

Abstract

Accessibility improvements that can be made to rich web based media applications are discussed. Intensive background along with a controlled experiment was used to gather both qualitative and quantitative data on how to increase accessibility, particularly for internet ready 3D imaging software. Using the data gathered, a set of recommendations is proposed with the aim of helping developers create accessible rich web based media.

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3D IMAGING FOR PEOPLE WITH DISABILITIES

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Introduction

The Internet has changed the way people live by bringing seemingly limitless amounts of information to our fingertips. Now, it is often unnecessary to leave the comfort of our homes in order to take advantage of countless services, such as those associated with shopping, banking, and corresponding with others. Unfortunately, millions of people are not able to reap the full benefits of the Internet because of physical and cognitive impairments. Disabilities, such as poor vision or motor skills, coupled with a lack of accessibility-minded Web development have hindered many individuals from achieving the greatest gains and satisfaction online.

Our present day culture is becoming a technology-hungry animal, and many crave new capabilities, higher efficiency, and smaller, more impressive designs. Devices of convenience, such as PDA's, notebook computers, and cellular telephones, have taken their place in society as a means of speeding up business and communicating with others regardless of location. And like these, the Internet has won its share of stock in our lives. Many of us rely on it daily for keeping in touch, paying our bills, and getting work done. Like the explosion of the popularity and commercial use of the typewriter in the mid-1950s, computers and even the Internet are becoming not simply sources of convenience, but indispensable tools, with which one is expected to be proficient, particularly in the business world.

Just as commercial businesses have found extensive uses for Web-based information systems and technologies, governmental institutions have adopted them as

well. This has led to much legal debate, which has resulted in legislation forcing all government (and government funded) institutions to make their websites and IT systems accessible to everyone, including those with disabilities (Section 504, 1973). There has also been disagreement over the definition of “public accommodations,” and whether the term should be expanded to include public websites. If this were to happen, developers would have to make drastic changes to their Web environments in order for them to be accessible to all.

Aside from its uses in business, the World Wide Web (Web) has attracted many young adult users with online communities and dating services. Society has seen a reshaping, which has resulted in a change in public thought towards technology. The activities of communicating and even initiating relationships online have not just become acceptable, but mainstream. However, the Internet’s audience is not restricted to the young. In fact, over the course of the last few years, the rate in growth of new elderly online-goers has surpassed every other age group. Furthermore, many individuals from the “Baby Boomer” generation, who have come to rely on the Web since its birth, are now becoming older. The shift in the average age group of Internet users from young to old is so apparent and significant, it has been referred to as the “graying of the Internet” (Morris, 1996). This is proving to be a very problematic effect, because as people age, they generally gain common disabilities, such as poor eyesight and a restricted range of motion. In addition to the aging “Baby Boomer” generation as a source of growth in the percentage of people with disabilities (PWD) using the Internet, there has also been growth because of medical advances. Less and less babies afflicted with physical disabilities are dying as a result of improvements in medical science. Currently, the

online world is not equipped to accommodate the influx of users with disabilities, and as a result, their Internet experience is often limited at best.

There do exist many physical devices and software tools that allow PWD to interface with their computers. There are screen magnifiers for those with visual impairments, head-sticks and special keyboards for those with mobility restrictions, and trackball mice and low-contrast screen settings for people with cognitive disabilities. However, these devices do not always aid individuals with disabilities in navigating the Internet, especially specialized Web applets found online, such as those designed to demonstrate 3-D product models.

One developer of 3-D Web applets, Kaon Interactive, is concerned with making their software usable by PWD. To meet that end, this project will research the usability and accessibility of Kaon's software for people with various disabilities. First, the most affected disabilities must be identified. Physical disabilities, such as poor vision, limited motor skills or range of motion, and deficiencies in the upper and lower extremities will be tested. The success of a user's experience with the product will be related to five distinct categories of usability: ease of learning, efficiency of use, memorability, error frequency and severity, and their overall subjective satisfaction. Second, after research and testing is completed, applets were developed and modifications were implemented to the software that will improve usability among people with disabilities. Finally, guidelines are constructed to advise Kaon and other developers in creating 3-D Web applets that are accessible to a greater percentage of the population. We plan to fulfill this need by identifying relevant disabilities that must be addressed, developing hypotheses and research methodology, conducting qualitative and quantitative testing, and producing

conclusive recommendations. The following sections of this report constitute our review of current literature on the subject, suppositions of problems encountered by PWD when dealing with 3-D Web applets, implementation and testing plans, and finally, analysis and conclusions based on our test results.

1.1 Project Background

A leader in rich media presentation on the Web, Kaon Interactive, is endeavoring to improve accessibility and usability on the Internet with their applet designs by sponsoring this project. Our primary contact with Kaon Interactive is Chief Technology Officer, Joshua Smith. Mr. Smith communicated Kaon's primary goal for this project to the project group. To understand more about the work that will be done, it is important to learn about Kaon Interactive and what it does. Based in Maynard, Massachusetts, Kaon develops 3-D product models and the software that allows them to be displayed on Web pages. Its clientele includes well-known companies such as Fisher-Price, Dell, Sony, and Ricoh (Kaon Interactive About Us, 2004).

The software allows 3-D models to be viewed at all angles and provides options for demonstrating the product's features. A sample from Sony's website can be seen in Figure 1. The model layout is very similar for the websites of other clients. There are two main sets of controls. One set is similar to a menu that contains a list of the product's features (seen in Figure 1 on the left). When a feature is selected from this menu, the three-dimensional model performs a demonstration of that feature. The other set of controls allows the user to manipulate the view of the product. As can be seen in Figure 1, the options include zoom, turn, move, measure, and reset. With all of those options, a typical user can manipulate and view the product nearly any way they wish.



Figure 1: 3-D Applet by Kaon

Kaon’s software is built on the Java platform, which allows small programs, called applets, to be embedded into Web pages. Kaon uses its own suite of interconnected technologies called “Meson” to interpret an object oriented programming language into commands used in the Java runtime environment. The company uses this proprietary language for the purpose of displaying 3-D content using Meson technology. The specifications of this language can be found at <http://www.kaon.com/docs/language.html>. An open platform such as Meson will make modifying the applets designed to accommodate PWD an easier task because documentation is provided to guide the modifications.

1.2 Project Goal

The goal of this project is to present solutions for problems that PWD may have using the 3-D software. This project will research what modifications could be made to Kaon's software, if those modifications are beneficial, and whom they would benefit. Another area worth researching is how PWD use their computers. Questions to be answered include is there any special hardware or software technologies PWD require and if so, what is their impact on the users' Web browsing experience. The answers to these questions will form the basis of our hypotheses.

In order to perform this research, it will be necessary to evaluate Kaon's current software as well as the changes that are made to it during the course of the project. By combining the most common features found in the current forms of 3-D Web display models, a sample will be developed for testing. Modifications will be made to this sample based on the hypothesis developed. Both the sample of current software and the modified versions will be tested. The testing will need to be performed by PWD most affected by these software modifications. These people include those that use special devices to assist them using a computer and those that have visual impairments. Testers, as well as information and guidance, will be obtained through two organizations: TecAccess and Easter Seals.

2 Literature Review

In order to identify relevant disabilities and appropriate methodologies, we conducted an extensive literature review which we present below. We begin with an examination of the ever-growing role of the Internet, and how the need for advancements in online accessibility is becoming increasingly important.

2.1 The Importance of Web Accessibility

Companies like Kaon Interactive are beginning to confront the issue of Web accessibility. Kaon is interested in making changes to their software so that it will benefit the greatest number of individuals in the ever-expanding World Wide Web. By making complete accessibility a goal, they are not only taking the role of an industry leader, but also situating themselves to benefit financially by increasing their potential sales audience. The Internet is no longer a place attracting exclusively the young or the technically savvy. Improvements in computer technology and interconnectivity are not only pushing more people online, but also, creating an increased dependency on the services provided by the Internet. This growing reliance on Internet services, as well as changes in the online age demographic and to our culture as a whole, has made Web accessibility a vital concern.

2.1.1 The Role of Online Services

Among the factors bringing Web accessibility to the forefront of public attention are the changes being made to the way that the Internet is used as a commercial device by businesses. When the Web was first expanding and large companies were just beginning

to stake claims in cyberspace, many of them were using Internet-based services as an addition to those services already provided by their physical establishments. For example, popular banks, such as Fleet and Sovereign, began offering online banking tools, but for the most part, these systems saw limited use. This was either because the general public was not aware of the existence of such online offerings, or people were simply suspicious of the security and protection available on the Web. Currently, “net banking” is provided as a convenience that works in conjunction with the physical bank. All of the most common banking functions are possible without leaving the home, but under certain circumstances, a customer must actually make a trip to the local branch. Banks are actually pushing the use of these new systems because they are faster and relieve some of the load on human tellers, allowing banks to operate with a smaller staff. In the future, banks and other companies will potentially shift their entire business online, or to such a great degree that visits in person would become uncommon. This can be seen already with companies such as the Digital Credit Union (DCU). The shift in the role of the Internet in business is making it necessary for changes to be made to Web environments. If businesses want their clientele to take full advantage of their online services, they must consider their customers with disabilities and create websites that are as easy to navigate as their physical counterparts.

2.1.2 The Baby Boomer Generation

Another factor necessitating leaps forward in the arena of Web accessibility is the issue of the aging Baby Boomer generation. This should not be surprising as this group of individuals has acted as the stimulus of change for many areas, including health care, social security, and trends in the economy (Isidro 2004). In 2000, people 65 years and

older comprised 13 percent of the United States population, but by 2050, this number is estimated to jump to 22 percent. And even more drastic are the numbers of those in the 80-plus age bracket – a population that will have increased as much as 10 times from 1950 by the year 2050. Our society is in a maturing state, as 41 percent of U.S. citizens will be above the age of 45 within 15 years. It would seem that the youth population (those less than 20 years old) is exploding, but in fact it is shrinking, and will drop to 22 percent from today's 29 by 2050 (Isidro 2004). This is a very serious matter when considering that as people age, they tend to accrue more physical and cognitive disabilities (see Figure 2 and Figure 3). This truism can be seen statistically, as those who fall within the 50-plus age bracket constitute over 62 percent of American individuals with disabilities (NTIA 2000). Therefore, as the Baby Boomer generation grows older and pushes the average age of Americans up, the percentage of PWD will jump. With respect to the issue of Internet accessibility for PWD, these numbers may not seem significant; however, this is only because most operate under the assumption that the Internet is largely a playground of the young. In actuality, Americans born before 1964 hold the most rapidly-growing presence on the Web. In a single year (2003), the number of Americans using the Internet who were 40 years and older grew by 25 percent (NewTechMedia 2003). Not only had the Web's aged population shot up faster than that of the "Internet generation" (young people who grew up with the Internet), but they are going online more frequently, staying longer, and clicking through more websites. Remarkably, Figure 4 and Figure 5 show that 23 percent of people with disabilities aged 50 years or older are using their computers on a regular basis and about 25 percent have Internet access in their homes (NTIA 2000). Seeing that Ebay, PointCast, and

previewtravel.com are among their favorite sites (based on either total browsing time or views per month), online businesses should not take the above figures lightly. The 50-plus age bracket is a great target for Web advertising because they generally have a large disposable income and more time to surf. Within a tested month, they surfed 19 percent longer than all the other Internet users combined (NewTechMedia 2003).

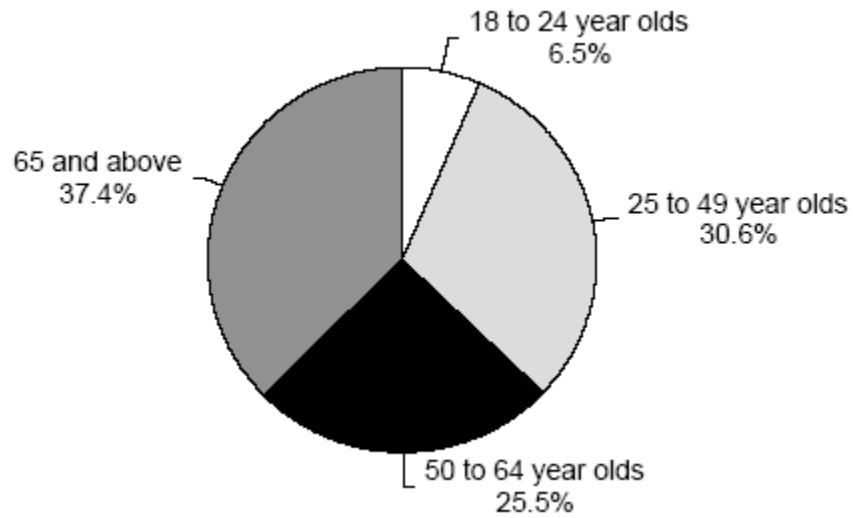


Figure 2: Age Distribution for PWD

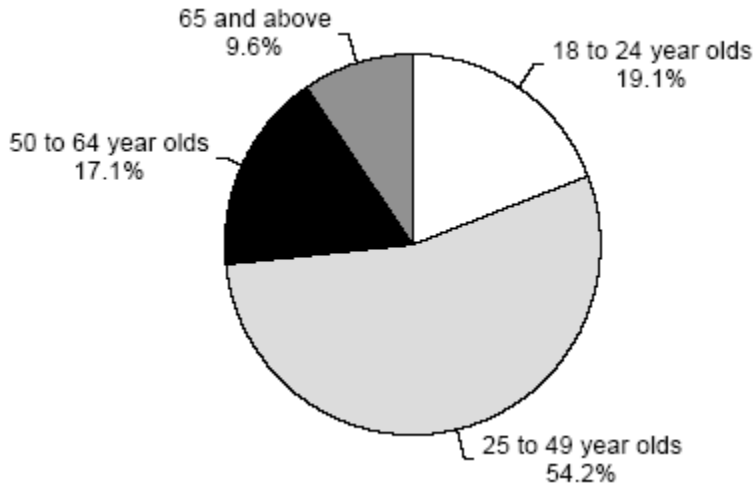


Figure 3: Age Distribution for People Without Disabilities

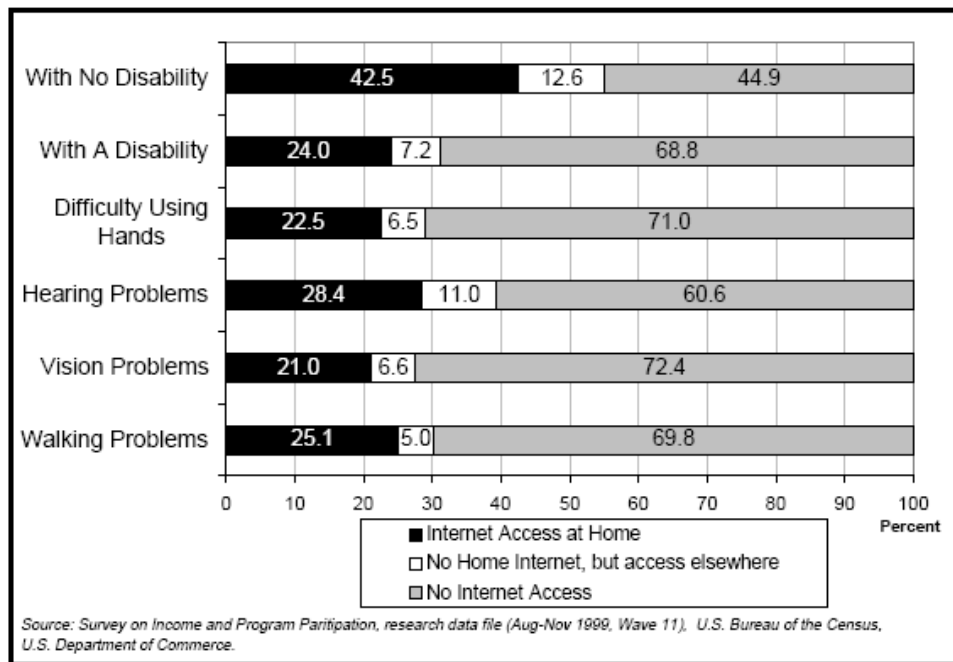


Figure 4: Internet Access among 50-64 Yr Olds by Disability (1999)

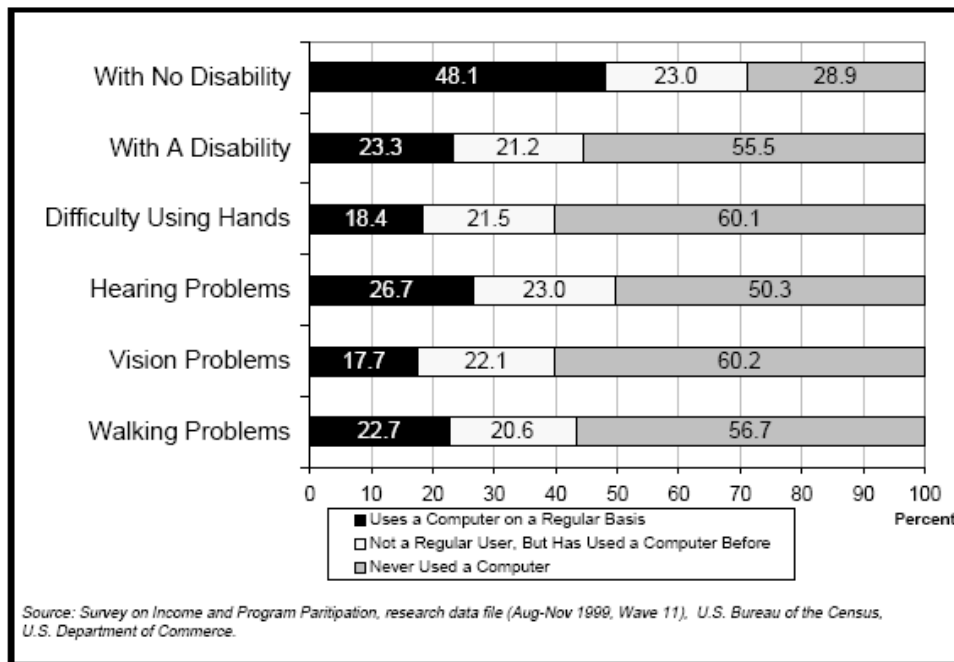


Figure 5: PC Use Experience among 50-64 Yr Old by Disability (1999)

According to a survey taken in the United Kingdom by BTopenworld, there are several important reasons that draw older people to the Internet (BBC Online 2003). The chief motivation is to maintain correspondence with family and friends. Many also report using the Internet to feel more at ease with modern society and to become more accustomed to and accepting of the way the world is changing. Older people enjoy the ability to expand their circle of friends and open themselves up to new and exciting experiences. But most important perhaps to Web retailers is their interest in using the Internet to shop and save money, all while enjoying the comfort of their own homes. In fact, the 45-to-64 age group went online an average of 6.3 more days a month than the 18-to-24 bracket and visited 150 more unique pages, which is big news to advertisers (Media Metrix 2003). The “graying of the Web” could very well mean an increase in overall online spending, and ads targeting these aging Americans could equal big bucks

for retailers. In fact, in 2002, seniors spent \$16.7 billion online, “[accounting] for 21 percent of total e-commerce spending in the United States” (eMarketer’s eUser & Usage Report 2002). However, profits will not be lifted to their full potential unless commercial sites begin to take serious steps in making their sites accessible to all. Common disabilities such as poor eyesight and limited motor skills will lead to great losses in sales for those who do not provide accessibility-minded interfaces.

2.1.3 The Emergence of the Cyber Culture

A third factor that is creating a shift in social communities from the physical world to cyberspace is the drastic change taking place to our culture as a whole. We are becoming a very technologically reliant society enjoying the benefits of our flat screen TVs and our cell phones. Many people rarely leave the house unless they are equipped with their Personal Digital Assistants (PDAs) or cell phones, devices which allow fast communication with others via text messaging, voice, or email. The Internet is becoming infused with our culture, as we are exposed to it daily at work, school, or in TV advertisements. It is becoming “hip” for young people to have experience with the Internet and to be part of the online community. Many socialize in message boards or forums, correspond with friends through email, and seek membership in special interest groups. Using the Internet as a means for finding compatible people and initiating dating relationships has achieved social acceptance. For PWD, the development of cyber cultures and communities could mean great things. Whatever self doubt a person experiences in the physical world, online they can find acceptance. There is a great feeling of inclusion online. Those suffering from speech impediments can communicate easily with others using text messaging or email. People bound to wheelchairs or

individuals who have trouble walking may have difficulty going to clubs or other social venues, but they can now meet friends online and use dating websites to initiate relationships. Not surprisingly, nearly 40 percent of Internet users aged 16-24 have a disability, and about 36 percent from the same age bracket are Internet users with some sort of learning disability such as ADHD (NTIA 2000). Teens with ADHD (or displaying ADHD-inattentive symptoms) comprise between 3-5 percent of the youth population (Woods 2003). In Figure 6, there is a breakdown of various common disabilities, and among those, the percentage of each who uses computers on a regular basis. Within the 25-49 age range, which contains a significant number of individuals actively seeking new relationships, there is a large percentage of PWD who use their computers regularly – more than 1 out of every 3, in fact. Out of those with learning disabilities, 30 percent frequently go online. Over 32 percent of people with motor deficiencies in their hands, and over 30 percent with vision impairments browse the Internet on a regular basis (NTIA 2000). All three of these types of disabilities could require specific Internet accessibility features. Online businesses, such as Web dating services and community forums that strive to appeal to the greatest number of individuals in order to amass a large number of users, should make steps to design accessible sites. These online hotspots are highly attractive to the disabled as they provide means of interacting with others and meeting new friends or love interests. As inclusive communities in nature, these websites should open their doors to all by design.

