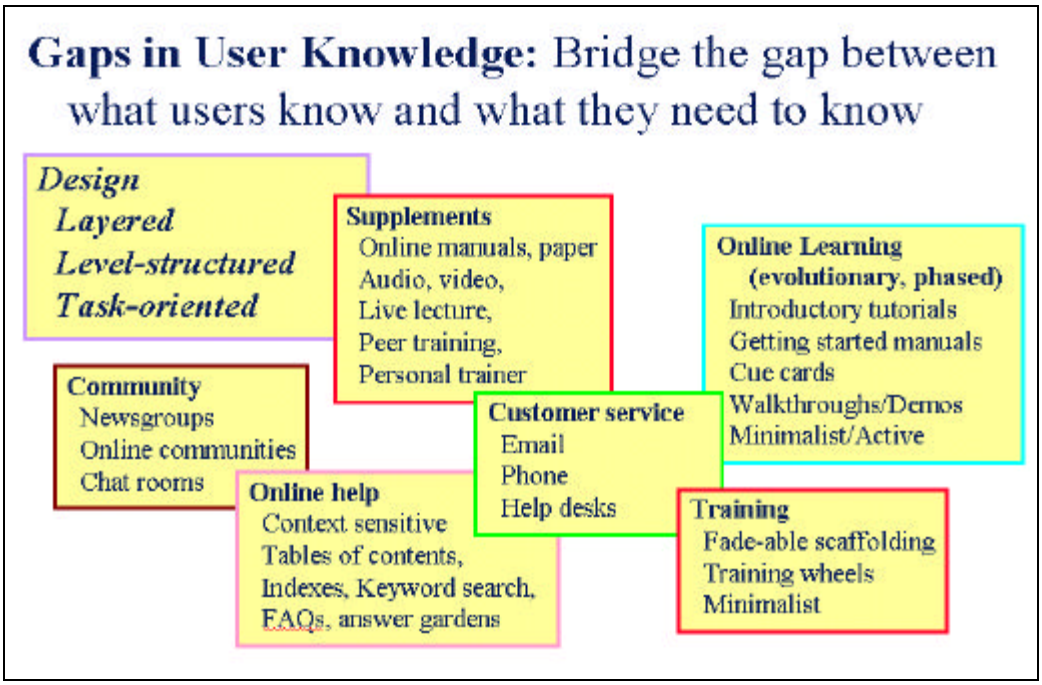

Figure 4: The third challenge is to bridge the gap between what users know and what they need to know.

Raising awareness through Web Universal Usability Statements

The World Wide Web is an obvious focal point for universal usability efforts. Despite its importance, universal usability of the web may be a challenging goal to reach. Since many ideas compete for research attention and commercial development, it will take some effort to make universal usability more visible. Too many users are complacent about the poor quality of user interfaces and blame their failures on themselves. Too many web developers perceive universal usability as too difficult to attain or they put other priorities higher. An impressive animated introduction to a corporate website still has high appeal for developers even if only a tenth of the users have the necessary plug-in and computing capability. A large eye-catching graphic produces a higher level of developer pride even if most users are frustrated because their slow network connections produce long load times. Eye-catching roll-overs or pop-up boxes may be sources of delight for developers even if blind, text-only, text-to-speech, or translation users can't benefit from them. In many cases, these extra features may not add anything useful to the user experience.

To promote research on the three challenges of technology variety, user diversity, and gaps in knowledge and to encourage commercial website developers to attend to universal usability will require a shift in public awareness. That shift will be successful when users complain that download times are too long because of excessive image size, that translation tools were crippled by a thoughtless design, and that mobile devices were useless because of poor website layout.

To begin the process of raising user awareness and to encourage developer pride in having accommodated more users, we propose that websites include a universal usability statement (Hochheiser and Shneiderman, 2001). Just as clearly written privacy policies provide users with an understanding of the privacy implications of a web site, universal usability statements will help users understand what they might expect in terms of site usability features.