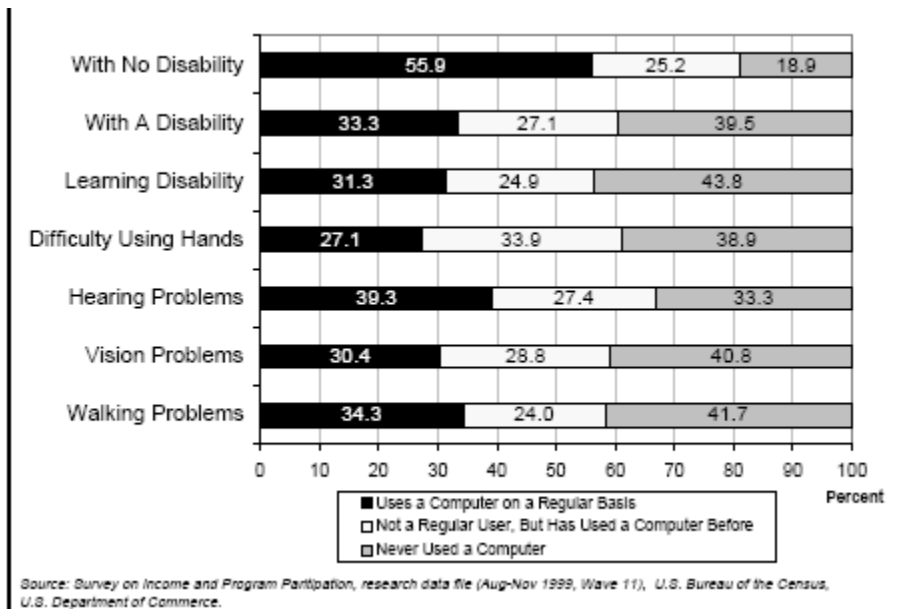


Figure 6: PC Use Experience among 25-49 Yr Olds by Disability (1999)

2.1.4 Accessibility and the Law

Just as certain societal changes have pressured companies to consider accessibility in their Internet ventures, so have certain legal developments. Today, accessibility for PWD continues to be a hot topic in the legal arena, and many big questions have yet to be settled. At the center of much of this controversy is the question of how the Internet should be defined in terms of legislating mandatory accessibility standards. In the past 15 years, there have been several milestone pieces of legislation that have at least partially dealt with this issue. Most notably, various amendments to the Federal Rehabilitation Act, specifically Section 508, as well as the Americans with Disabilities Act of 1990.

Section 508 of the Federal Rehabilitation Act of 1973 addresses the issue of accessibility of information technology that is created by, or for use by, federal workers. The amendment, passed in 1998 by President Clinton, mandates that all information

technology that federal agencies “develop, procure, maintain, or use” is accessible to both the general public as well as to federal employees. Section 508 defines information technology as any “equipment or interconnected system or subsystem of equipment that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information” (Section508.gov, 2004). The legislation goes on to specifically include “computers, ancillary equipment, software, firmware and similar procedures, services (including support services), and related resources” as information technology (Section 508). The enforcement of this legislation is the charge of the Federal Access Board (<http://www.access-board.gov>). While the amendment certainly has resulted in higher levels of accessibility in today’s society, its enforcement is limited to government agencies, and thus does not directly apply to private organizations and establishments. However, it does mean that all government websites are required by law to be accessible to PWD.

Another amendment to the Federal Rehabilitation Act, Section 504, requires that no one with disabilities “be excluded from the participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance” (Section 504, 1973). This applies immediately to all public schools, including colleges, as well as to private schools who receive federal funding. Section 504 results in a push to have a school’s curriculum be either as accessible as possible, or to provide a reasonable alternative to the inaccessible content.

While Sections 508 and 504 relate to the government’s usage of information technology, there exists legislation that deals with accessibility in private life as well.

One such law is the Americans with Disabilities Act (ADA) of 1990, which was passed by President George Bush. The ADA prohibits discrimination against those with disabilities in employment, state and local government, public accommodations, commercial facilities, transportation, and telecommunications. The key reason this law plays a role in determining accessibility as it relates to the Internet is it requires that public accommodations must be made accessible. In 1990, the term public accommodation was written as a means of requiring actual physical locations, such as hotels, to be made accessible.

However, now there is much debate, and even a few lawsuits, on whether or not inaccessible websites and online services violate the A.D.A, on the grounds that the Internet is a public accommodation. One such in 2002 involved a legally blind man, named Robert Gumson, who sued Southwest Airlines on the grounds that it was very difficult for him to use his text to speech software on their website, impeding him from getting the best rates, which were offered exclusively online. The case ended when U.S. District Judge Patricia Seitz found that Southwest's website did not qualify as a public accommodation and threw out the case. While Mr. Gumson had little luck with the outcome of his case, there have been some more encouraging developments as well. In 1996, Assistant Attorney General Deval Patrick wrote a letter to a Senator stating that the ADA could apply to websites. Additionally, many companies have found that, when faced with potential lawsuits, the cost of accessibility has been less than the cost of a lengthy court battle and the associated bad public relations. This was exactly the case when the National Federation of the Blind (NFB) brought suit against America Online (AOL) in 1999 for failing to be accessible to people with visual impairment, in violation

of the ADA. AOL and the NFB eventually settled the case out of court a year later, and no ruling was made on the issue.

The settlement sought by AOL also demonstrates another reason that companies wish to pursue accessible products; to avoid the negative public relations. Refusing to make a product or service accessible could be viewed by many as intolerant or as a violation of the ADA. Whether this sentiment has the support of the law or not, companies must carefully consider public sentiment when deciding to undertake the effort and expense of becoming accessible.

Concluding, certain pieces of legislation, such as the ADA and Section 508, set the framework for making accessible Internet content a legal requirement of doing business. The ramifications of these two sections of the Federal Rehabilitation Act to Kaon is that for their product to be used by the federal government or by an organization at least partially funded by the federal government, it must be accessible, or at the least have an accessible alternative. In addition, much more debate, and possibly more legislation, is likely to come as more and more legal issues regarding Internet accessibility arise. Undoubtedly, as time passes more of the open issues will certainly be resolved in the courts. Until that time comes, however, the legal requirements for accessibility on the Web, at least for private organizations, remains vague and questionable. As a result, companies may feel pressed to provide accessibility now, rather than face the costs later in a lawsuit.

2.2 Existing Accessibility Devices

Both society and government have been pushing companies to develop accessibility devices for computers. A large industry of accessible technology (AT) manufacturers has evolved. The manufacturers develop products to assist PWD with their problems interacting with the computer. These problems can be easily grouped into three separate categories: providing input into the computer, recognizing and understanding the computer's output, and reading supporting documentation that is available for the programs or devices they wish to use. Both hardware and software tools have been created to assist people with such problems. For people with mobility impairments, physical accessibility devices have come a long way to improve their computer interaction experience.

2.2.1 Physical Accessibility Devices

Mobility impairment is the leading cause for physical accessibility devices, which range from restructured keyboards to eye-tracking technology. One popular device that is available for computer users who have limited to no mobility with their hands is the mouth/head-stick keyboard. A stick is attached to either a mouth piece or a forehead strap and is used in conjunction with a specially designed keyboard. Many of the common letters are grouped in the center of the keyboard, which minimizes the movement of the user's head in an effort to relieve some of the strain that is associated with these types of devices. The ALT, CTRL, and SHIFT keys are also configured as toggle keys since the user cannot press more than one key at a given time. Since these keys are relatively far

away from the letter keys, combinations of CTL, ALT, and letters leads to stress for these people. An image of a young boy using the head stick is shown in Figure 7.

Another type of keyboard that is available for people with mobility impairments are one-handed keyboards. One-handed keyboards have a similar layout to the keyboard are illustrated in Figure 8. Many of the letters are placed close together to provide for easier use and less strain, and the device has a curve for ergonomic benefits. The number pad and function keys are on a different side and is intended for separate use since it may be difficult for a person using this keyboard to quickly switch between the number pad and the alphanumeric keys.



Figure 7: Child Using Head Stick¹

¹ TELEMATE Demo Pro; <http://www.fernuni-hagen.de/FTB/telemate/demo-crs/pictures/headstck.jpg>



Figure 8: Keyboard used in conjunction with mouth/head stick (Maltron, Inc)²

Keyguards and expanded keyboards are other devices that assist PWD. While their range of motion may be unaffected, some people with mobility impairments have a difficult time with precise finger movement. To avoid hitting many keys at once, these devices can be placed on the keyboard to separate each key (Figure 9). At the other end of the spectrum, some people may have a limited range of motion, yet very precise control of their fingers. A miniaturized keyboard is available for these people to avoid expansive hand movements.

² Maltron Inc, <http://www.maltron.com/images/press/maltron-mouthstick-keyboard1.jpg>



Figure 9: Expanded keyboard with key separation (Maltron, Inc)³

Trackball mice are one of the most common assistive devices in use today. With extensive periods of computer use, some people develop Carpel Tunnel syndrome. People that are affected by this syndrome may experience sharp pains when using a regular mouse. The trackball mouse eliminates the hand motion and provides easy cursor control for people with a limited range of motion. In addition to the trackball, eye-tracking technology is also assisting the interaction between PWD and their computers. A headset with several cameras is positioned on the users head, and based on where the person is looking, the mouse cursor moves. Currently, it is very difficult to get a hold of such a device, and so the exact accuracy is still unknown. However, in the future a similar technology such as this may replace a mouse as well as speed up computer use for these people.

³ Maltron, Inc; <http://www.maltron.com/images/press/maltron-expanded-keyboard1.jpg>



Figure 10: Trackball Mouse (Logitech, Inc)⁴

Touch screens have also improved human computer interaction for PWD. Several cognitive disabilities make it difficult for people to associate mouse movements with the cursor movements on screen. By using a touch screen, the user can simply touch buttons on the screen instead of trying to move the mouse to that location. This technology can also be used by people with carpal tunnel syndrome, but since the range of motion is larger, speed is often times sacrificed.

In addition to the aforementioned hardware devices, many software manufacturers include accessibility features within their software to further increase a user's experience. A combination of hardware and software can usually provide a perfect fit for most users.

⁴ Sapo.pt; <http://gameover.sapo.pt/gfx/139821.gif>

2.2.2 Software Devices

All mainstream modern day operating systems incorporate several programs to help PWD. Since Microsoft Windows is still the most widely used operating system today, it is important to explore all of its accessibility features. These usually work in conjunction with assistive hardware devices to simplify a user's computer experience.

Poor eyesight is one disability which complicates interpretation of a computer's output. Changing the resolution of the screen, while not really an accessibility feature of the operating system, is one simple way of helping people with poor eyesight. Magnification tools are also available through the operating system to allow for easier reading. By moving your cursor around the screen, the magnifier program, as the name implies, magnifies the portion of the screen where the mouse over. This portion is displayed in a window at the top of your monitor screen. Figure 11 illustrates how the magnifier program functions.



Figure 11: Magnification tool on Microsoft Windows XP

Screen readers are also available for people with poor eyesight. A screen reader simply reads whatever text is on the screen. The user has to solely rely on keyboard controls to navigate since mouse control is impossible without seeing the cursor. The problem that is oftentimes encountered with a screen reader application is that it is difficult to use non-accessible, friendly applications since text is usually encompassed inside a graphic. Some accessibility-friendly Web browsers attempt to lessen the problem, but this technology is not 100 percent effective.

“Filter Keys” and “Sticky Keys” are two more software features available in Microsoft Windows that help people with some mobility impairments. The Sticky Keys feature replicates the toggle switch features that are available on some assistive keyboards. To invoke this function, the user simply presses and holds a key for 5 seconds and the key is toggled on. Then she/he can press other keys to produce multiple key combinations. Once this is done, the key can be depressed by simply hitting it one more time. Filter keys remove subsequent key presses that may happen if a user cannot move his finger off the key fast enough to avoid a repeated keystroke. Keystroke repetition can also be completely turned off. Cursor speed can also be controlled to lessen the effects of some slight motions, which make navigation through the user interface difficult. Cursor speed can be increased for people that can use their mouse precisely, but have a limited range of motion. (Figure 12)

Another type of assistive technology is voice recognition systems. There has been much research in the field of voice recognition, and these systems are now more accurate and powerful than ever before. Properly trained systems are accurate to about 99 percent and can process up to 160 words per minute. In addition to the speech-to-text functionality, many voice recognition systems allow for control of most programs through simple voice commands. The only problem with voice recognition systems is the lack of absolute control over the computer. It is sometimes difficult to “undo” a misunderstood command which may lead to unsatisfied users. IBM’s ViaVoice group and L&H are still investing funds for voice recognition research and these numbers are bound to increase in the future. Regardless, these voice recognition systems can help most people with the majority of musculoskeletal disabilities.

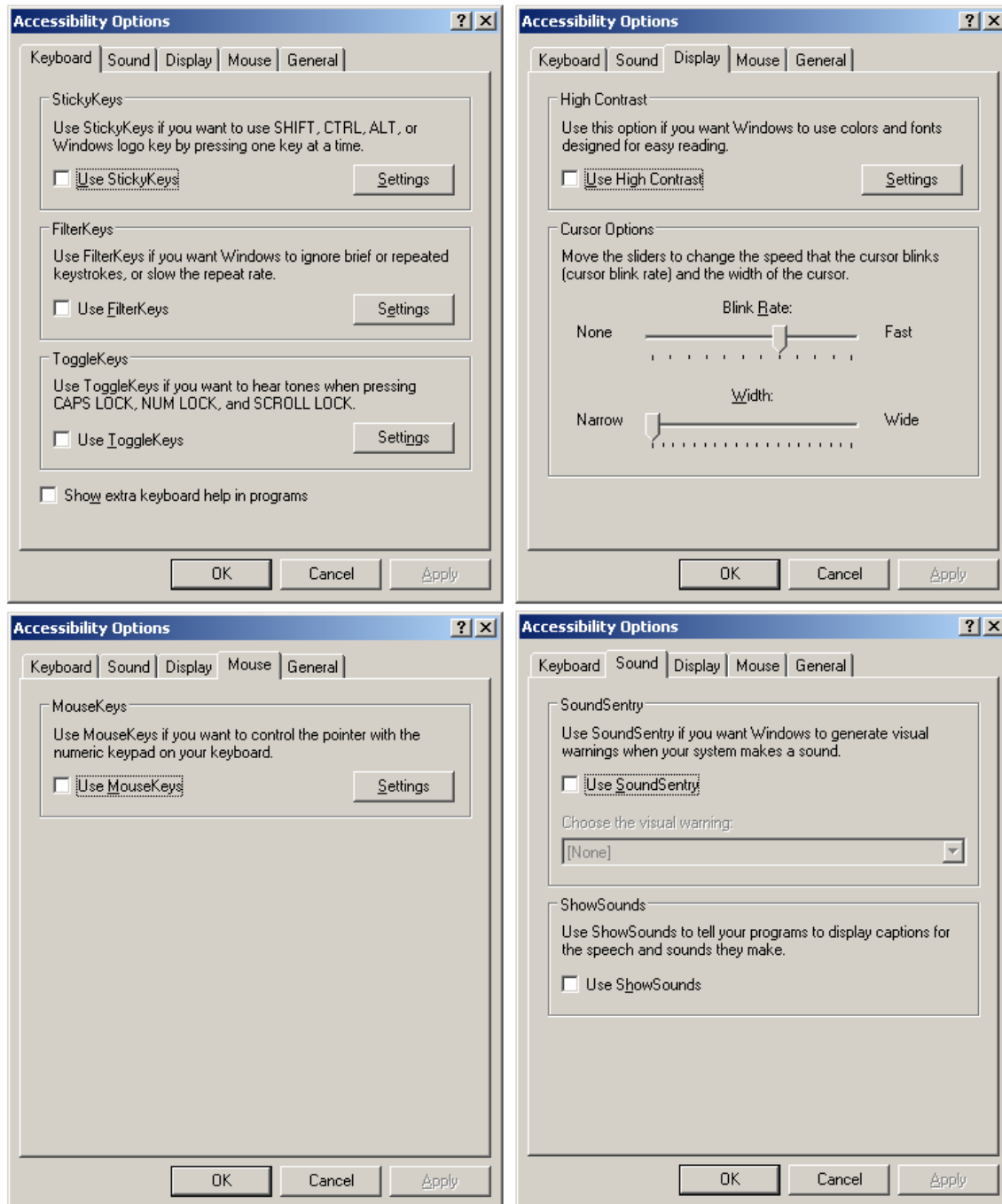


Figure 12: Accessibility options available through Windows XP Control Panel

People with cognitive disabilities can also enable auditory feedback and alternate visual schemes. Studies have shown that people with cognitive disabilities respond better

when some type of feedback is provided. Almost all windows commands can provide some type of auditory feedback to help these people. While high contrast might help people with poor eyesight, people with attention deficit may suffer from too much contrast variation. Softer color schemes are available, which allows for people with attention deficit disorders to keep their concentration.

A consistent user-interface throughout many applications helps people with memory impairments. Since many applications are designed in the same format with similar toolbars and hot-keys, people with memory difficulties oftentimes do not have to relearn how to do simple commands such as print and save for each application. A choice between using icons and text (or both) is also available to these people to further simplify and enhance their experience.

Customization of the user interface enhances everyone's experience with the operating system. The combination of all the devices that are available for PWD drastically improves their user experience and productivity. As long as developers keep accessibility in mind, the tools are available for PWD to have a satisfying experience.

2.3 Limitations on Usage

After researching the available forms of assistive technology (AT), as well as looking into the accessibility issues various disabilities present, certain hypotheses can now be formulated. It is evident that certain disabilities will present significant usability problems in regards to Kaon's 3D applets, while other PWD will not have accessibility problems. Due to the existence of many effective alternative input devices and other forms of AT, many people with what would otherwise be a limiting disability are able to accomplish all of the ordinary tasks associated with computing. On the other hand,

people with certain disabilities may still find it difficult to use the 3D applet, with out new accessibility improvements.

Those with upper mobility impairments, such as quadriplegia and reduced motor control, can utilize the previously discussed AT, such as a head wand or eye tracking technology, to move a mouse cursor across the screen. Considering the advanced alternative input devices available as well as the current simplistic interface of Kaon's 3D applet software, the research done so far would suggest that major changes to assist mouse navigation will not be necessary. However, there are other navigational methods in use which the applet may prove to be completely inaccessible. Debra Ruh, an expert on accessibility and usability testing at TecAccess, stated that she believed keyboard navigation to be the most popular method of navigating software by those with impaired motor control (Appendix 2.A.1). Currently, Kaon's 3D applets can not be navigated using a keyboard alone. Taking into account that the applet is displayed within a webpage, traditional methods of keyboard navigation, such as keyboard mnemonics and tabbing through components, may not be possible. The testing phase of the project will be crucial in identifying the specific accessibility issues that exist in using the applet with only a keyboard.

While using Kaon's software those with a motor impairment disability may have minor to serious accessibility issues, those who are deaf or hearing impaired will have no accessibility issues beyond what a person with no disabilities would experience. Obviously, this is due to the fact that the 3D imaging software is devoid of any type of sound or auditory feedback. As a consequence, there is no perceived need for usability tests for people with a hearing impairment.

People with visual impairments may also have usability problems with Kaon's applet. Those who wish to use a screen reader to read the textual parts of the applet, such as the captions on the buttons, may find that the applet is incompatible with their AT. In order for Java applets to be accessible with AT, the software must be coded in a manner that follows Java accessibility guidelines. For these reasons, it will be necessary to perform usability tests with testers who have visual impairment. However, while a person with impaired vision can still find the 3D imaging useful, the very nature of the software, a 3D visualization, makes the applet inapplicable to those who are blind.

The last group of disabilities that may have accessibility problems consists of those with cognitive disabilities. Cognitive disabilities such as dyslexia, dyscalculia, ADHD, mental retardation, and Down syndrome also affect a user's ability to interact with information technology. The improvements that can be made for people with cognitive disabilities are a less understood, and often overlooked, area of accessibility. However, improving usability for this audience also usually means improving usability for everyone. Most improvements to usability in this category deal with the organization and presentation of important content, and less to do with compatibility with accessibility technology. Accessibility improvements for those with cognitive disabilities include condensing navigation into a single place, using concise and simple language to present important ideas, and to use illustration to provide support to the main points the content is trying to make. Also important is to give the user the ability to control any sorts of movement or flashing on the page, as it could potentially prove to be distracting for those with certain disabilities. Keeping this in mind, it is possible that the Kaon Applet as a whole could prove to be a distraction to people with cognitive disabilities if it is not

displayed in the proper manner, since it displays motion. Kaon's own interface also has potential for improvement in regards to disabilities, but diagnosing what those areas may be is tricky without consulting either a person with a cognitive disability, or an expert in the field of accessibility.

In summary, different disabilities present different usability problems when using the 3D applet. People with certain motor impairments should not have much difficulty using the software, as long as they can operate some form of mouse cursor. However, those who rely on the keyboard may have trouble. Those with hearing impairments are not affected, while those with visual impairments potentially will be. Lastly, possible solutions exist to improve the product for people with cognitive disabilities, such as ADHD.

2.4 Proposal for Research Process

Developing a research design that will provide accurate results is the most important part in any study. For this study, we will loosely follow a procedure that has already been defined by social scientist Earl Babbie in his book, *The Practice of Social Research*, in combination with procedures highlighted in *Don't Make Me Think!: A Common Sense Approach to Web Usability* by Steve Krug. In *The Practice of Social Research*, Babbie outlines the nine major steps that should exist in the research process. Meanwhile, Krug adds a perspective of practicality on how to develop and test with usability in mind. His book illustrates testing methods which will elicit valuable information from the tester. Combining the procedures that are used in both books, we will be able to create a study that will produce both quantitative and qualitative results. The study design that we will use for this project is illustrated in Figure 13. The

following sections will discuss the eight steps that we will follow in our preliminary research, methodology, analysis and conclusion sections.

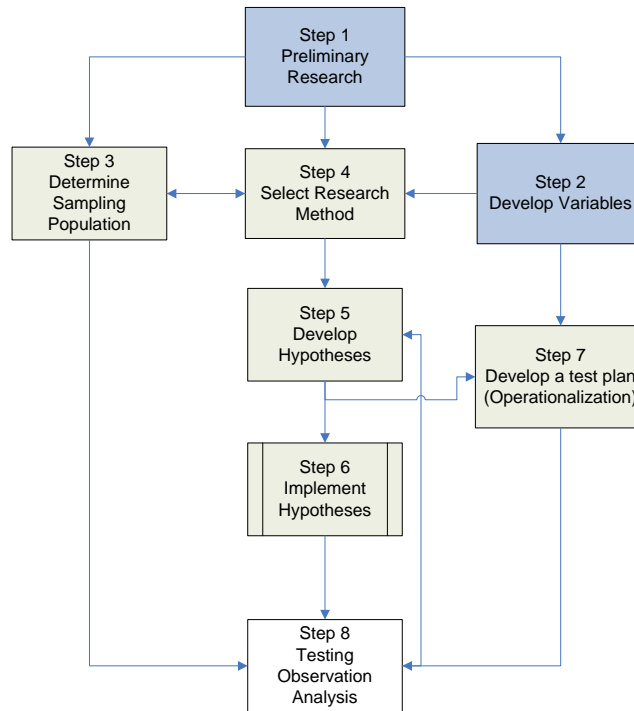


Figure 13: The Research Process

2.4.1 Preliminary Research – Steps 1 & 2

The first part of the research process is conducting preliminary research. During this phase, background literature was reviewed and important concepts were developed. After understanding what PWD face while using their computers, and why it is important to cater to their needs, we can define a purpose. The purpose of our project illustrates the dire need to complete the rest of this project. In addition to the purpose, we have defined what qualifies as an “accessible applet”. From our preliminary research, we have learned that there has only been a limited amount of accessibility studies done on Java applets with enhanced media. After talking with experts in the field, we have devised variables

that we will test to determine the level of accessibility of an applet. These variables are further explained and illustrated in the methodology section.

2.4.2 User Profiles (Population Sampling) – Step 3

Developing user profiles, or population sampling, will determine the accuracy of our experiment. “The population for a study is that group about whom we want to draw conclusions”(p.109, Babbie, 2001). Since this project primarily deals with PWD, it is important to select participants that will give us a good representation of a larger audience. For example, the general nature of this applet does not lend itself to use by people with severe visual impairments. On the other hand, people with hearing impairments should not encounter any issues with this product at all. According to Debra Ruh of TecAccess, people with mobility impairments will be able to use this applet, since people “with the right assistive technology (AT) and training ... can do any type of task”(Appendix A.1). While this is true, the time and complexity to perform a certain task will vary based on how well the applet has been designed. Some computer operations are much more difficult to perform than others. Since ease of use and speed are of major concern, we will want to conduct tests on people with physical disabilities. Finally, a group of users without disabilities is needed in order to provide a reference of the general usability of the applet. This group of users can be selected from an audience of average internet users. Once this population sample was created, a research method needed to be defined.

2.4.3 Selecting a Research Method—Step 4

This project borders on both a scientific research study and a social science research study. As mentioned earlier, the quantitative results are just as important as our qualitative results. For this reason, it is important to take both a positivist and interpretive approach while conducting the test. Positivist research generally tends to “measure precisely things about people, and test hypotheses by carefully analyzing numbers from the measures” (p. 58, Neumann, 1994). Interpretive social science theory generally says that “when people study text, they absorb or get inside the viewpoint it presents as a whole and develop a deep understanding on how its parts relate to its meaning of the whole.” (p.58, Neumann, 1994). By interpreting the results of our surveys, we will get a better idea of the issues that are faced by the population and understand the complexities of the applet. A testing plan has been created that will attempt to retrieve both subjective and objective information from the participant. Using this information, we can further develop better hypotheses as well as monitor actual increases in speed and performance.

2.4.4 Developing Hypotheses – Step 5

The interpretive research method has enabled us to fully understand the issues PWD have with general computer use. Once we understood those issues, we were able to envision some problems that PWD would have using Kaon’s applet. Following Babbies’ procedure, we generated several ideas on how we could fix problems that may be encountered by people with various disabilities (the variables in our study). From this point, we were able to produce several hypothetical applets that would combine

variations of these ideas(p. 106, Babbie, 2001). Table 1 illustrates an example of interests and ideas that have been developed for our project.

Table 1: Example of Interests & Ideas

Interests	Ideas
Vision	Eliminate Drag & Drop
Limited Range of Motion	Large Buttons
Difficulty Controlling Motion	Keyboard Control
Difficulty with Pointing Device	Help Screen
Learning Disabilities	Intuitive Keyboard Commands

The hypotheses that we have developed, which serve as the foundation of our conceptual test applets, are fully explained in the methodology section. Once they were outlined, a testing plan was created to examine differences in user interaction among different versions of the applet. Simultaneously, several applet implementations were compiled to test the hypotheses.

2.4.5 Applet Implementation – Step 6

With the completion of steps one through five, we are able to begin the final stages of our project. Three variations of applets will be implemented using Kaon’s Meson language. These applets will be accessible versions of the original applet. In practice, the chosen “accessible applet” will not be a standalone unit; instead, it will serve as an additional option for users of this software. Implementation will begin as soon as

all the hypotheses are completed and approved. Simultaneously, a testing plan will be developed from our current hypotheses and applet mock-ups.

2.4.6 Testing Plan – Step 7

There are many factors that need to be taken into account while designing a testing plan for this applet. Since the user population of our applet is very narrow, it will be impossible to perform the test on-site and monitor the users at all times. It could also be difficult to track exactly what the user is doing and how they went about their actions. In attempt to counteract these issues, we will add controls to the applet which will allow us to interact with the user and retrieve the time it takes for them to perform certain tasks. This interaction will allow us to make quantitative comparisons between variations of the applet. In addition, provided video documentation will be examined closely to reveal any problems experienced by the user.

The testing plan that we have defined will ask the user to perform several non-trivial tasks. These tasks will not only measure the user's comprehension of the applet controls and their ease of use, but also, the overall performance of the applet. Once the tasks have been completed for a given applet, the user will fill out a survey asking them to qualitatively rank that applet in comparison to the others, as well as the ease of performing the given tasks.

2.4.7 Testing & Analysis – Step 8

The applet testing will be performed by TecAccess. The test plan has been designed to make this test autonomous and easy to understand. The user will go to a webpage and be guided by onscreen instructions. Once they have completed all the

instructions and filled out all the appropriate surveys, the test will have been completed. The only deliverable that is expected from TecAccess is video documentation of each users experience with the applet. Once the testing is done, analysis of the data will yield our project conclusions and recommendations.

An analysis will be performed after each test is conducted. The types of information that will be examined include:

- Time to perform tasks
- Apparent difficulty in performing the tasks
- Number of errors that were made
- Subjective Satisfaction index
- Speed increase in performing tasks as user becomes more accustomed to them and to the applets
- Different approaches users took to perform the tasks

Using this information, a guide describing the necessary implementation changes will be created and then followed in the final product. Time and resources permitting, the product will be moved back into the testing stage where improvements can be measured.

2.5 Usability Testing

In order to overcome the problems that PWD face with application, it is important to design keeping accessibility in mind. The only way to make a design fully accessible, iterative usability testing must be performed. Since no one user is exactly like the other, proper implementation of accessibility features can only be done by performing usability tests on an audience that all have differing disabilities. If the final product has simplified human computer interaction, user satisfaction will undoubtedly increase. The quality and

satisfaction of a user's experience can generally be related to five distinct categories: ease of learning, efficiency of use, memorability, error frequency and severity, and their overall subjective satisfaction (Usability.gov, 2004). Table 2 describes five categories of usability, explains a test method, and lists potential problems that may be encountered by PWD.

Table 2: Usability Methods

Description	Test Methods	Potential Problems
1. Ease of Learning		
Web applications generally come with limited documentation. User interface has to be simple to learn and understand	Give user a procedure to perform and time how quickly they are able to figure it out.	People with cognitive disabilities often have a difficult time translating between text/icons. People with Physical Disabilities might have a hard time with 3D Options
2. Memorability		
Since users will be using this applet throughout the whole website. Will it be easier for a user to perform a task during another instance?	Allow the user to use the program and time the time taken to perform a task. Give the user a break and test again to compare times.	People with cognitive disabilities may not remember usage from one time to another. The results will show whether or not this can be helped.
3. Frequency and Severity of Errors Made		
In the KAON application, it is easy to perform the wrong function by pressing the wrong key. How often does this happen and how hard is it to recover?	Over several typical sessions, we can count the amount of errors the people with disabilities make. How does this compare with a control group.	People with motor impairments might have a difficult time selecting the proper buttons on an applet since they are small. If the keyboard keys are not obvious, they might also press improper keys to perform a task.
4. Efficiency of Use		
The user must be able to navigate the 3D environment pretty quickly and easily in order for them to keep using it.	After allowing the user to use the applet for several minutes. Measure how long it takes to perform a task. How does this compare to a control group.	People with some physical disabilities might be much less efficient since they will have to use the keyboard for all 3D Navigation.
5. Overall User Satisfaction		
The end user is the one who will be the one using the product. It is important that the user is satisfied with their whole experience	A survey will be created to ask the users about their experience. The survey will reflect their satisfaction.	After performing an iterative usability test, it is our goal to make all users satisfied with the final product.

2.5.1 Interviewing Strategies

In addition to the five factors considered, a crucial part of usability testing is effectively acquiring the knowledge and opinions of the testers. The means of gathering this information is via an interview. During the course of the usability testing there will need to be interviews with many people in a variety of mediums. The purpose of these interviews, as previously stated, is both to retrieve the opinion of experts as well as to gather feedback from usability testers. Depending on the goal of the interview, the respondent, and the medium for the exchange of information, various strategies and techniques must be considered. Many of the interviews will simply be questionnaires emailed to either experts or usability testers. Others may perhaps be done via the telephone, or even in person. These different methods all have their advantages and disadvantage.

When doing an interview either through email or a survey on a webpage, special consideration needs to be given so that the questions are answered in a way which you desire. For example, if asking a multiple choice question over email, it is possible that the respondent will choose two of the options, when only one is desired. One study did by a researcher named Mick Couper showed that 21 percent of respondents asked to reply to a survey via email did not answer the questions in an unexpected manner (Gubrium, 2002). Email interviews need to be clear, concise, and have explicit instructions to help avoid confusion. Consideration to the format of the email must also be given. Not all people read their email through a program that can display HTML. Thus, if this format is chosen for the interview, some respondents may not be able to read it correctly. However, moving the survey or questionnaire over to a webpage can solve many of these

accessibility issues that arise in email. Through a Web browser and a dynamic webpage, the interviewer can have a lot more control over how the questions are answered. The disadvantage of the Web based survey is it is more time intensive to set up (Gubrium, 2002).

Another disadvantage of both email and Web interviews is that since they are done via the Internet, they are impersonal. This lack of physical connection in turn leads to a lack of rapport between the interviewer and the respondent. Rapport is very important when giving interviews, as often times how someone presents themselves and how they present their answers is as important as the answer itself. In email and Web interviews, the interviewer loses some of the ability to detect if the respondent is uncomfortable, genuine, sarcastic, and all the other human emotions that an astute person can distinguish. Developing rapport in an online environment usually involves textual descriptions of how the person is feeling at the moment. Internet users use acronyms such as “lol” (laugh out loud) to indicate laughter, and emoticons, text written to look like a human face, to display a wide range of emotions (Gubrium, 2002). However, given that the interviews for this project will be of a technical nature, as well as that the usability testers will be familiar with the job of testing a product and communicating the problems experienced, detecting the emotional condition of the respondent seems less important, as the goal of the interview is not to probe their feelings on an issue.

Despite the deficiencies of the Internet as a means of doing an interview, it is still the most practical and likely medium for this project. In addition to the considerations already discussed, there are a many other steps that can be taken to improve both the efficiency and value of the interview, as well as to make the respondent feel comfortable

and appreciated. Firstly, when scheduling an interview that is to be on the phone or in person, always allow the interviewee to set the time of the meeting and always refer to the time in terms of their local time zone, so as to avoid confusion (New York Times, Campus Weblines, 2001). Next, it is important to be forthcoming about what the interview is about, that they are participating in a formal interview, and what they say may be put into print (New York Times, Campus Weblines, 2001). Similarly, since it is a formal interview, the interview should be recorded if possible. This allows for the respondent's answers to be transcribed later. Preparation for the content of the interview is also important. Always have as much knowledge about the subject prior going into the interview. Asking questions whose answers are commonly attainable is a sure way to annoy or frustrate a contact (New York Times, Campus Weblines, 2001). Before the interview, all questions should also be prioritized. This way if the interview goes for too long, the most important questions get asked first. Lastly it is important not to attempt to set the tone of the conversation. If the contact wishes to be casual and informal, the interviewer should mirror this attitude, to make the respondent feel comfortable, however, if the contact is businesslike and professional, do not try to make casual chit chat. Lastly, it is important to not immediately interrupt a contact while they are speaking, even if it is perceived that they have gone off topic. Having patience can result in knowledge that would not have been achieved through the prepared line of questioning (New York Times, Campus Weblines, 2001).

Interviewing a respondent is a difficult task. Getting the most out of interviews takes much practice and much preparation. In addition to being comfortable and well versed on the topic of the interview, the interviewer must also know the advantages and

disadvantages of the particular medium, be it a web page, email message, phone call, or traditional face to face encounter. Lastly, maintaining a professional and courteous relationship with the respondent is crucial in obtaining the information that one needs.

2.6 Project Timeline

This project was divided into four main phases. They consist of researching, proposing a solution, testing the solution, and the final report describing the results. Each of the four phases is then divided into individual tasks. By dividing the project into smaller pieces, it is easier to focus on the specific task at hand. Some of the phases and tasks are dependant on each other. Once the first tasks are completed, the entire group knows that the next ones can be started. Other phases and tasks can be performed concurrently. This will be necessary given the limited time schedule to complete the project. A Gantt chart was developed to organize the tasks on a timeline and shown in Appendix H. With four group members, the concurrent tasks can be divided evenly and much will be accomplished in a short amount of time.

In the first phase, research, all four group members worked to develop a foundation for the project. Existing work done by Kaon is explored. Also researched was who will be able to perform the tests. This was done with the cooperation of TecAccess and Easter Seals. Also researched was why projects such as this are necessary. The research concluded with how this project should be performed. The group members looked into how to perform usability testing and the correct way to perform interviews.

A proposal was developed in the second phase. Here the research done previously was formalized. The proposal also consists of the methodology for user testing

and descriptions of the tests. When the proposal is finished, it is presented to Kaon for approval. After approval, the project continues to the next phase.

The third phase is comprised of testing. After Kaon agrees to the proposed testing, the tests are finalized and the actual testing begins. The testing lasts as long as two weeks. When testing is complete, the results are analyzed. This analysis concludes with the implementation of any findings.

The final report is the fourth and final phase. The majority of this phase takes place concurrently with phase three, testing. As the tasks are performed, the corresponding report sections are written. The report also includes a discussion of the final conclusions. When all the sections are compiled, editing consists of three drafts. Each draft is reviewed by the advisor for approval. At the conclusion of the project, a documentation of the entire process will be delivered along with a set of guidelines describing our recommendations for 3-D applet accessibility.

3 Methodology

Conducting a proper experiment requires a methodology which will accurately test the variables that have been defined, while controlling all other variables. While this is ideal, it is almost impossible to perform such an experiment. With every disability being unique, it is difficult to keep this variable from affecting results. With this issue, quantitative results become as reliable as their qualitative counterparts. In the following sections, several hypotheses will be developed, along with explanations detailing the intent of each of the proposed hypotheses. Once these hypotheses are developed, the report will delve into creating a usability test, and the actual test plan that we will follow. Steps three through seven in Figure 14 illustrates the portion of the project that this chapter will cover.

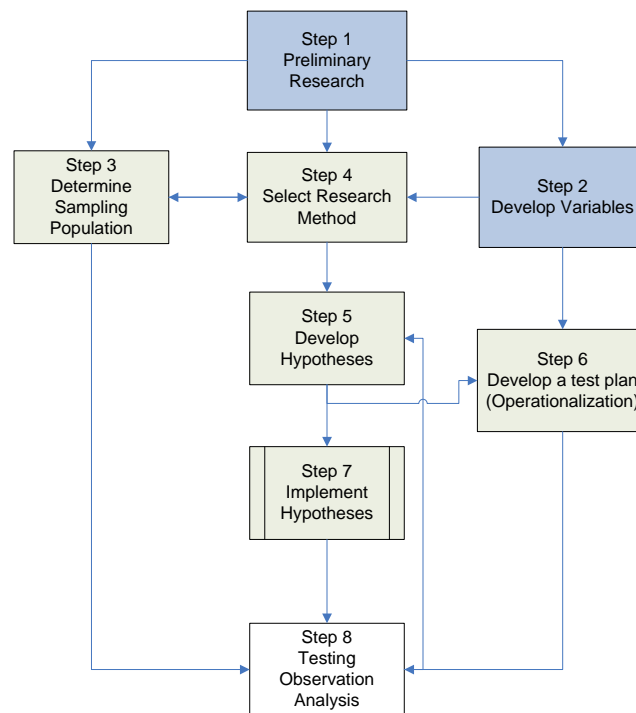


Figure 14: Project Layout, Usability test procedures in tan and white.

3.1 Hypotheses

Based on our research, we have generated a set of hypotheses in the form of design goal criteria. The idea is that by following these criteria, we will generate an applet that maximizes the ease of use for everyone, with a focus on individuals with physical disabilities. These hypotheses are based on knowledge of the most common disabilities inflicting Internet users, as well as the types of devices used to navigate online. Adhering to these goals will minimize the number of steps needed to control each applet function and improve overall ease of use.

3.1.1 General Goals

The following goals are set forth to serve as guidelines for accessibility improvements. Each of these goals is considered when a change to an applet is implemented.

Goal: Controls are constantly visible and do not shift location

Intent: Graphical flourishes like shifting placement or transparency are less desirable for PWD, as such features can be confusing.

Goal: Clicking and dragging is never necessary in controlling the viewed object, either via the control bar, or when manipulating the object itself

Intent: Clicking and dragging is by far the most complicated type of action when using mouse simulating devices.

Goal: Buttons are large enough to see and activate with ease

Intent: Large buttons are helpful for individuals with poor motor control or limited eyesight.

Goal: Buttons are spaced far apart from one another

Intent: This ensures that an unintended function is not activated, and provides leniency for those with poor motor control, especially people with jitters.

Goal: Text is included with all controls to describe functionality. Large font and appropriate colors are used with considerations for the visually impaired and color blind

Intent: Textual descriptions should be coupled with images to provide further clarity. Some individuals respond better to text, while others to graphics. Large fonts are necessary for the legally blind and for those with other visual impairments. Green and red tones should not be used together, as they are indistinguishable to most people who are color blind. Bright, high-contrast images should be implemented when possible.

Goal: The functionality of all controls is easily discernable

Intent: Communicating an applet's functionality to the user quickly and completely is very important. Not only does a good design improve usability for people with cognitive disabilities, but it heightens the experience for everyone.

Goal: Simplistic, uncluttered control environment to reduce confusion

Intent: Simplistic designs will enable great functionality with minimal controls. This enables users with poor range of motion to access everything they need in a small workspace. An uncluttered environment aids understanding for people with cognitive disabilities, as well as helping those with motor impairments to activate the controls they want.

3.1.2 Applet Designs

Using the design goals that have been established as a guideline, many areas of improvement on Kaon's 3D applet have been identified. The changes to the implementation of the program will be done to two distinct versions of the applet, both of which will be tested by all testers, as well as a control applet, which is a Kaon applet as it is now. Below is a listing of the new improvements and changes to each of the applets.

3.1.2.1 Applet 1

The first applet (Figure 15) that will be tested is a control applet, which is the Kaon applet as it appears on a product website right now. This applet should perform the worst in the test, since it implements none of the design/goal criteria.



Figure 15: Applet 1

3.1.2.2 Applet 2

The idea of Applet 2 (Figure 16) is to test all of the improvements made to the interface that have been developed using the goal guidelines, but to not include new hotkeys and tool tip information that may have a confusing or overwhelming effects. The following changes will be made to the applet.