We have developed a universal usability statement template (http://www.universalusability.org/about/template.html) that developers can use to create universal usability statements appropriate for their sites. This template contains entries for describing the usability measures in three main topic areas:

1. Software requirements: Browser and basic system requirements categories include operating system, browser software, and browser configuration requirements such as minimal HTML version, plug-ins required, browser versions tested, etc.
2. Input and Output: Input devices, display, audio/video, and network categories address the flow of control, information, and feedback between the user and the computer. Requirements for controlling the interaction, receiving the information from the browser (display and audio/video), and network bandwidth constrain the range of possible interactions.
3. Adaptations for user requirements: Users with physical disabilities, speakers of non-English languages, inexperienced users, and others often have particular usability concerns associated with their individual needs and abilities. Template items regarding access for users with disabilities, diverse users, and user support address these concerns.

For web surfers, these statements will become signposts, warning them of hazards due to display size expectations, software requirements, the need for optional browser plug-ins, or other usability concerns that could make a site treacherous for unprepared users. Fortified with the information in a universal usability statement, users can make appropriate decisions regarding which sites to browse. Faced with a statement indicating the need for a high-resolution display, users might forego visiting the site with a mobile device, preferring instead to wait until a desktop display is available. In other circumstances, users with low-bandwidth connections might opt to view web pages without images, thus avoiding the "speed limit" associated with complex graphics. In these cases and others, universal usability statements will help users understand the implications of visiting a site and plan their browsing accordingly. They can avoid the wasted time and frustration often associated with visiting sites that are less than universally usable.

Many users may not bother to read these statements, but their existence may prove useful for intermediaries who review and compile lists of relevant websites for user groups. Trainers, educators, journalists, and librarians may feel more confident in their recommendations if they have universal usability statements.

Web site operators and developers may also benefit from universal usability statements. Professionals who have worked to increase usability can use these statements to highlight their efforts, potentially making universal usability a selling point that can build visitor confidence in

the site and increase traffic. Developers of sites that are not yet universally usable can use the statements to warn users of any potential pitfalls. The reduced user frustration that may result from this information can build user trust and confidence while potentially reducing customer service costs. These statements can also act as usability "to-do lists", identifying areas of the site that should be revised or rebuilt to increase usability.

Achieving universal usability will be a gradual process. Due to the expense and difficulty of modifying existing web content, many sites will continue to have usability limitations for some time. During this time, universal usability statements can partially fill the gap between goals and reality. For many web sites, the universal usability statement template can be used to construct a statement in just a few hours. With this minimal effort, web site operators can establish themselves as being concerned about their visitors, while hoping to promote the vision of universal usability.

In some cases, these statements may describe aspects of the site that may decrease usability. Although some developers might be reluctant to explicitly acknowledge these limitations, we hope that the benefits to the users and developers will be sufficient justification for costs associated with these disclosures. Experience with the National Institute of Standards and Technology's Common Industry Format (http://www.nist.gov/iusr/) leads us to believe that standard approaches to usability reporting can benefit software producers and consumers.

Of course, these statements are just a first step towards universal usability. Ideally, these statements will encourage web developers to increase the usability of their sites, and researchers to develop methods and tools that can help in that process. Lessons learned from web universal usability statements will also provide valuable insight into increasing the usability of office productivity software, small portable devices, and other applications.

The next steps for a research agenda

Once user awareness and developer enthusiasm for universal usability has been increased, there will be a strong demand for improved software tools to support universal usability. We see five directions for research and new products (Figure 5):

(1) *Prioritized guidelines and automated web site analysis tools.* A variety of on-line tools have been developed for evaluation of web pages. Tools such as Netscape's Web Site Garage (http:///websitegarage.netscape.com) evaluate compliance with the HTML specification, download times, and other aspects of a page's design. BOBBY, a web tool provided by the Center for Applied Special Technology (http://www.cast.org/bobby), can be used to determine the extent to which a site is accessible to users with disabilities. Using the W3C's Web Accessibility Guidelines (Chisholm, et al., 2000), BOBBY provides an accessibility rating in terms of priority levels, along with suggestions for changes that can be made to achieve higher compliance levels. Developers of web site authoring software are beginning to incorporate similar capabilities for automated analysis. Macromedia's DreamWeaver is a widely-used tool that recently added accessibility-checking facilities (Macromedia, 2001).