Enlarged Buttons and Increased Font Sizes

The clickable area for the rotate and turn buttons will be enlarged as will font size.

Horizontal Zoom Bar (centered)

The zoom bar appears horizontally instead of vertically and is elongated to aid the motor impaired. A wedge shape is used to graphically depict a larger or smaller zoom and is colored on a gradient. A solid black vertical marker can be moved across the wedge to control the zoom level.

Zoom Control Buttons

In addition to the graphic zoom controller element, which requires a click and drag mouse movement, buttons will be included on each side of the bar to help people using mouse simulating devices, who are restricted to mainly point-and-click. The buttons will contain either a plus (+) or minus (-) symbol depicting their function, and will be colored in the same manner as all the other control buttons to clearly show that they can be pressed.

Separated Rotation/Turn Controls

Instead of appearing as a single graphic with many clickable parts that have varying functionality, the rotation and move controls in this applet will be broken apart into 4 separate buttons. The buttons will each be made larger and will be far enough apart to give leniency for hand jitters. In this way, it will be made apparent that each button is a separate control with its own function, and that it is clickable. The buttons will be colored like every other button control for clarity.

Measure Tool Enhancement

Similar to the rotation enhancement, the measure tool enhancement will allow the user to measure between two points on the object without having to click-and-drag. When the measure control is activated from the toolbar, the user can simply click once anywhere in the object viewing area, and then move the mouse to measure between two points. Upon the first click, a textual notification will appear explaining that the user can move the mouse to take a measurement. A crosshair will mark the first click, and a second crosshair will appear at the current mouse position. The distance will be displayed as a textual notification between those points. The

measurement mode can be abandoned by the user selecting another control from the toolbar.

Loading Screen Enhancement

Currently, the loading screen has small grey print which says “Loading...” under a short horizontal progress bar. This information is hard to see, and because the applets are sometimes large and could take time to load, the user may be confused as to what is going on during the loading period. The user may think the page is malfunctioning and become impatient or browse elsewhere. To remedy this, the loading screen will feature a company or title graphic across the top, a larger progress bar, and a message that clarifies the loading process, such as “Applet is loading. Please wait...”. Underneath this will be simple instructions describing how to use the applet.

Help Button

The applet will include a help button in the top right corner. Clicking the button or pressing its hot key will bring up a box of text which lists all of the hot keys in the applet as well as other helpful information about how the applet can be used.

LCD
Memory
Optical Drive
Hard Drive
Battery
D/Module
D/Port
D/View
D/View Adjuster
D/Monitor Stand

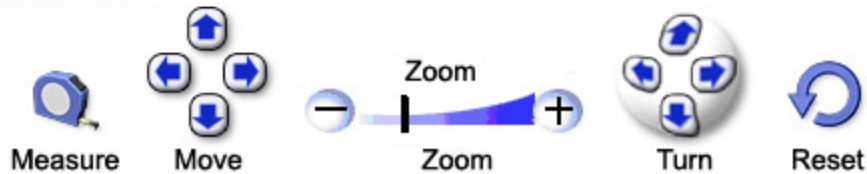


Figure 16: Applet 2

3.1.2.3 Applet 3

Applet 3 (Figure 17) has all of the same improvements that Applet 1 has, however with a few key differences. Applet 3 will present much more hotkey information. Additionally, it will also have different move and rotate buttons than the first applet. The buttons on this applet will basically be enlarged versions of the existing Kaon applet, but with a hotkey hint written on them. If the design goals presented in section 3.1.1 are correct, Applet 3 should perform best in the test, followed by Applet 1, followed by the control. This is of course due to the fact that Applet 3 has the most accessibility recommendations implemented. In addition to the accessibility improvements listed below that are also included in Applet 2, Applet 3 will have the following improvements.

Enlarged Buttons and Increased Font Sizes (see above explanation)

Horizontal Zoom Bar (left hand side) (see above explanation)

Zoom Control Buttons (see above explanation)

Measure Tool Enhancement (see above explanation)

Loading Screen Enhancement (see above explanation)

Keyboard Control for Sidebar

The sidebar can now be made the mode, just as turn and rotate can. This is done by clicking a button above the sidebar, or by hitting the hot key associated with that button. Once the sidebar is the mode, the arrow keys can be used to cycle through each of the options, and the enter key can be pressed to activate it. The tool tip associated with each sidebar item will explain this functionality. When a certain sidebar item is highlighted via the keyboard, the tool tip associated with it will still pop up. See Appendix E for a complete list of keyboard to action mappings.

Keyboard Navigation

All control functions for the applet will be accessible via the keyboard. Controls can be mapped directly to single keys, i.e. the letters W, A, S, and D could control the rotation of the object. Alternatively, a key such as the spacebar could toggle access to the control toolbar. Then, the arrow keys or number keys could be used to choose a function such as zoom or pan. These controls would highlight a different color upon selection, and then the keyboard could be used to manipulate the object with the activated controls. A particular control's key assignment would be available in the alt message displayed by hovering the mouse over that control button, and also in the help box. As stated before, for a complete list of keyboard to action mappings see Appendix E.



Figure 17: Applet 3Testing Plan

The testing plan for this interactive applet will be divided into two separate tests. With the limited resources available, the first test that is conducted will be a purely qualitative measure on the performance and ease of use of the separate variations of the applet. The second test that will be performed will include both a quantitative and qualitative analysis.

3.1.3 Phase 1: Analysis via Easter Sales

From conducting interviews and performing background research on the field of accessibility devices, it is easy to recognize many of the nuances that people with mobility impairments face while using their computer. The various implementations of our hypotheses attempt to eliminate the nuances that are encountered. In the first round of testing, different implementations of the applets will be sent to Easter Seals specialist Jeff McAuslin. Depending on the results of the form they fill out, the user will be redirected to an implementation of the applet. Some users will also be redirected to the original applet and their comments will be taken into consideration into the development of further hypotheses'. Once the applet is selected, Mr. McAuslin will use the applet during his training sessions for users who are new at using AT. He will also be able to provide feedback on any problems that he notices during this time. This information that he is gathering will be used to help fine tune the improvements made to Kaon's product.

3.1.4 Phase 2: TecAccess Testing

Once several different applet implementations are made, testers at TecAccess will be used to perform a much more formal and scientific test. In this experiment, testers will follow a very rigid and defined test plan, in an atmosphere that attempts to quantitatively measure their performance. Simultaneously, the testing environment will also attempt to control as many outside variables as possible. Unlike qualitative testing, variable control becomes a necessity in quantitative issues. Since different testers with varying skill sets and disabilities are being measured, it is impossible to completely eliminate all outside influences on the results, as some testers may inherently be better at using the 3D applet.

As stated prior, testing done with TecAccess will have to be done via long distance. To overcome the difficulties and lack of control a long distance test presents, a very specific testing atmosphere has been developed. Testers will use a website developed for the purpose of delivering this test. The website will present the applets and various surveys in a controlled environment, while simultaneously recording their performance in a variety of metrics. Figure 18 outlines the flow of the testing website.

When a tester first arrives at the website they are presented with a set of explicit instructions (Appendix D) about what they should expect and what they can and can not do during the test. The tester must acknowledge that they have read the agreement, and they are willing to participate in the test.

Following the initial instructions and agreement, the tester is taken to a pre-test survey (Step 2, Figure 18). The purpose of this survey is to assess both the affect of their disabilities on their computer usage as well as their familiarity with computers and 3D images. The survey asks them to rank the difficulty they experience doing common computing tasks, like using the keyboard and mouse. It also asks how often they use a computer and about any accessibility technology they may have.

The third step in the test is to present the tester with the first 3D image they will see. This 3D image is presented for the sole purpose of familiarizing the tester. They will be asked to perform a set of trivial tasks on this applet. The 3D image of the familiarization applet will have a different navigation template, and will not have any of the new accessibility improvement features. The hoped for end result of exposing the tester to this 3D image is that they conquer their learning curve, a variable that differs from tester to tester, before quantitative measuring begins. With this step, and with the

information gathered in the pre test survey, it may be possible to gauge and or partially eliminate the variables of learning curve and degree of disability

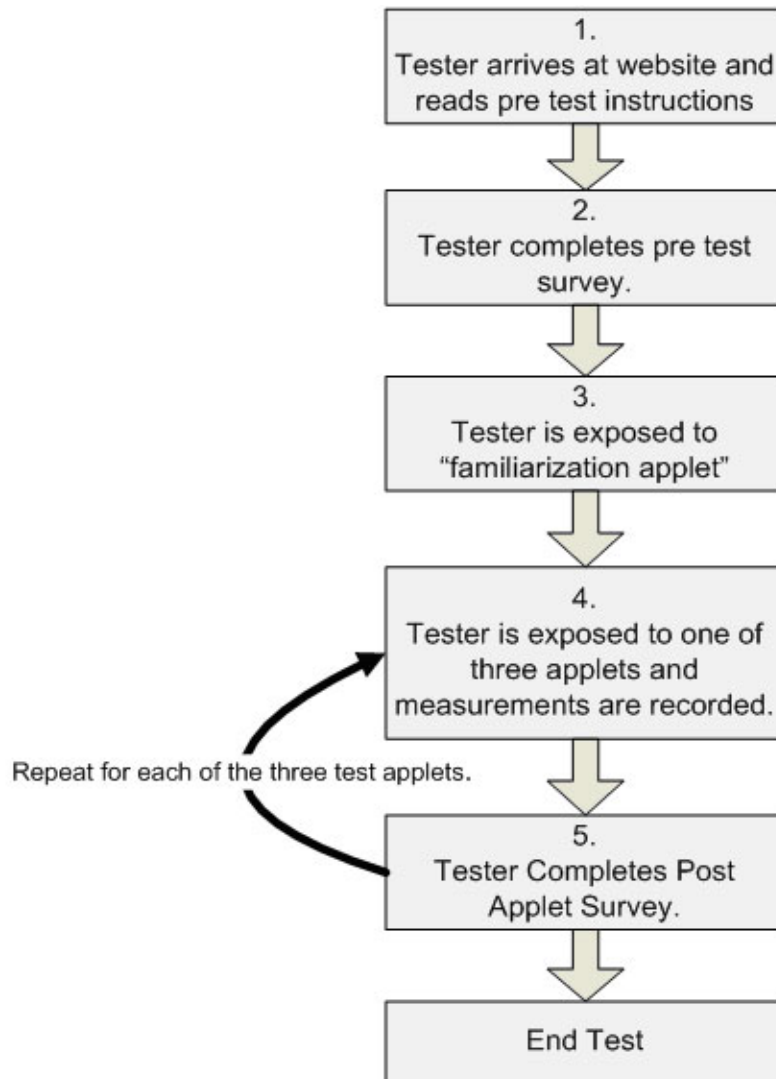


Figure 18: Flow of Testing Website

After completing the trivial tasks in step 3, the tester is displayed the first of the three test applets. In Figure 18 above, steps four and five are repeated three times each, once for each applet we are testing. The applets are presented in the order of accessibility improvements, from the least accessible (Figure 15) to what is hypothesized to be most

accessible (Figure 17). In addition to the applet itself, also presented to the tester is a task and a set of three buttons which are various options of how successful at completing the task. A task can be marked Completed, Failed due to accessibility Issue, or Failed due to uncertainty. Figure 19 displays the testing environment. The set of tasks for each applet will require the tester to utilize all of the applets functionality, and the tester will never be asked to complete the same task twice. Each applet uses tasks that are slightly different. This is done to try to negate the affect of familiarity achieved by testing a similar 3D image three times.

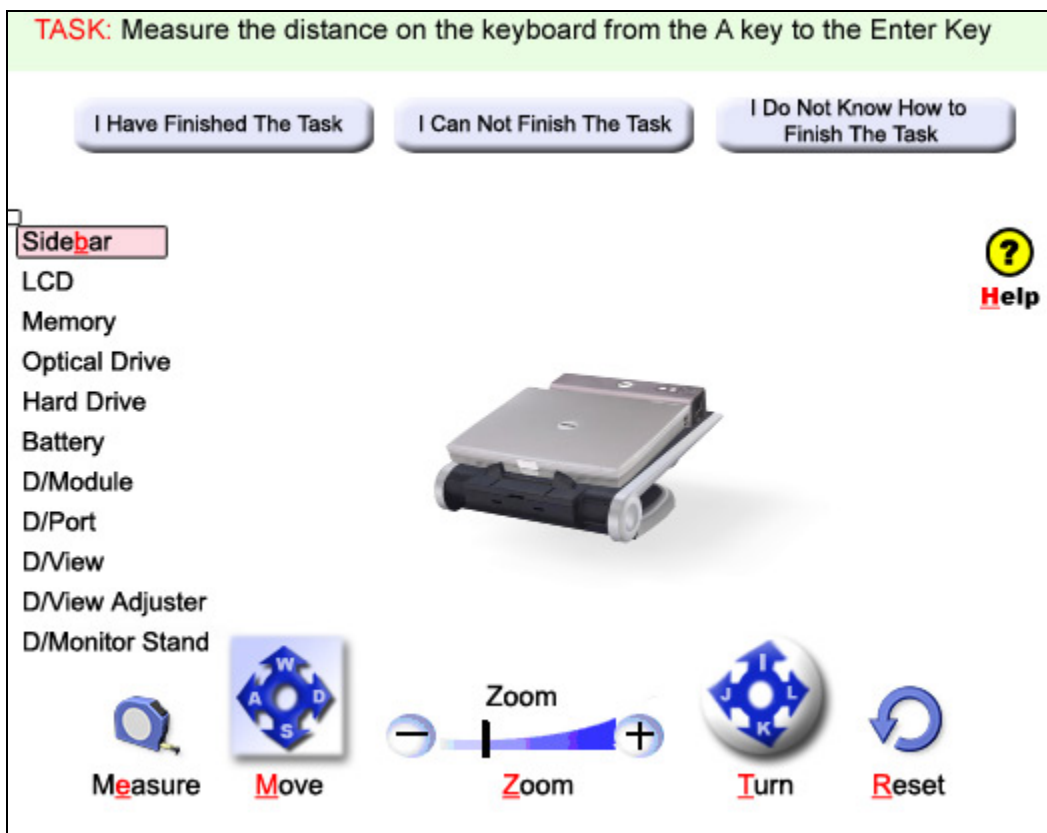


Figure 19: Kaon Applet with Testing Functionality

Perhaps the most important feature of the testing plan is that while each task is being performed, the applet will be logging their performance. The website records into a database the following metrics:

- **Key Presses:** Each time a user presses a certain key, the specific key and the time it was pressed is logged.
- **Mouse Clicks:** Every time the user clicks the mouse, the time, and coordinate of the mouse click is logged.
- **Task Completion:** Each time a user completes a task, the time it took them is logged.

The data recorded in this test will be analyzed to determine if the changes made to improve accessibility were successful. The performance of the testers while using the two applets designed with accessibility in mind will be compared against the tester's performance against Kaon's product. Also, the qualitative measure attained via the user satisfaction survey will also be taken into account. With the combination of these two methods, conclusions can be extracted to prove or reject our hypotheses.

Once all of the tasks are completed for each of the applets being test, the tester will be asked to fill out a short survey (Appendix C). The purpose of the survey is to ascertain what the tester liked and disliked about the particular applet implementation. Performing the entire test should take approximately one hour. Table 3 illustrates the time tables that will be used during the test. Fifteen minutes has been allotted per test and five minutes allotted at the end for final comments and recommendations. Note that this is just a guideline. None of these times are actual limits, with the exception of the ten minutes allotted to the very first applet, which is only done to familiarize users to the controls.

Table 3: Time Schedule for Applet Testing

Time:	Task:
0:00-0:15	<i>Learn to use the applet and pretest survey. Attempt to use all the features that the applet provides.</i>
0:15-0:30	<i>Test Applet #1 Comment on Performance and Recommendations</i>
0:30-0:45	<i>Test Applet #2. Comment on Performance and Recommendations</i>
0:45-1:00	<i>Test Applet #3. Comment on Performance and Recommendations</i>

3.2 Analysis

The results of the testing are analyzed to determine whether or not the hypotheses developed are correct. Both quantitative data as well as qualitative data will be collected and analyzed. The quantitative data can be graphed to show trends and the effectiveness of the applets while the qualitative data will show the users' preferences and responses to the applet structure.

The location of mouse clicks as well as actual keys pressed are recorded. The number of mouse clicks and/or key presses is also recorded. If a task requires more actions to be performed on one applet than another, the ease of use can be determined. With this data, the number of attempts to perform an action can be analyzed to establish how simple it is to discover the necessary steps to carry out the requested act. If a given action requires the user to click on a button, but the user clicks near the button 3 times before the actual button is clicked, the problem may be that the button is too difficult to click. Similarly, if the user is required to click a button, but clicks three other buttons

before the correct one, the problem may be that it is too difficult to determine the function of the buttons. Any of those actions can be considered errors. The applet on which users make fewest errors may be found to be the better applet. Graphs can be developed for visual representations of the errors made. Histograms of the average errors per applet and task will show on which applet and task the most errors occurred.

For each user, times required to perform the given tasks will be compared for each version of the applet. This will show which applet the user can most easily navigate and how easily the user can interpret the operations of the interface. A time-series plot of errors per task can show trends of familiarity or learning as the user progresses through the tests. Bar charts are used again for the time spent per applet and task to show variations per user on time spent performing the tasks. Finally, histograms of the average times spend on each applet and task are used to illustrate how long it takes to perform the given tasks.

TecAccess will provide video documentation of the testing. This video will be analyzed for any difficulties the users may have had while using the applet. After each applet is tested, the user will fill out a survey of questions relevant to the applet they had just used. The first portion of the survey asks the user to rate the functionality of the applet in terms of ease of use. These ratings of each applet will be compared and graphed in a histogram to show which portions of the applets the users found easiest to use. The other survey questions will provide more of an insight into the users' preferences by providing space for the users to fill in their own responses. The most attention will be paid to the responses from the TecAccess representatives as they are experienced testers and are more familiar with this type of work.

The results of each analysis will be compared across each version of the applet. This will allow the best aspects of each applet to be determined and can be combined into final recommendations for the best user experience for PWD.

4 Analysis

In the previous phases of this project, all of the accessibility issues that Kaon's 3D Imaging software presents to PWD have been researched and investigated. From this research, several methods to alleviate these problems were generated and hypotheses were drawn from these ideas. In the following sections, the data gathered from the experiment that was outlined in section 3.1.4 will be analyzed. From this analysis, the hypotheses about how the accessibility of the applets can be improved can either be validated or invalidated.

4.1 Overall Change in Accessibility and Usability

Before analyzing the effects of the implemented changes and validating or invalidating each hypothesis, it would be valuable to look at how the general level of accessibility of each applet changed. This view point will show the sum effect for the changes made to the applets, as well as showing if the test applets were well received by the testers.

Perhaps the best way to determine if the modifications implemented in the test applets have any value is to look at how testers responded when they were asked to rank the three applets from best to worst in terms of overall preference. .This question was given in the third post test, after the participant had used each of the three test applets. Of the 32 participants who completed the test, 22 of them voted Applet 2 as best over all applet, 7 for Applet 3, and 3 for Applet 1. Figure 20 below illustrates the results.

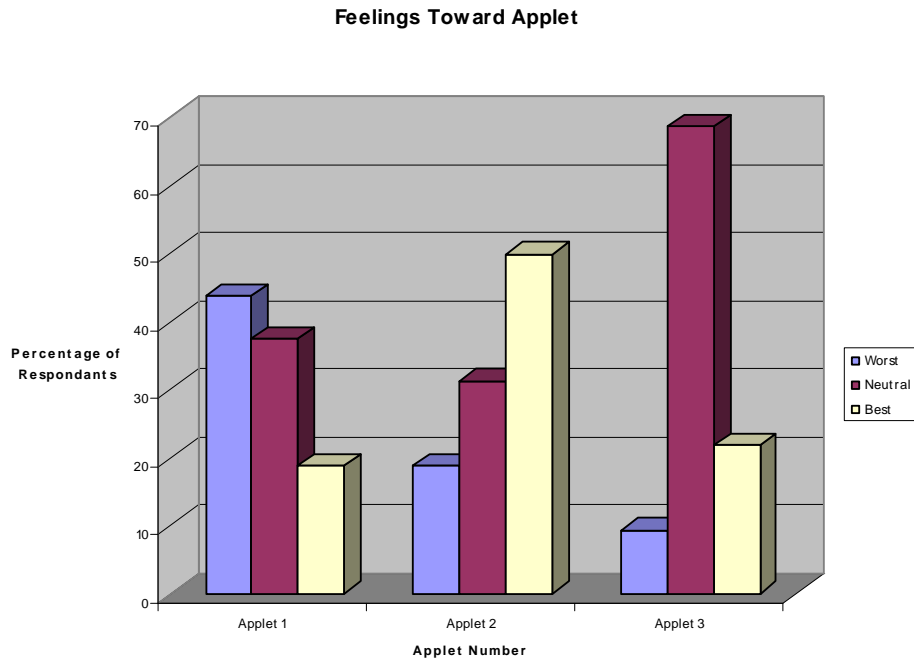


Figure 20: Participant Response to Question “Please Rank Applets in regards to Best Overall”

When this same question was posed to testers with a disability (TWD), they also voted strongly for the applets with accessibility improvements. Of the nine TWD, 4 chose Applet 2, 4 chose Applet 3, and one ranked applets 2 and three equally. None of these users believed that the current applet was the best option. See Figure 21 for a graph of the results.

Feelings Toward Applet (Users with Disabilities)

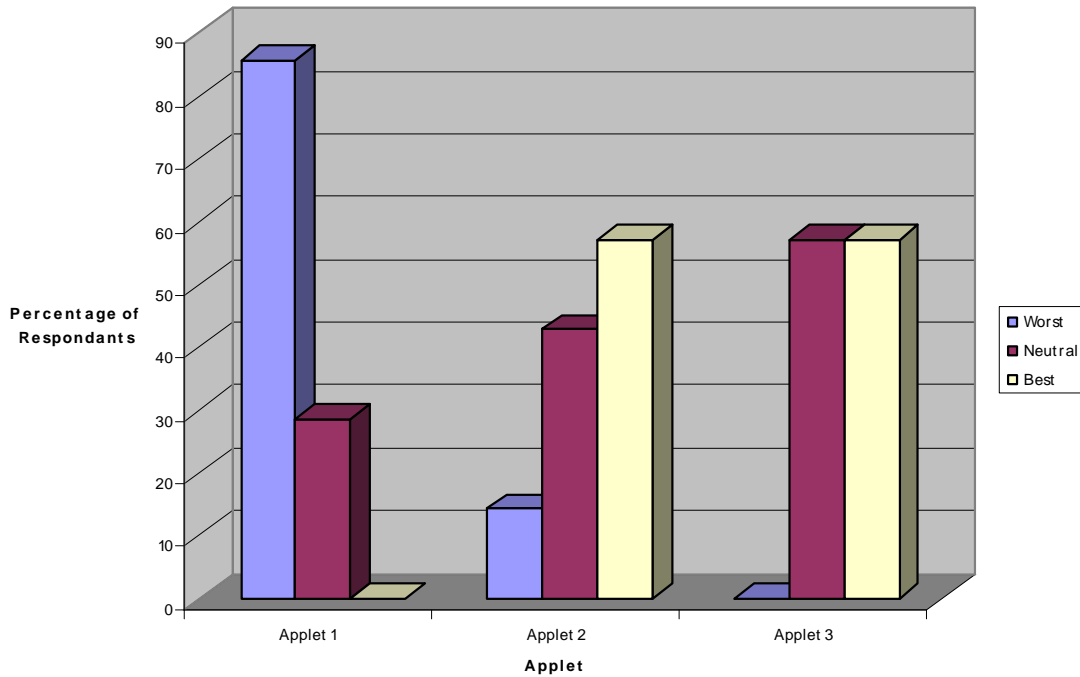


Figure 21: Feelings towards applets by TWD

In addition to asking the testers their opinion on best overall applet, they were also asked to rank the applets in terms of accessibility. The results here were very similar to the results of best overall, with Applet 2 ranking the best and Applet 1 ranking the worst. Nearly 80% of the testers believed one of the applets with accessibility improvements was the most accessible. Figure 22 depicts a graph of the votes of the test participants.

Applet Accessibility Ratings

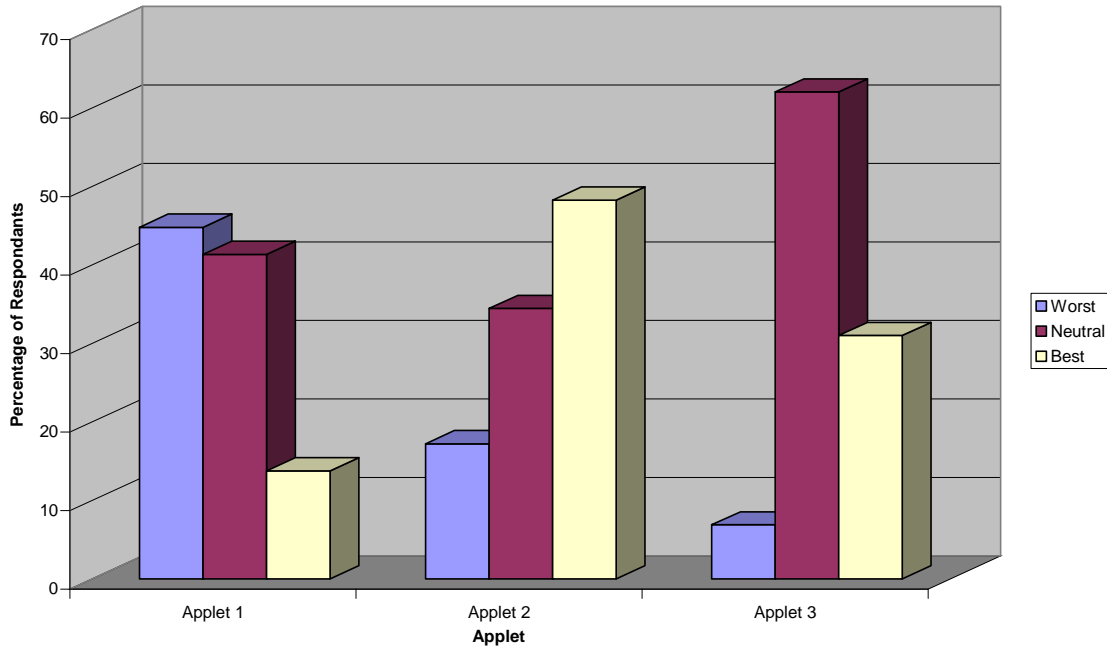


Figure 22: Accessibility Ratings of Applets by All Users

When TWD were posed with this question, they favored against the current applet even more drastically. None of these users believed that the current applet was the most accessible, and they were nearly evenly split over which of the two improved applets was most accessible. Figure Figure 23 displays the results.

Applet Accessibility Ratings by TWD

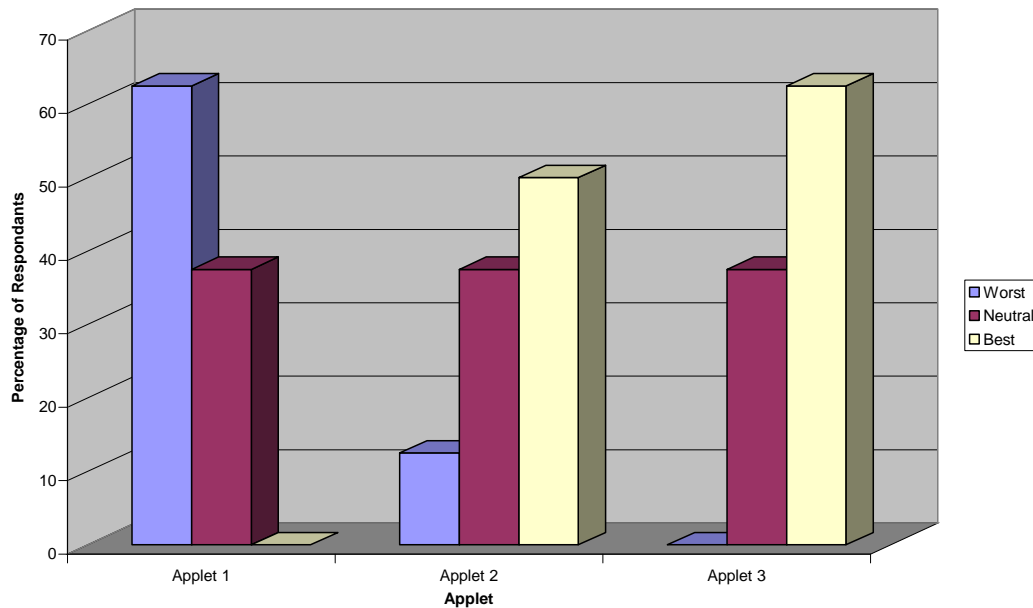


Figure 23: Accessibility Ratings by TWD

4.2 Provide Alternatives to All Drag and Drop Actions

One of the largest accessibility concerns of the current applet is that the user is forced into a drag and drop motion in order to execute certain actions, most notably the measure tool. Thus, in applets 2 and 3 the measure tool was modified so that the drag and drop motion was eliminated. The other actions that could be accomplished by drag and drop are move and turn. The current applet would also allow the user to accomplish these two actions using the keyboard; however it was not immediately apparent that this was possible. It was hypothesized that by increasing the size of the arrows on the buttons, by providing a link to a help section that describes the applet's controls, and by labeling the arrows with their hotkey, the drag and drop alternative would be much more used.

In analyzing the effect of modifying the measure tool, perhaps the most valuable data gathered was the subjective comments that the users entered in the post test survey. Even after removing the drag and drop requirement from the tool, nearly 25% of all test participants made a comment about how they had difficulty with the measure tool or a suggestion of how to improve it. The feedback on the measure tool was stronger and more prevalent than on any other feature in the applet. Table 4: General Comments on Measure Tool below lists the user comments that discuss the measure tool. From reviewing these comments it is obvious that the measure tool still does not function as a user would expect. However, the user's comments do not seem to indicate that the confusion with the tool was caused by the modifications made to eliminate the drag and drop.

Table 4: General Comments on Measure Tool

Applet	Comment
2	It would be better if the measure tool selected with one click and the stopped measuring with a second click. I felt like i could never "let go" of the measuring.
3	This model seemed as easy to use as the second one, however when measurement was attempted, occasionally if you click, drag to the measurement spot, then unclick, the applet did not acknowledge that you had unclicked
3	the measure tool is still horrible
3	measure tool [When asked if anything was distracting about the applet]
3	The "Measurement" still needs the Mouse Cursor...
3	Measure tools second click should not remove the value.
3	Same measure tool problem as last one...

The last change aimed at providing an alternative to a drag and drop motion was to make the keyboard controls more apparent. The method of doing this was different for applets 2 and 3. In Applet 2, a help button was added to the top right corner which brought up a page describing how to use and navigate the applet. In the third applet, the controls were actually labeled with their keyboard hotkeys. The response to the help section was not overly strong. As expected only a small portion of all experiment participants used the help section. However, a larger percentage of the testers with disabilities took advantage of it. See Figure 24 and Figure 25 to view charts of help section usage.

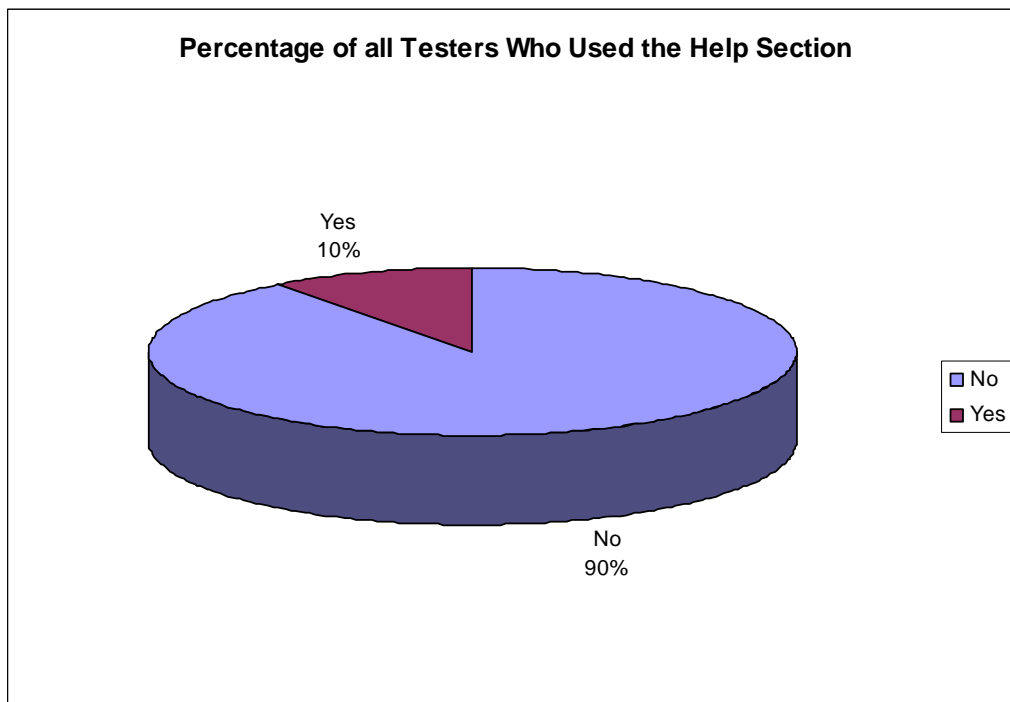


Figure 24: Percentage of Testers Who Used the Help Section

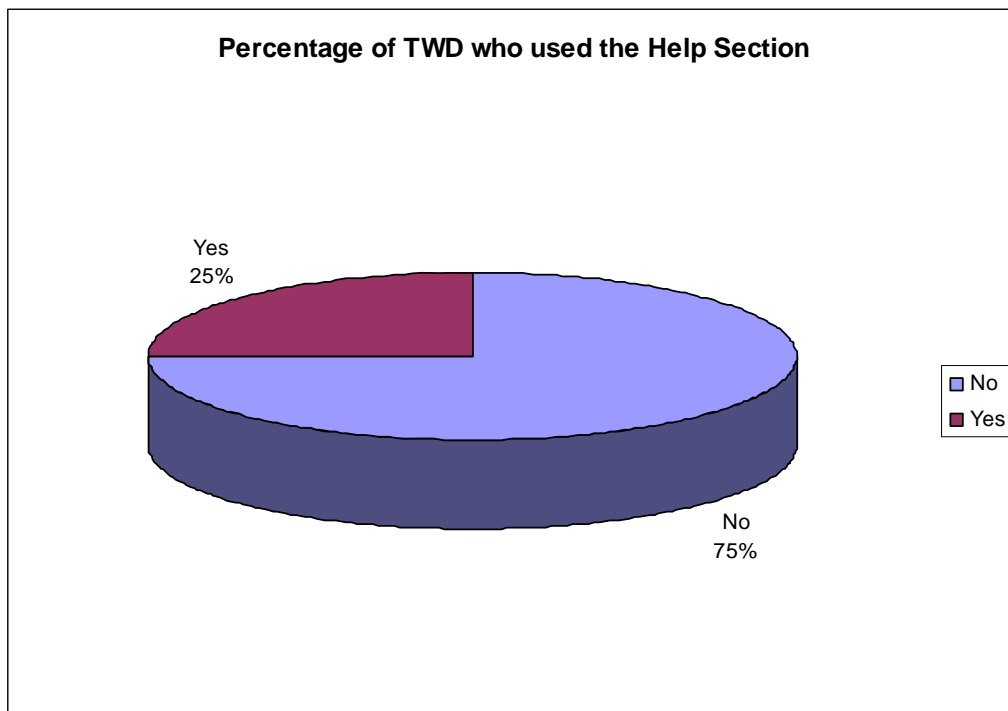


Figure 25: Percentage of TWD who use the Help Section

However, while the usage of the help section was not widespread, it can still be considered have value as an accessibility improvement since the presence of the additional button was not commonly considered to be a distraction by the experiment participants. In fact, only one tester listed the button as a distraction when viewing the 3D model.

The other method of making the keyboard control more apparent was to add labels on the arrows themselves. While the help button did not prove distracting, there was much more feedback about the labels being distracting and confusing. Ten percent of test respondents found the lettering on the controls to be either distracting or aesthetically unpleasing. Only one test respondent commented that the lettered graphics

made them aware of the keyboard control. Considering that the graphics of the controls were the only appreciable difference between Applet 2 and Applet 3, this feedback combined with the testers' rankings for overall best applet would seem to indicate that lettered controls were not well received. For more analysis on the success of keyboard usage as an alternative to drag and drop, please reference the section on keyboard navigation.

4.3 Larger controls increase accessibility

In addition to drag and drop interfaces, a large accessibility issue with Kaon's current applet is the small buttons located on the bottom toolbar. Many people with mobility impairments use alternative mouse devices which lack the precision of the standard mouse. To alleviate these problems, a toolbar with larger buttons and greater spacing between the buttons was implemented (Figure 26).



Figure 26: Applet 1 (Left) and Applet 2 (Right)

To measure how large controls were affecting the performance of testers, detailed analysis was performed on the quantitative data. To measure the error frequency of toolbar clicks, a metric was devised that used a ratio of toolbar region clicks vs. non-

toolbar clicks per applet. The toolbar region is defined as the region 10 pixels higher than the top button, to the bottom of the applet (Figure 27).

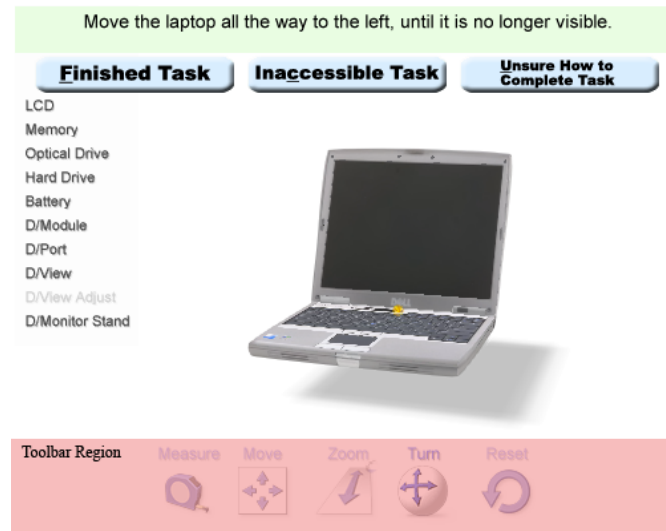


Figure 27: Illustration of Toolbar Region

Figure 28 shows an interesting distribution of clicks between Applet 1, and the more accessible applets 2 and 3. More than half of the participants in this study had more than 45% of their mouse clicks in the toolbar region for Applet 1. As the applets became more accessible, the ratio of clicks in the toolbar region decreased significantly to around 25-30%. We can also couple this data with statistics about average mouse clicks per applet. From this data, we notice that as the button size increases, the amount of mouse clicks per applet goes down. This would seem to indicate that the users' ability to efficiently manipulate the 3D image increased on the more accessible applets (Figure 29).

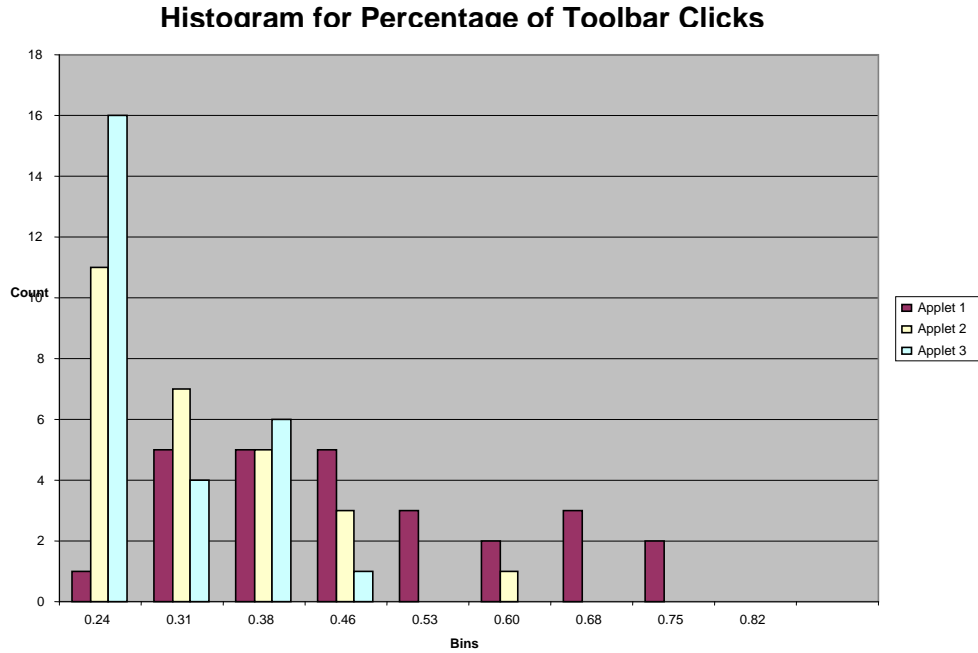


Figure 28: Ratio of Toolbar region mouse clicks vs Total mouse clicks

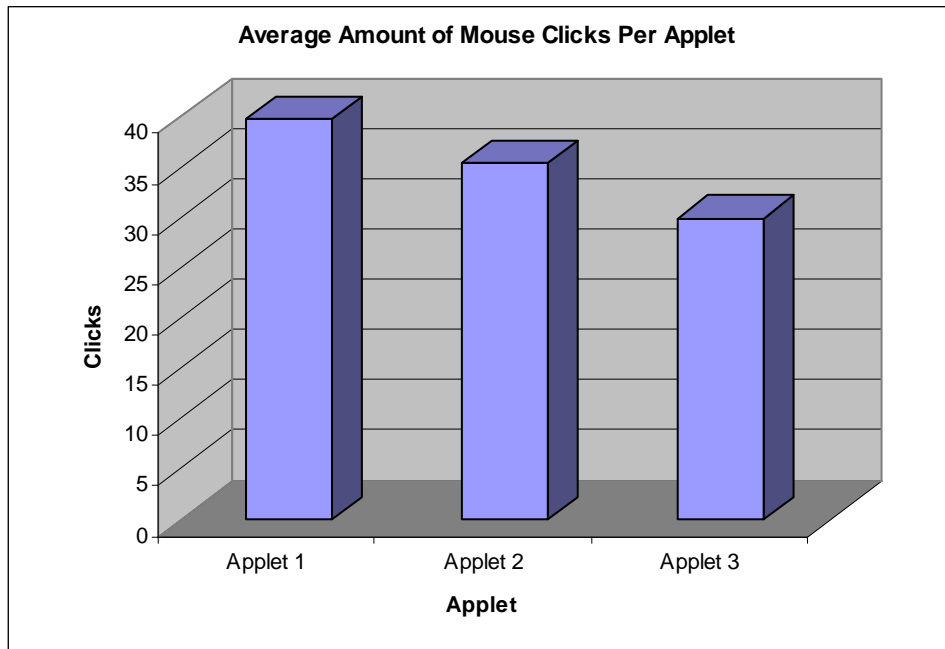


Figure 29: Average Mouse Clicks Per Applet

Qualitative data agrees with our original hypothesis. As illustrated in Figure 20, testers found that applets 2 and 3 are more accessible than applet 1. Since applets 2 and 3

both exhibited use of the large buttons, it can be said that the larger buttons helped in the accessibility ratings. In the comments section, 44% of respondents mentioned that they liked the larger buttons better than the smaller ones and found those to be more accessible. One respondent even mentioned that they believed that the screen area was larger on the second one than the first one. Instead of eliminating the viewable space, these buttons actually gave the illusion that the applet was larger.