Building on these tools, we can imagine automated analysis of web pages for universal usability. Development of these tools involves two main challenges: creation of a prioritized set of usability levels, similar to the W3C's web accessibility priority levels, and development of tools to evaluate pages with respect to the universal usability criteria. The first challenge is largely conceptual, involving judgments with respect to priorities (Vanderheiden, 2000). Development of appropriate evaluation tools may require further research and clarification. For example, what does it mean to say that a web site can be used on a small display, or with low-bandwidth? Must the entire site be usable, or just some subset of the functionality? These tools will never fully eliminate the need for subjective evaluations of some elements of web site design, but any assistance that they do provide will help lower the cost and effort associated with providing greater usability. For example, WAVE (Kasday, 2001) attempts to automate review when possible and facilitate human review in other cases.

(2) *Web page generators that simplify and automate the process of producing universally usable websites.* Many web pages and sites are generated with authoring or site management systems that help developers layout web pages, build templates that enforce a common look and feel, and coordinate pages that include dynamic content. These tools can play a significant and constructive role in web universal usability. Tools that support modularity and separation of layout from content can simplify the process of accommodating a range of users (Perlman, 2000). These tools can also encourage developers to take constructive steps such as providing alternate descriptions for images, while discouraging harmful practices such as using HTML tables for layout. Other possibilities include the use of cascading style sheets to separate web content from presentation while supporting user customization (Jacobs and Brewer, 1999). Tools that promote these good practices can have the desirable effect of reducing the real or perceived overhead of universal usability. If developers are building sites using preferred tools that just happen to support increased usability, the benefits essentially come "for free", without any cost to the developer.

(3) *Improved usability of customization tools.* For many users, universal usability means configuring software to work with their needs. Color-blind users who choose displays with colors that can be easily distinguished, speakers of right-left languages such as Hebrew or Arabic, or novice users who prefer less complex interfaces all engage in some form of customization. However, configuration tools that provide the necessary level of customization are often complex and inaccessible, buried several levels deep in menus and dialog boxes. Universally usable customization tools would help users find the options that are appropriate for their needs, without having to wade through complicated configurations or settle for something less than ideal. To help users easily transfer usability configurations from one machine to another, a standard universal usability profile format might be established. By encoding a user's preferences in a machine-readable format, this profile would insure that the user's preferences were available on any machine, from hand-held phone to full-size desktop.

(4) *Improved guidelines, methods, and models for usability testing.* Testing for universal usability involves significant challenges, expense, and uncertainty. How many users are needed? From which populations? These questions do not have any simple, obvious answers, as needs and requirements will vary with the technological variety, user diversity, and gaps in user

knowledge, as described above. Models, tools, and criteria that can be used to reduce the cost and complexity of conducting thorough usability evaluations are needed.

(5) *Extending universal usability beyond the web.* Office productivity applications, email clients, educational software, games, chat programs, professional software, and desktop operating environments are just a few of the computer applications that could benefit from universal usability. Even users with years of experience struggle with features of complex software. Microsoft and Apple have made great strides in making windowing systems accessible to individuals with disabilities, but there is still much more that can be done for these and other groups of users. Building on lessons learned from efforts like the W3C's Web Accessibility Initiative, the long history of user interface design guidelines, and ongoing work in universal usability, researchers can develop techniques and methodologies that make universal usability apply to all of the computing activities of all users.

Research Agenda for Universal Usability

(1) Prioritized guidelines and automated web site analysis tools.

(2) Web page generators that simplify and automate the process of producing universally usable websites

(3) Improved usability of customization tools.

(4) Improved guidelines, methods, and models for usability testing.

(5) Extending universal usability beyond the web.

Figure 5: Research Agenda for Universal Usability

Closing

Developers of e-commerce, e-learning, e-healthcare, and e-government applications are well aware that they must design software and websites that are universally accessible. To reach broad audiences requires reliable, comprehensible and useful designs that serve the needs of the broadest possible set of users. By attending to the needs of diverse users, researchers and developers will create breakthrough technologies.

For example, if users want mobile navigation systems with detailed local information on small displays, then designers must be much more careful than designing for desktop machines with large displays and fast network connections. For designers to send useful maps to portable devices requires innovations such as interface designs to help users request only maps that they need, careful caching to preserve re-usable data locally, and customized data compression to reduce the amount of data. Adding requirements to perform this task in a foreign language or for a blind user increases the challenge. Further requirements to do this in bright sunlight, in total darkness, or under condition of intense vibration adds even more complexity.

One of the lessons of universal usability projects is that diversity promotes quality. The challenge of designing for experts and novices, English and non-English speakers, low-motivated users, users with disabilities, elderly users, or children promotes creative thinking that leads to better solutions for all users.

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