4.3.1 Zoom Orientation and Size

In addition to larger buttons, the zoom orientation was changed from the vertical position to the horizontal position while increasing the size of the buttons. Both quantitative and qualitative data show that this feature change improved both usability and accessibility.

In the first applet (Figure 30), the zoom buttons are not clearly defined and the ball that is located in the upper right hand corner is not clearly visible. It is also difficult to apply intuition on which way the zoom works. Some users may think that by clicking the lower arrow, the subject is moving away from the 3d image, while other users might think that the image is moving closer to us. This adds confusion and decreases usability. In the second and third applet, the zoom bar illustrates the + and – images which clearly mean zoom in and zoom out. Additionally, the bar illustrates that as we move the ball from left to right; the images will expand and get larger. This is a much more intuitive way of understanding zoom functionality.

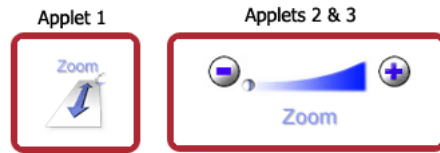


Figure 30: Zoom Controls in Applets

To validate this hypothesis, we can measure the time that it takes a user to complete the zoom tasks in Applet 1 and compare them to applet 2 & 3. From the chart illustrated in Figure 31, we notice almost a 40% increase in speed while performing the zoom task from the first applet to the third. The increase in speed from the first applet to the second might be smaller due to the fact that between the introductory applet and the first applet, the tester would become more accustomed to the up/down zoom interface.

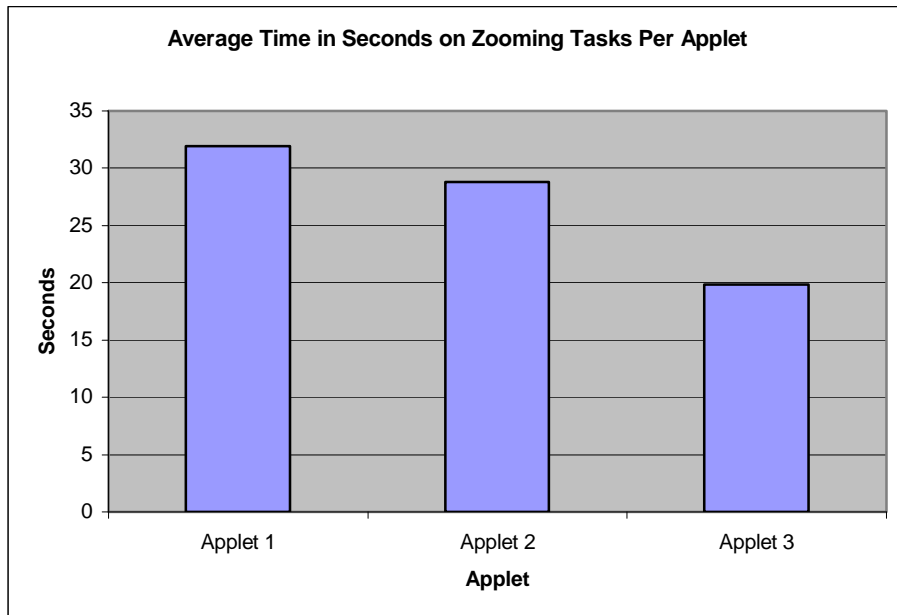


Figure 31: Average Time for Zooming

Qualitative data also agrees with our quantitative values. On a scale from one to ten, testers were asked to judge the zooming tasks between all of the applets. Applets 2 and 3 are ranked easier than applet 1 by one point (Figure 32). User responses have also

indicated that the zoom feature in the accessible applets is much more intuitive and easier to use and understand.

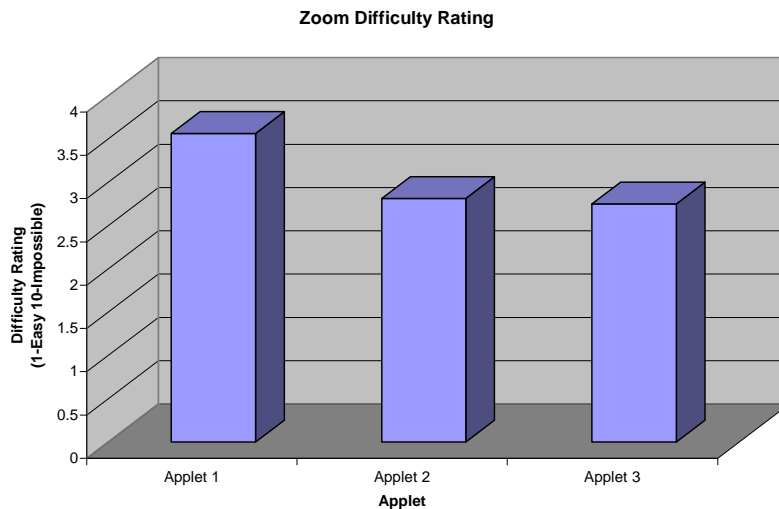


Figure 32: Difficulty of using zoom control

4.4 Key Navigation Aids Applet Navigation for PWD

A more robust keyboard navigation interface was found to be a successful addition to the test applets. In comparison to Applet 1, Applet 2 won 19 more votes (out of 32 testers) for overall best applet and was the most preferred applet in the experiment. The numerous key control improvements of Applet 2 undoubtedly contributed to the strong user preference. Additionally, the average time testers spent to complete the tasks dropped consistently from Applet 1 to Applet 2. Not surprisingly, the average number of mouse clicks dropped as well, as users shifted from navigating with their pointing devices to using their keyboards.

Keyboard control proved to be rewarding in both a qualitative and a quantitative sense. The more key presses the testers used in a given applet, the more they seemed to enjoy the experience, based on survey feedback. Also, people that started to use the

keyboard in one applet, continued to use the keyboard throughout the remainder of the test. According to Figure 33, the number of testers who made use of the keyboard grew over the course of the experiment, and those numbers were not just from the PWD group. This data suggests that many found the keyboard easier than their pointing devices.

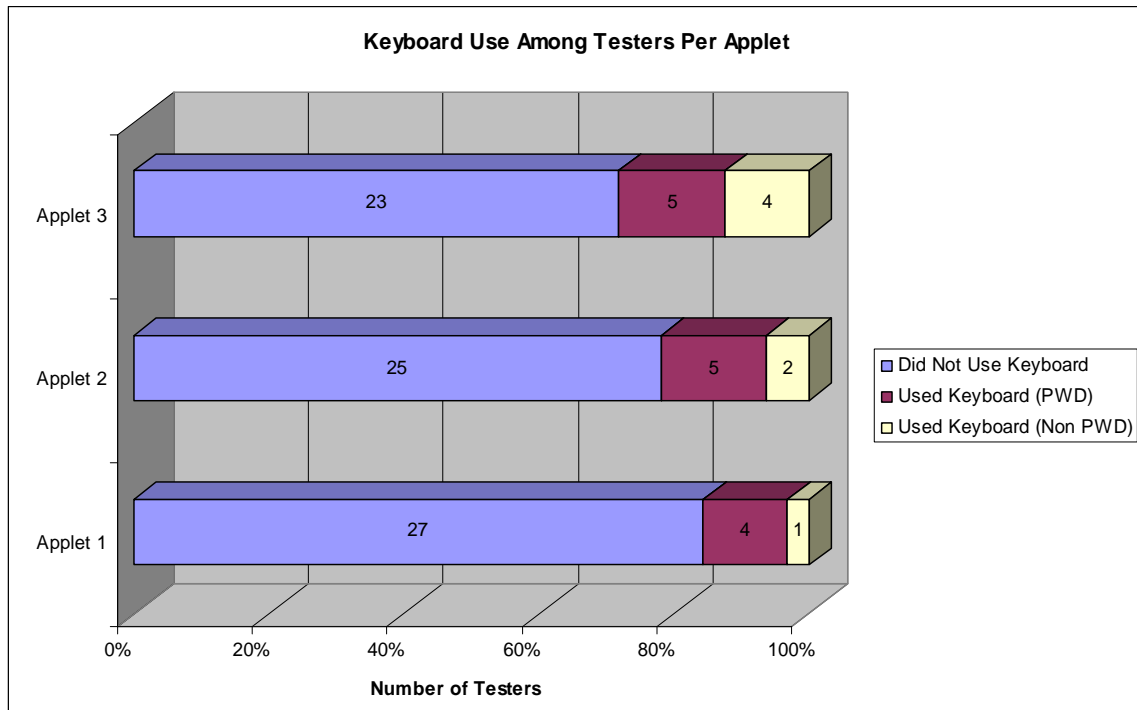


Figure 33: Keyboard use Among Testers Per Applet

Applet 3, although just as popular among testers with disabilities, among all participants it was not as much as liked as Applet 2 was in terms of “overall best”. According to survey comments, this seemed to be due to an “overly accessible interface”; one that was just too cluttered and not as pleasing to the eye. However, users were able to complete measuring, moving, and zooming tasks more quickly in Applet 3 than in the others. Although the total number of key presses in Applet 3 did drop slightly from Applet 2, as shown by Figure 34, the total number of mouse clicks fell just as drastically. This would suggest that the testers felt more comfortable with the accessibility-improved

interfaces by the time they reached the final applet and therefore were able to complete the tasks more efficiently, but that they were still relying just as much on the keyboard as they had in Applet 2. According to the difficulty ratings given by the users, Applet 3 seemed to be easiest in nearly every type of task.

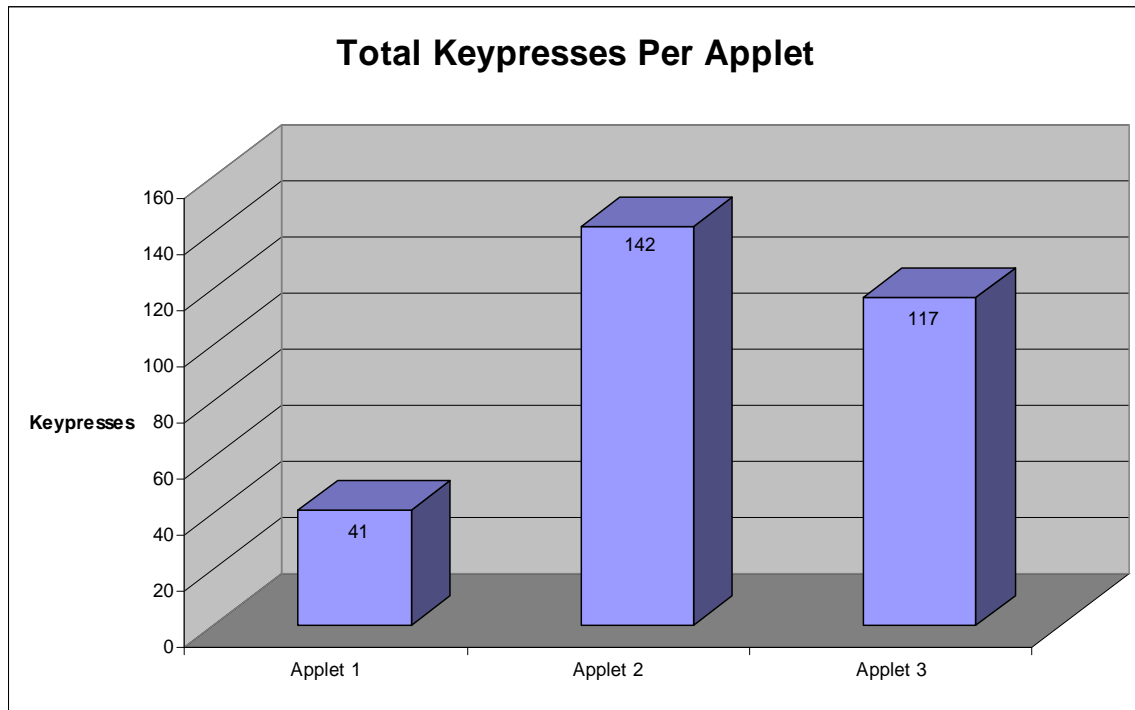


Figure 34: Total Key Presses per Applet

Improved keyboard navigation seemed to drastically enhance speed, ease of use, and overall user satisfaction. The more the testers were made aware of their ability to utilize the keyboard, the more they did so. Additionally, the feature did not have a novelty effect, but rather allowed the testers to perform tasks with more efficiency and greater flexibility. In fact, some testers recommended that applets always advertise their keyboard navigation features. One user said: “Keyboard navigation makes it easier. On-screen instructions ... should be available to point out to the user that the option is available.” Ten percent of all testers did take advantage of the supplementary help screen

(25% from the PWD group), which pointed out keyboard controls. The convention of using underlined letters to denote which keys are associated with each function seemed to be beneficial, as more people started to use the keyboard when this feature appeared. Roll-overs for the controls containing keyboard shortcut information may be a viable and beneficial addition in the future.

5 Conclusions

As outlined in the background research section of this report, integrating accessibility features into rich media applications is no longer an option, but quickly becoming a necessity. As American's generation gets older, more and more people with accessibility issues are signing on to the web. Companies that wish to stay ahead of their competition need to consider this growing and accommodate this growing audience. In the following sections, the final results of our accessibility study will be presented and a set of guidelines will be set forth to allow companies to begin developing more accessible rich media applications.

5.1 Final Results

The accessibility improved applets that were created ranked significantly higher in both terms of overall satisfaction as well as overall accessibility. Users with and without disabilities had difficulties in using the original applet. The final results illustrate that two of the three hypotheses put forth can be completely validated, and inconclusive results on our third hypotheses.

As illustrated in previous sections, both keyboard navigation and enlarged buttons have a large impact on accessibility and overall applet usage. From our least accessible to most accessible applet there was an increase in speed, reduction in errors, and increased user satisfaction. The changes observed in tester feedback and performance were significant enough that even with a small sample size, it can be definitively said that implementing larger buttons and improved key navigation with a reference screen improves both performance and overall user satisfaction.

The hypothesis on removing drag and drop from the measure tool was more difficult to validate. Drag and drop is primarily a concern for users with severe upper mobility impairments that makes it necessary for them to use alternative mouse devices. Since the sample size of PWD was rather small, the feedback did not establish whether the elimination of drag and drop was actually useful. Most users still mentioned difficulty understanding and using the measure tool even after drag and drop was eliminated. In the future work section, a new way of implementing a measuring tool will be presented. This new method eliminates the need for any mouse interaction with the applet while additionally delivering a simplified measuring approach. Finally, in order to completely validate or invalidate this hypothesis, it is necessary to increase the sample size of people with upper mobility impairments and obtain their qualitative feedback.

From the results of this experiment, a list of recommendations that describe several ways of making rich media more accessible has been compiled. Also included in this list are recommendations that were generally not applicable to 3D Applets because of their very visually oriented nature, but could be applied to other enriched media.

5.2 Recommendations

A recommendation document has been compiled to help developers create enriched media that will be accessible for PWD. Below is the list of eight general suggestions that web developers should follow in order to maximize accessibility in their rich web based media.

- Clicking and dragging should not be necessary for performing any action.
- Multiple key combinations should be avoided if possible. Multiple key combinations are difficult for people with upper mobility impairments.

- Buttons and other controls requiring click activation should be spaced far enough apart to enable easy interaction. Each control with a different function should be also completely separate entity, rather than having a single control with multiple points of activation. Minimum spacing requirements cannot be imposed due to inconsistent user viewing environments (i.e. differing screen resolutions) and restrictions on a particular interface's design, but developers should be mindful of the limitations of people with jitters or poor motor control.
- The shape, appearance, and positioning of the controls should make functionality intuitive. Any symbols used should be easily recognizable and non-distracting.
- Buttons and other controls requiring click activation should be large enough to manipulate with ease. Designers should keep people with vision and motor impairments in mind when creating the applet interface.
- High contrast colors should be used throughout the applet to aid those with attention impairments or vision problems.
- Whenever possible, the use of potentially distracting graphic elements such as changing transparency and pop-up windows should be kept to a minimum to reduce confusion and increase overall usability.
- Keyboard controls should be available to perform any action that is possible with the mouse. These controls should also be advertised in some manner so that users are aware of their presence. One non-obtrusive method of accomplishing this would be to provide a supplementary help screen listing the controls. Other methods include underlining specific letters in the control labels to denote the

associated keyboard controls, or including mouse roll-overs that display pertinent keyboard shortcut information.

- Accessibility guidelines should be followed by the underlying programming language. Java and Flash both support accessibility features which allows for screen readers to access their fields.

5.3 Future Work

Although research, testing, and analysis of this project have vastly improved the accessibility of one rich media product, there are many potential extensions and continuations to be made in the area of web accessibility for 3D imaging. In the future, further accessibility and usability testing should be performed on these types of applets with more people to gain a better representation of what problems the greater population face. In this project, a somewhat small group was tested, and therefore, the issues given the most attention in this report may not be the same issues that stick out when applets are tested with a larger or more representative sample.

Aside from just increasing the test group, more quantitative testing could be performed in order to provide more exact applet design guidelines. For example, various font and button sizes could be tested among a substantial number of people with vision impairments. This would help to determine precisely how large is large enough in terms of making the applet controls easy to read for the greatest number for users without compromising the integrity of the design. The same could be done for the spacing between controls, and tested by people with limited motor abilities. One possible test could involve users being timed to switch between and activate various controls, and the test could be repeated with different spacing between the controls. The goal would be to

determine how much space is necessary around the controls in order for users to perform tasks quickly and efficiently, and with the least number of errors.

According to the research, the biggest point of criticism with the current Kaon applet, and even in the more accessible applets that we designed, was the measuring tool. In the future, the tool could be improved to function by clicking once to set the starting point of the measurement, and a second time to set the end point. Although this implementation is multi-modal, our testers considered this the most intuitive design. Another improvement to this tool could be pre-defined measurements. Depending on the current view of the object within the applet, a listing of common measurements could appear automatically when the measure tool is activated. This would save the user from having to manually collect the data with the standard tool. When the user clicks on an item from the list of pre-defined measurements, the selected area would highlight on the object, as shown in Figure 35. This list would be completely dynamic, so as the view of the object changed, the list would reflect the current related measurements.



Figure 35: Pre-Defined Measurements

Lastly, a major accessibility leap in 3-D applet design would involve making the applet compatible with screen reader software. Currently, the content of the applet is not detectable by screen readers like JAWS, rendering them useless while a user interacts with the applet. Hopefully this will change in the future, allowing for an enhanced experience for PWD.

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7 Appendices

A. Email Correspondence

A.1 Debra Ruh Thread (TecAccess)

Debra Ruh,

Thank you for your interest in the IQP project we are doing regarding 3-D software testing for people with disabilities. We would like to arrange an appointment with you to discuss some questions we have concerning accessibility issues. We will set up a conference room where we can conduct a phone discussion with you whenever you have some time. Please let us know what days and times you are available. We have included some questions that we would like to discuss with you, so that you can look them over if you would like. We suspect that many, if not all, of these questions have different answers depending on the disability of a particular user. Please feel free to give specifics if answering the question in general is not appropriate. We can go over these questions when we have the voice conference.

1. Even with the use of accessibility software and/or hardware what sort of computing tasks do people with disabilities have trouble doing? What sort of tasks can they not do at all?
2. In general, what kind of tasks do people with mental handicap or disability have trouble with when using a computer?
3. When replacing the common mouse as an input device, do you believe that people with motor / mobility problems have a preference for a certain device? More specifically, do you find that software that allows navigation via a keyboard is popular?
4. Is a certain browser preferred over another by people with disabilities? In the general population, Microsoft's Internet Explorer is used by nearly 75% of users; do you think this is true for disabled people as well?

5. Do you think that the mouse action of “drag and drop” is one that, in general, makes computers less accessible? Does existing technology make this an easy action for those with reduced motor control?
6. Do you believe people with disabilities take advantage of online shopping more or less frequently as people without disabilities? Are many, major commercial websites frustrating to use for the disabled?
7. When it comes time to test our proposed solutions to make Kaon’s technology more accessible, what sort of disabilities will the testers have?

Thank you very much for your help. We look forward to hearing from you.

Sincerely,

Blake, Jason, Paul, and Glenn

Sorry for the delay, I am sort of slammed. Would you like me to pass this to some of my team members that have disabilities for their comments? Here are my comments:

1. Even with the use of accessibility software and/or hardware what sort of computing tasks do people with disabilities have trouble doing? What sort of tasks can they not do at all?

Debra’s comments: With the right assistive technology (AT) and training people with disabilities can do any type of task. This has been proven many times. Also keep in mind that AT is not always software and hardware sometimes it is something as simple but valuable as a mouth stick or head pointer.

2. In general, what kind of tasks do people with mental handicap or disability have trouble with when using a computer?

Debra's comments: Just a quick note, be sure to always put the person before the handicap and the term mental handicap is now called cognitive disabilities. I say this just so you don't accidentally hurt anyone's feelings. Okay, back to the question: People with cognitive disabilities have problems with any program, website or product that uses difficult language, anything that has usability issues, and sophisticated navigation. It is hard to answer this question properly without more information because people with cognitive disabilities have such a large range. Someone that has the reading skills of a 1st grade level versus someone with reading skills at a 6th grade level will have different accessibility problems. However, regardless of their skill levels if the product or website hasn't carefully considered accessibility and usability it will cause problems for people with disabilities.

3. When replacing the common mouse as an input device, do you believe that people with motor / mobility problems have a preference for a certain device? More specifically, do you find that software that allows navigation via a keyboard is popular?

Debra's comments: In my opinion, the most popular is keyboard navigation but this is a question best asked to some of our testers with these types of disabilities.

4. Is a certain browser preferred over another by people with disabilities? In the general population, Microsoft's Internet Explorer is used by nearly 75% of users; do you think this is true for disabled people as well?

Debra's comments: Yes, I believe this is true, one of the main reason Internet Explorer works with most AT and Netscape has major accessibility issues and works poorly with most AT

5. Do you think that the mouse action of "drag and drop" is one that, in general, makes computers less accessible? Does existing technology make this an easy action for those with reduced motor control?

Debra's comments: "Drag and Drop" can be made accessible, certain rules must be followed but it can be done. Certain AT does exist that can help this action, it all depends on the disability. The best thing to do is to design 'drag and drop' to be accessible then the AT isn't as big an issue.

6. Do you believe people with disabilities take advantage of online shopping more or less frequently as people without disabilities? Are many, major commercial websites frustrating to use for the disabled?

Debra's comments: I believe that people with disabilities do take advantage of online shopping much more frequently than their peers without disabilities and studies have been done (I don't have them, you would have to search the internet for them but they have been done). The studies said that people with disabilities are online shopping 50% more than their non-disabled counterparts. Most major websites have started to address usability and some accessibility. When a site considers usability carefully this will help with accessibility. Much more work needs to be done, but major efforts are being made by the retailers that want to drive business to their websites. For example, we have done accessibility testing for Circuit City.

7. When it comes time to test our proposed solutions to make Kaon's technology more accessible, what sort of disabilities will the testers have?

Debra's comments: Our testers have many types of disabilities, all fall into one of these categories, upper or lower mobility impairment, visual impairment, hard of hearing or deafness, blindness or a combination of several disabilities.

Hope this helps, thanks Debra

Debra,

Thank you very much for taking the time to help us with this project, we greatly appreciate your expert input. If your testers would not mind answering the questionnaire, it would be great to get their feedback as well.

There are a couple of follow up questions we have as we move from the preliminary research into accessibility issues and start designing our usability / accessibility tests. We were curious if you have seen an example of Kaon's 3D imaging yet and if any accessibility issues immediately jumped out at you. Kaon has examples of their products on some major websites, such as Sony, Fisher-Price, and Dell.

Here are some links to some of Kaon's work. It would be great if you and your testers could give us your first impressions of the product in terms of accessibility, so that we may consider any problem areas when designing our usability test.

Fisher-Price:

http://www.fisher-price.com/us/powerwheels/racers/default_flash.asp

Click on Product Info

Click on one of the Cars

Choose "COOL 3D DEMO"

Dell:

http://www1.us.dell.com/content/products/productdetails.aspx/inspn_xps?c=us&cs=555&l=en&s=biz&~tab=viewstab#tabtop

Click on the Inspiron XPS 3D Tour link

Sony:

http://www.sonystyle.com/is-bin/INTERSHOP.enfinity/eCS/Store/en/-/USD/SY_DisplayProductInformation-Start;sid=ijtzJpNYgohzPtJgU2N5LdxIfIsMPLux-

[4s=?ProductSKU=DCRVX2100&Dept=dcc_DICamcorders&CategoryName=dcc_DICamcorders
_MiniDVHandycamCamcorders](https://www.audiovox.com/demos/VOX8610.html)

Click the 360 degree logo

AudioVox:

<http://www.audiovox.com/demos/VOX8610.html>

We also have questions in terms of how we should go about scheduling testers for the usability tests, and also what the costs are. Our sponsor, Kaon, has indicated they would be willing to compensate the testers for their time. Any information regarding these matters would be most helpful. Lastly, do you have any favorite books, resources, or tips, on how to set up / design a usability test / experiment?

Again, thanks in advance for your time.

Sincerely,

Blake, Glenn, Jason, and Paul

Hi Blake, Glenn, Jason, and Paul,

I am putting my testing manager in this loop. I will ask her to give us a quick quote of hours for our testers to review these links and products. We are happy to support the project but don't want to move forward with out everybody being on the same page about the test and the pricing. We will discount our pricing to help out the study and try to only charge costs. As far as the Usability questions, I am going to put Gordon Montgomery in this loop. Gordon is an international usability expert and he is in your backyard at least for right now in MA. He is relocating to Texas very soon. Anyway, when I need any information on usability, I turn to Gordon.

Tracy, Will you look at the links and the email string and give me and Rich your feedback. Let me know if you have any questions for the student team.

Gordon, Will you take a look at the email string and let the students know how you might be able to support their efforts.

Thanks, Debra

Debra Ruh

A.2 WPI Disability Services Office

JoAnn Van Dyke and Dale Snyder,

Myself and three other WPI seniors are in the middle of collecting information for our IQP, which deals with making improvements to web environments so that people inflicted with disabilities can navigate them. Seeing you deal with the issues that people with disabilities must confront, we thought you may have some input and suggestions for our research. We are particularly interested in problems that they may have dealing with keyboards and mice, especially when navigating the web, and any other Internet-related accessibility issues. If you have any free time, would it be possible to set up an appointment to meet with one of you? We would love to have some questions answered.

Thank you very much in advance for your help,

Blake Dunkel, Jason MacInnes, Paul Liberman, and Glenn Watkins

Hello,

I have some names of people on this campus as well as off that might be able to give you the information you are looking for.

WPI, please contact Prof. Hoffman. He and Prof Ault sponsored a workshop last May and probably would have the handouts from that program.

One of the presenters at the workshop is from Easter Seals and he shared a lot of information regarding adaptations to computers/ mice/ keyboard. His name is Jeff Mc Auslin and can be reached at (508) 757-2756.

Both Professor Ault and myself would be interested in reading your IQP when you are done.

JoAnn

JoAnn,

Thank you for your interest in our IQP. Our advisor is Prof. Eleanor Loiacono. We will try to contact Prof. Hoffman for our research, thanks for the tip. We have actually already sent an email to Jeff McAuslin and are awaiting a reply.

We will definitely send you and Prof. Ault a copy of our IQP when it is finished in B-term.

Thanks again for the information,

Blake

A.3 Edward LoPresti

[edlopresti@acm.org]

Mr. LoPresti,

I am writing as a member of an academic project at Worcester Polytechnic Institute regarding accessibility for Java applets, particularly applets that display a 3D visualization of a product. This project is being worked on by me and three other students, advised by Doctor Eleanor Loiacano, and sponsored by a company called Kaon, a leading provider of 3D imaging software for websites. Kaon's software is used by many Fortune 500 companies, including Sony, Dell, and Fisher Price. The goal of the project is to come up with solutions on how their Java applet can be made more accessible to people with disabilities, both physical and cognitive.

After looking over your research and interests, it is apparent that you are an expert in the area of web accessibility for people with cognitive disabilities. I am writing to inquire if you would be willing to correspond with us via email, and perhaps give us some feedback on how Kaon's 3D imaging software does in terms of usability for people with cognitive disabilities. If you would like more information on the project, or have any questions, please feel free to email.

Thanks in advance for your time.

Sincerely,

Jason MacInnes

Dear Mr. MacInnes,

I would be happy to provide some feedback on accessibility for Kaon's software. I don't know that I'd bill myself as an expert on web accessibility for folks with cognitive disabilities, I'm continually learning myself, but I'll be happy to share any insights based on what I've learned so far.

Best regards,

Ed

A.4 Other Correspondence

[jeffm@eastersealsma.org]

Mr. McAuslin,

Myself and three other seniors at Worcester Polytechnic Institute are currently working on a project called an IQP (Interactive Qualifying Project), the purpose of which is to solve a real-world social problem involving technology. Our advisor, Prof. Eleanor Loiacono, gave us your contact information, as your work deals directly with the subject matter we are researching. The goal of our project is to improve the issue of accessibility that people with disabilities face when they browse the internet, specifically when using interactive web applets. We would like to produce a set of recommendations developers can use when designing web pages or applets, so that individuals with disabilities can have a better and richer online experience. Right now we are researching accessibility issues they face online, and we were wondering if you would be able to meet with us in person or by teleconference to discuss this matter. We would be very appreciative

if you could give us some input. Please let us know if you have any time to lend us, and we can schedule a date for a discussion.

Thank you in advance for your help. We look forward to hearing from you.

Sincerely,

Blake Dunkel, Jason MacInnes, Paul Liberman, and Glenn Watkins

[jb@trace.wisc.edu]

To Whom It May Concern,

I am writing as a member of an academic project at Worcester Polytechnic Institute involving accessibility for Java applets, particularly applets that display a 3D image of a product. This project is being worked on by me and three other students, advised by Doctor Eleanor Loiacano, and sponsored by a company called Kaon, a leading provider of 3D imaging software for websites. Kaon's software is used by many Fortune 500 companies, including Sony, Dell, and Fisher Price.

My team members and I are currently in the process of reading over all of the recommendations on your site, nearly all of which is directly applicable to our project. I am writing to inquire if, during the course of our research that there may be a contact person at your organization willing to share their expertise on Java applet accessibility issues, if we were to have any questions. If there is anyone there who is willing to serve as a resource, we would be very grateful.

Thanks in advance for your time.

Sincerely,

Jason MacInnes

B. Implied Consent Form

INFORMED CONSENT TO TAKE PART IN A RESEARCH STUDY

TITLE OF STUDY: **Measuring difficulties people with disabilities face while interacting with Kaon's 3D Java Applet.**

INVESTIGATORS: **Blake Dunkel**
Paul Liberman
Jason MacInnes
Glenn Watkins

ADVISOR: **Prof. Eleanor T. Loiacono, Ph.D.**

SPONSOR: **Kaon Interactive, Inc**

Introduction

You are being asked to participate in a research study. It is important that you read the following explanation of the proposed procedures. This form describes the purpose, procedures, benefits, risks, discomforts, and precautions of the study, and your right to withdraw from the study at any time.

Purpose of Study

In this experiment, we wish to investigate the difficulties that people with disabilities face while using the 3D Java Applet provided by Kaon. This information will be collected and used to increase the accessibility of this Java Applet, as well as provide guidelines for future applet design.

Experimental Protocol

You will be given a set of tasks in both written and verbal form. For each task that is asked, you will need to attempt to perform that task to the best of your ability at your normal working pace. Between each task, you will be given a short break (about 1 minute) before you are asked to perform another task. There will be no more than 20 tasks that you will need to perform.

Benefit

There is no direct benefit to you.

Risks

There is some possibility of developing mental fatigue from the concentration that is required to complete a given task. Beyond that, the risks associated with this task do not extend beyond normal computer use.

Participation

Your participation in this study is voluntary. You are free to withdraw consent and discontinue participation at any time. You are free to seek further information regarding

the experiment at any time. The project investigators retain the right to cancel or postpone the experimental procedures any time they see fit.

Confidentiality

Records of your participation in this study will be held confidential so far as permitted by law. However, the study investigators, advisor, sponsor, and TecAccess will be able to inspect and have access to confidential data that identifies you by name. Any publication or presentation of data will not identify you.

Withdrawal

Data obtained in this experiment will become the property of the investigators and WPI. If you withdraw from the study, data already collected from you will remain in the study.

Questions

This study will be directly supervised by the investigators. Questions or comments about participation should be directed to Prof. Eleanor T. Loiacono, Ph.D. (508-831-5206).

You may also contact Debra Ruh (TecAccess) via email at druh@tecaccess.net or by phone at 804-749-8646.

Photography and Videotaping

You may be photographed or videotaped during this experiment. You will be informed when/if such recording is to occur. Videotapes and photographs will only be available to the principal investigators, advisor, sponsor and TecAccess. In addition, investigators

will make every effort to not include any identifying marks. These photographs and video records are the property of the investigators and WPI.

Cost/Payment

Cost and payment will be negotiated through TecAccess for this experiment.



PLEASE CAREFULLY READ THE DIRECTIONS BELOW BEFORE PROCEEDING

You are about to participate in a scientific experiment, and it is important that you follow the instructions given to you very closely. Please read each instruction below carefully. Failing to follow the instructions could taint the results of the test.

- Please **DO NOT** use your browser's Back button at anytime during the course of this experiment.
 - Please **DO NOT** use your browser's Refresh button at anytime during the course of this experiment.
 - Please **DO NOT** close your browser window at anytime during the course of this experiment.
 - Please **set aside at least 1 hour** of your time before starting. During this time, you should be free of any distractions, including instant messaging, email, telephone calls, or television.
 - Please carefully read all instructions you will receive during the course of the test.
- I have read and understand the instructions above, and have freed myself of distractions for the next hour. I am ready to begin the test.

C. Initial Test Instructions

Begin The Test

D. Pre-Test Survey



PRE-TEST SURVEY

Again, thank you for your time and for participating in this experiment. Please start by answering the following questions about yourself and your computer experience.

1. Full Name (optional):

2. Age:

3. Types of Disabilities you have: (check all that apply)

- Vision Impairment
- Poor Range of Motion
- Poor Motor Control
- Hand Tremors
- Color Blind
- Without Arms or Use of Arms
- Other:

4. If you have physical disabilities, please select the severity of your disabilities with a rating 1 to 5. If you do not have any disabilities, please select "No Disability":

(Slight) 1 2 3 4 5 (Severe) No Disability

5. How many hours per day (on average) do you spend on a computer?

6. Please select the types of technology that you frequently use while operating a computer:

- Standard Keyboard
- Standard Mouse
- Trackball Mouse
- One-handed Keyboard
- On-Screen Keyboard
- Custom Keyboard
- Speech Recognition Software
- Screen Magnifiers
- Head Stick
- Mouth Stick
- Eye-tracking / Head-tracking Device
- Touch Screen
- Screen Reader
- Filter Keys / Sticky Keys
- Other:

7. Please rate the difficulty you have performing the following computer actions with the help of your assistive technology, if any. If you have no experience performing a given action, please select "Don't know" for that action.

	No Difficulty	Slight Difficulty	Moderate Difficulty	Severe Difficulty	Impossible	Don't Know
a. Clicking a webpage link	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Entering the equivalent of keypresses on a keyboard, such as letters and numbers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Entering the equivalent of other keypresses on a keyboard, such as Tab, Escape, Alt, etc.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Entering the equivalent of multiple keypresses on a keyboard, such as holding down 2 keys at once	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Typing in a document	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Performing "drag and drop" actions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. Performing a "double click"	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h. Reading the text on this page	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

8. When using a computer, how often do you make use of keyboard shortcuts or hot keys instead of using the mouse to perform the same action?

- Never
 Rarely
 Sometimes
 Often
 Always
 Don't Know

9. How many purchases do you make online over the course of an average month?

10. Have you ever tried viewing 3-D models (pictures you can view in 3 dimensions) online?

11. If so, at what website(s) did you view them? (check all that apply)

- Dell
 Audiovox
 Nortel
 Ricoh
 SonyStyle
 Other:

12. Overall, did you have any difficulties when viewing them?

When you are finished, please click:

E. Pre-Test Submission Screen



**THANK YOU!
PRE-TEST SURVEY SUBMITTED!**

Thank you for filling out the survey. You are about to be presented with a 3-D model common to many large websites on the Internet. Underneath the model, you will see some instructions followed by a listing of 4 tasks. Please try to perform each of these tasks on the model in the order that they appear. If you cannot complete a given task, you may skip it and move on to the next task. Please note that it is up to you to determine when you are finished with a task. You will receive no message when a task is completed.

When you are ready to begin, please click on the link below.

[Begin with First Model](#)

F. Familiarization Applet



Instructions:

Please note that it is up to you to determine when you are finished with a task. You will receive no message when a task is completed. If you become stuck on a task, you may skip to the next one. When you have been through all the tasks below, please click on the "Continue" link at the bottom of the page.

Task #1: Rotate the camera all the way around to see the other side.

Task #2: Click on the "Tape" menu option on the left-hand side toolbar to see a demo of where the tape is inserted into the camera.

Task #3: Zoom in on the "Sony" writing found on the hand strap directly in front of the tape drive on the camera.

Task #4: Reset the view by using the Reset button located in the toolbar along the bottom.

[Continue](#)

G. Familiarization Survey

FAMILIARIZATION SURVEY

1. How long did you spend using the 3-D model?

2. Were you able to complete all the tasks given?

3. Do you feel familiar with these types of 3-D models now?

When you are finished, please click:

H. Familiarization Survey Submission Screen



FAMILIARIZATION MODEL TESTED!

You have finished familiarizing yourself with a 3-D model. The model you just used was not an actual test, but rather, was to familiarize you with the types of models you will be testing during the remainder of the experiment. However, as you proceed, please keep this last model in mind.

The remainder of the experiment will proceed as follows: You are about to be presented with 3 test models. Each model will display a set of 6 tasks, one at a time, at the top of the screen. After completing each task, click on the appropriate response button directly below the task instructions to proceed to the next task. If you would rather use the keyboard to activate the appropriate response button, simply type the letter that is underlined on the button's text. Please note that it is up to you to determine when you are finished with a task. You will receive no message when a task is completed.

After each of the 3 test models, you will be presented with a post-test survey. Fill out this survey to proceed to the next model. When you are ready to begin, please click on the link below.


[Begin with First Testing Model](#)

I. Test Applet 1

Move the laptop all the way to the left, until it is no longer visible.

Finished Task **Inaccessible Task** **Unsure How to Complete Task**

- LCD
- Memory
- Optical Drive
- Hard Drive
- Battery
- D/Module
- D/Port
- D/View
- D/View Adjust
- D/Monitor Stand



Measure Move Zoom Turn Reset



Please note, that it is up to you to determine when you are finished with a task. You will receive no message when a task is completed.

J. Post-Test Survey 1

POST-TEST SURVEY #1

Please answer the following questions about the applet you have just tested.

1. Please indicate how easy you found it to use the various actions and tools in the 3-D model you just tested. A rating of 1 means it was very simple and 5 means very difficult.

Action	Ease of Use					Don't Know
	Easy			Hard		
	1	2	3	4	5	
a. Zooming (bringing the model closer or further away)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Rotating (spinning the model)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Move (moving the model left and right, or up and down)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Measure (taking the distance between two points)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Feature Selection (using the text along the left-hand side)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Viewing what you wanted to on the model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. Switching between the controls (i.e. changing from the measure tool to the rotate tool)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h. Selecting the correct control	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
i. Reading the tasks, and understanding them	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

2. Would you use this 3-D model if you saw it on a website?

3. Did any parts of the 3-D model you just tested seem distracting to you?

4. If so, please explain in the box below what was distracting to you and why:

5. Any comments you may have on the 3-D model you just tested:

K. Post-Test Survey 1 Submission Screen

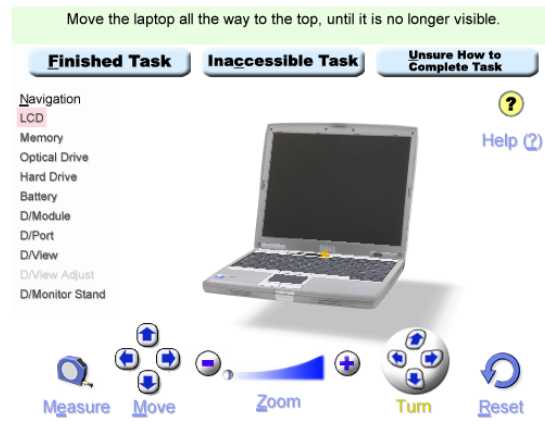


FIRST 3-D MODEL TESTED!

You have finished testing a model. As you proceed to the next model, keep the one you have just tested in mind. Try to make conscious comparisons between the 3-D models in terms of accessibility, usability, features, and overall design. Please note that it is up to you to determine when you are finished with a task. You will receive no message when a task is completed. When you are ready to continue, click the link below.

[Begin with Second Testing Model](#)

L. Test Applet 2



Please note, that it is up to you to determine when you are finished with a task. You will receive no message when a task is completed.

M. Post-Test Survey 2

POST-TEST SURVEY #2

Please answer the following questions about the applet you have just tested.

1. Please indicate how easy you found it to use the various actions and tools in the 3-D model you just tested. A rating of 1 means it was very simple and 5 means very difficult.

Action	Ease of Use					Don't Know
	Easy			Hard		
	1	2	3	4	5	
a. Zooming (bringing the model closer or further away)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Rotating (spinning the model)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Move (moving the model left and right, or up and down)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Measure (taking the distance between two points)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Feature Selection (using the text along the left-hand side)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Viewing what you wanted to on the model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. Switching between the controls (i.e. changing from the measure tool to the rotate tool)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h. Selecting the correct control	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
i. Reading the tasks, and understanding them	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

2. Would you say the 3-D model you just tested is more accessible or less accessible than the first one?

3. Overall, would you say the 3-D model you just tested is better or worse than the first one?

4. On the 3-D model you just tested, did you make use of the Help button?

5. Would you use this 3-D model if you saw it on a website?

6. Did any parts of the 3-D model you just tested seem distracting to you?

7. If so, please explain in the box below what was distracting to you and why:


8. Any comments you may have on the 3-D model you just tested:

N. Test Applet 3

Move the laptop all the way to the bottom, until it is no longer visible.

Finished Task **Inaccessible Task** **Unsure How to Complete Task**

Navigation
LCD
Memory
Optical Drive
Hard Drive
Battery
D/Module
D/Port
D/View
D/View Adjust
D/Monitor Stand



Measure Move Zoom Turn Reset

The image shows a 3D interface for a task. At the top, a green instruction bar says "Move the laptop all the way to the bottom, until it is no longer visible." Below this are three status buttons: "Finished Task", "Inaccessible Task", and "Unsure How to Complete Task". A list of components is on the left, with "LCD" highlighted in pink. In the center is a 3D model of a laptop. At the bottom are five tool icons: "Measure" (a magnifying glass), "Move" (a blue square with a white arrow), "Zoom" (a blue wedge), "Turn" (a blue sphere with a white arrow), and "Reset" (a blue circular arrow).

Please note, that it is up to you to determine when you are finished with a task. You will receive no message when a task is completed.

O. Post-Test Survey 3

POST-TEST SURVEY #3

Please answer the following questions about the applet you have just tested.

1. Please indicate how easy you found it to use the various actions and tools in the 3-D model you just tested. A rating of 1 means it was very simple and 5 means very difficult.

Action	Ease of Use					Don't Know
	Easy			Hard		
	1	2	3	4	5	
a. Zooming (bringing the model closer or further away)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Rotating (spinning the model)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Move (moving the model left and right, or up and down)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Measure (taking the distance between two points)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Feature Selection (using the text along the left-hand side)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Viewing what you wanted to on the model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. Switching between the controls (i.e. changing from the measure tool to the rotate tool)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h. Selecting the correct control	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
i. Reading the tasks, and understanding them	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

2. On the 3-D model you just tested, did you ever use the keyboard instead of the mouse to manipulate the model?

3. Would you use this 3-D model if you saw it on a website?

4. Did any parts of the 3-D model you just tested seem distracting to you?

5. If so, please explain in the box below what was distracting to you and why.

6. Any comments you may have on the 3-D model you just tested:

7. Please rank the three 3-D models you tested in terms of accessibility:

	Worst	Neutral	Best
First 3-D Model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Second 3-D Model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Third 3-D Model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

8. Please rank the three 3-D models you tested in terms of overall best:

	Worst	Neutral	Best
First 3-D Model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Second 3-D Model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Third 3-D Model	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

When you are finished, please click:

P. Thank You Screen



**THANK YOU!
YOU HAVE COMPLETED THE EXPERIMENT.**

We would like to thank you for investing your time to take part in this experiment. We hope to use this test data for our research in targeting problematic areas in 3-D (model) applet design. These types of applets are becoming more and more prevalent on the Web, and we hope to aid companies in developing user-friendly interfaces that are accessible to all. Thanks again for your contribution.

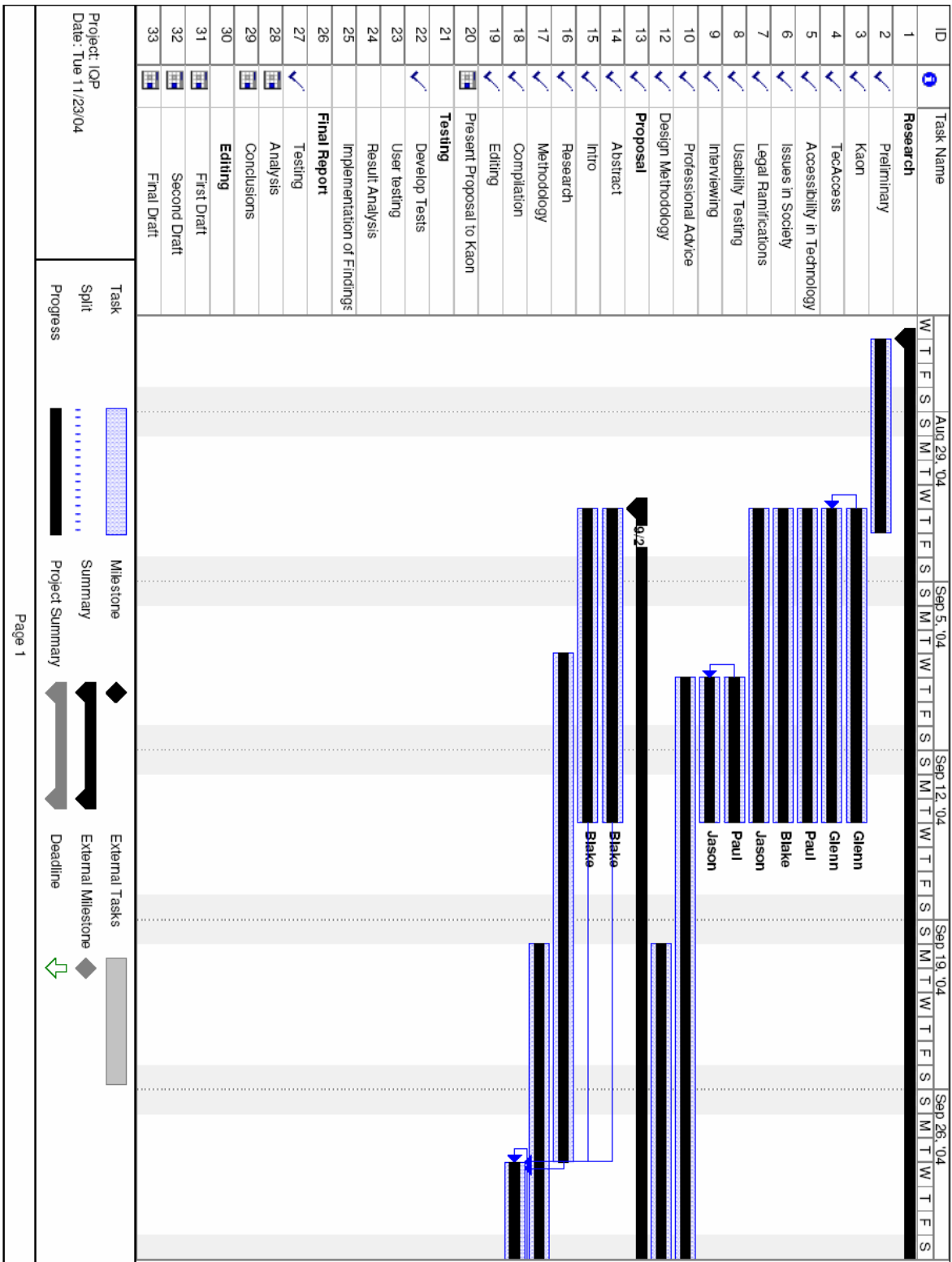
If you have any questions or comments regarding this experiment, please feel free to contact us at ouriqp@wpi.edu.

Q. Keyboard Mappings

Note that all arrow keys work both for the directional arrows, or the keypad arrows.

KEY	MODE	ACTION
W	Any	Object moves up
A	Any	Object moves left
S	Any	Object moves down
D	Any	Object moves rights
I	Any	Object rotates up
J	Any	Object rotates left
K	Any	Object rotates down
L	Any	Object rotates right
Space	Any	Mode is switched to next mode.
E	Any	Mode switched to measure
M	Any	Mode switched to move
Z	Any	Mode switched to zoom
T	Any	Mode switched to turn
R	Any	Object is reset
H	Any	Brings up help box
B	Any	Mode switched to side bar
Down Arrow	Side Bar	Next list entry is highlighted.
Up Arrow	Side Bar	Previous list entry is highlighted.
Enter	Side Bar	Activates sidebar entry
Down Arrow	Move	Object moves down
Up Arrow	Move	Object moves up
Left Arrow	Move	Object moves left
Right Arrow	Move	Object moves right
Down Arrow	Turn	Objects turns down
Up Arrow	Turn	Object turns up
Left Arrow	Turn	Object turns left
Right Arrow	Turn	Object turns right

R. Gantt Chart



ID	Task Name	Oct 3, '04							Oct 10, '04							Oct 17, '04							Oct 24, '04							Oct 31, '04							Nov 7, '04						
		S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
1	Research																																										
2	Preliminary																																										
3	Kaon																																										
4	TecAccess																																										
5	Accessibility in Technology																																										
6	Issues in Society																																										
7	Legal Ramifications																																										
8	Usability Testing																																										
9	Interviewing																																										
10	Professional Advice																																										
12	Design Methodology																																										
13	Proposal																																										
14	Abstract																																										
15	Intro																																										
16	Research																																										
17	Methodology																																										
18	Compilation																																										
19	Editing																																										
20	Present Proposal to Kaon																																										
21	Testing																																										
22	Develop Tests																																										
23	User testing																																										
24	Result Analysis																																										
25	Implementation of Findings																																										
26	Final Report																																										
27	Testing																																										
28	Analysis																																										
29	Conclusions																																										
30	Editing																																										
31	First Draft																																										
32	Second Draft																																										
33	Final Draft																																										

Project: IOP
Date: Tue 11/23/04

Task Split
Progress

Milestone Summary
Project Summary

External Tasks
External Milestone
Deadline

ID	Task Name	Nov 14, '04							Nov 21, '04							Nov 28, '04							Dec 5, '04							Dec 12, '04						
		T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S			
1	Research																																			
2	Preliminary																																			
3	Kaon																																			
4	Tacacass																																			
5	Accessibility in Technology																																			
6	Issues in Society																																			
7	Legal Ramifications																																			
8	Usability Testing																																			
9	Interviewing																																			
10	Professional Advice																																			
12	Design Methodology																																			
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14	Abstract																																			
15	Intro																																			
16	Research																																			
17	Methodology																																			
18	Compilation																																			
19	Editing																																			
20	Present Proposal to Kaon																																			
21	Testing																																			
22	Develop Tests																																			
23	User testing																																			
24	Result Analysis																																			
25	Implementation of Findings																																			
26	Final Report																																			
27	Testing																																			
28	Analysis																																			
29	Conclusions																																			
30	Editing																																			
31	First Draft																																			
32	Second Draft																																			
33	Final Draft																																			

Project: IOP
 Date: Tue 11/23/04

Task Split Progress
 Milestone Summary Project Summary
 External Tasks External Milestone Deadline

S. Public Relations Website Homepage



Old Version 20%



Improved Version 80%

Kaon Interactive, the industry leader in developing rich, high resolution 3D models, has teamed up with Worcester Polytechnic Institute (WPI) to advance the accessibility of their web based software. The project, undertaken by four Kaon sponsored WPI students, included [research](#), [implementation](#), and [testing](#) on various methods of improving overall accessibility and usability. The end result is 3D imaging software that has [proven to be better](#) in studies.

Explore this website to learn about the new accessibility technology in Kaon's interactive 3D Images, the results of the WPI student group's research, as well as more about Kaon and WPI.

Explore this Website

- [View the accessibility recommendations and testing results of the student group](#)
- [View the new recommended 3D image.](#)
- [Learn more about Kaon Interactive](#)
- [Learn more about Worcester Polytechnic Institute](#)

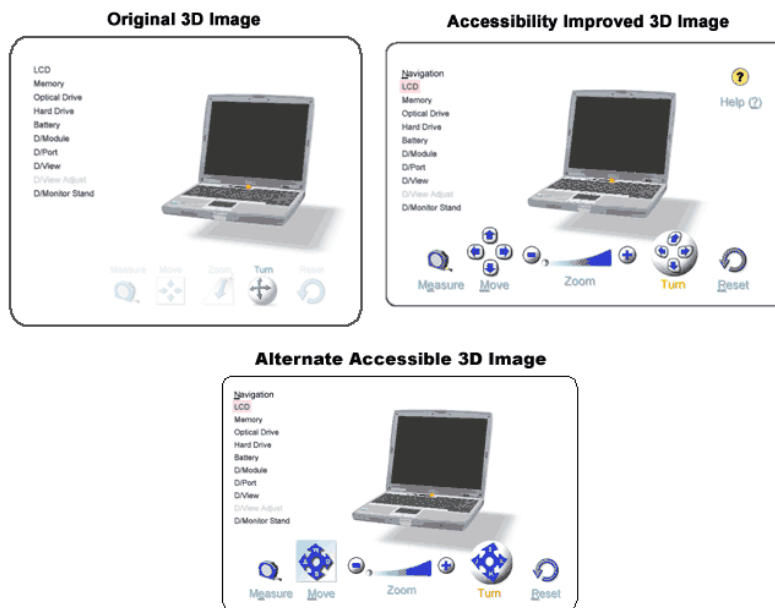


T. Public Relations Website Demo Page



View the 3D Images

Please select which 3D image you would like to view



Learn More about the 3D Images

Read about the differences between the two 3D images:

- [The Original 3D Image and Areas of Improvement](#)
- [The New and Improved 3D Image](#)



U. Public Relations Website Results Page



The Results...

The end goal of Kaon's partnership with WPI was to produce and implement a set of recommendations on how to improve the accessibility level of their industry leading 3D imaging technology. The task of accomplishing this goal was left to four WPI students. Under the advisement of WPI faculty member [Doctor Eleanor Loiacono](#) as well as [Kaon Interactive](#) chief information officer Joshua Smith, seniors Blake Dunkel, Paul Liberman, Jason MacInnes, and Glenn Watkins under took the research, development, and testing of accesibility improvements.

To learn more about what the student group researched and implemented, click a link below.

- [The Original 3D Image and Areas of Improvement](#)
- [The New and Improved 3D Image](#)
- [The Study: Testing and Evaluating the Recommendations](#)

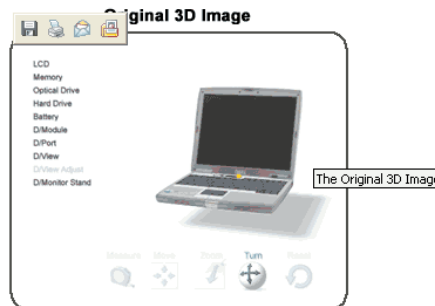


V. Public Relations Website Original Image Page



The Original 3D Image and Areas of Improvement

The first step toward creating a new and more accessible 3D image was to evaluate the problem areas of the current technology. Identifying the issues involved extensive research on how people with disabilities use computer technology. The students used all of the information available to them, including internet resources, books, and interviews with experts. When learning about various types of accessibility technology, the project was fortunate to benefit from the help of Jeff McAuslin, an accessibility expert at [Easter Seals](#) who helps teach people with disabilities learn how to operate a computer. After extensive research, a list of problematic areas was compiled. The original 3D image is pictured below.



The Recommendations

After reviewing the current applet, the following accessibility issues were identified.

- **Increase Button Size**
In the original 3D image, many of the buttons used to turn, rotate, and control the view are very small. As a result of the button's small size, a great deal of hand-eye coordination is needed to use the controls accurately. This poses a problem to some people with certain disabilities, especially those with a motor control impairment.
- **Improve Keyboard Control**
During the research phase, it was noticed that many actions that a user may attempt when using the 3D image must be done using the mouse. However, many people with disabilities would prefer to use a keyboard nearly exclusively over a mouse or alternative cursor control device.
- **Provide Alternatives to Drag and Drop Actions**
When reviewing accessibility technology with Easter Seal's Jeff McAuslin, the computing action that stood out far and away as most difficult to accomplish when using alternative technologies was the motion of "drag and drop". The original 3D image used drag and drop several different ways. In fact, the action was a necessity if a viewer wished to use the measure tool on the 3D image.

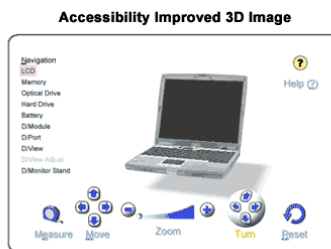
[← Back to Results](#) | [Read about the Improved 3D Image](#) [→](#)

W. Public Relations Website Improved 3D Image



The New and Improved 3D Image

After reviewing the original applet and identifying its accessibility problems, the WPI students put their engineering background to work and implemented their recommendations into the existing software. The new 3D image is pictured below.



The Recommendations

Many changes and improvements went into the new, accessibility improved 3D image. Below is a summary of the changes, and why each one is important.

- **Increased Button Size**
The new 3D image has buttons and controls that are over 50% larger than the original's. This means that less precision is required to accurately click and use them. As a result, people with poor hand eye coordination or a lack of motor control will find it less frustrating to use the new applet.
- **Complete Keyboard Navigation**
Worked into the new 3D image is the ability to accomplish nearly every user action using nothing but the keyboard. All of the control's descriptions have a letter which is underlined symbolizing that control's hotkey. Also, a new help button was added so that an interested user could easily learn how to use the keyboard controls. Keyboard navigation is important because some people with disabilities find it much easier to operate than a cursor device, such as a mouse.
- **No Drag and Drop Actions Required**
The action of drag and drop is no longer required to perform any action in the 3D image. The original software forced the user to perform a drag and drop motion to use the measure tool. This tool was reworked and is now more accessible. Also, as a result of the larger control buttons and the more prevalent keyboard navigation, users are now more aware that they can use the control buttons or the keyboard to accomplish a task that can also be done via drag and drop.
- **Improved Zoom Tool**
The original 3D image software had a zoom control which is slightly confusing. Also, it requires precise mouse clicks to operate. The control was reworked to be more intuitive and require less hand eye coordination.
- **Larger fonts and Increased Control Visibility**
All of the fonts used in the accessibility improved applet have been increased in size to allow for easier reading. Also, in the original applet the controls fade and become opaque when the mouse is not hovered over them. This feature was removed from the new applet because of concerns it would make it more difficult to use by those with a vision impairment.

[← Back to Results](#) | [Read about the testing](#) →

X. Public Relations Website Testing Results



Testing and Evaluating the New 3D Image

After researching and considering improvements that could be made to the 3D image, and following the implementation of the new recommendations into the existing software, the next step in the project was to evaluate and test the new 3D image. How would it compare to the old one? Would the changes make a difference for people with disabilities? A study designed and conducted by the WPI student group found that the answers to these questions were resoundingly clear.

The Study

To study the effects of their recommendations and to compare the new and original 3D image the WPI student group once again fell back on their technical expertise. By constructing an advanced testing website, the students made it possible for anyone with a computer and an internet connection to participate in the experiment. First, the site walked participants through a set of explicit instructions. Next, each tester was asked to complete a series of tasks for each of three different 3D images. The three 3D images were the original one and two different versions created by the students. The third 3D image is pictured below.



In addition to asking the testers to use the 3D images, the site also asked them to fill out a survey after using each of the three 3D images. These surveys were particularly important as they revealed the user opinion about the strengths and weaknesses of each version of the software.

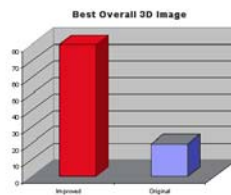
The Testers

The study was taken and completed by approximately 30 people over a 2 week period. Of the participants who finished the study, 9 of them identified themselves as having some sort of disability. Four of the people with disability were accessibility experts who were hired by Kaon Interactive to participate in the study. These test participants work for a company called [TactAccess](#). This company offered lots of valuable advice and assistance during the course of the project.

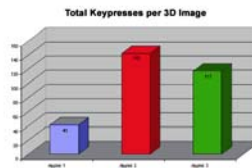
Study Results

So what did the testers say? After pouring over the large amount of data gathered by the testing website and performing an extensive analysis, there was a very simple conclusion to be made - the new 3D image was widely considered to be significantly better than the original one.

During the study, participants were asked to indicate which 3D image they thought was the best both in terms of overall performance and design as well as in terms of accessibility. In both categories, the general population preferred the new 3D image over the old one almost 4 to 1. Perhaps more importantly, people with disabilities preferred the new 3D image unanimously. Below is a chart of the results:



Besides just qualitative feedback, the data recorded by the testing site also showed that users found it easier to use the new 3D image. On average, testers spent less time performing the various tasks in the new 3D image. They also clicked the mouse less times than they did in the original. People with disabilities also took advantage of the keyboard features much more often. A chart of how many key presses were recorded in total for each of the 3D images is shown below.



The end result of this research and analysis is a 3D image that has improved upon an already rich and impressive 3D image software. It is the hope that the research done here can be applied beyond Kaon's 3D imaging software and can serve as a guideline of what to do and what to avoid in developing rich web based media.

[Back to Results](#)