

DETERMINING EFFECTIVENESS OF VISUAL DISABILITY GUIDELINES

PRESENTED ON A MULTIMEDIA WORKBENCH

by

Tim J. Al-Molky

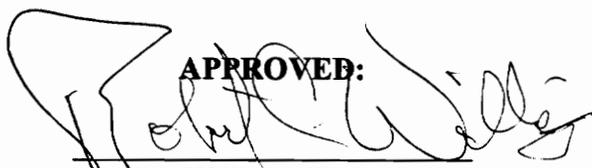
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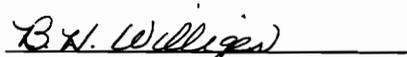
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# **Determining Effectiveness of Visual Disability Guidelines Presented on a Multimedia Workbench**

by

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## **(ABSTRACT)**

The research was conducted using a 2 x 2 between subjects design to compare the effectiveness of two methods of instructional training. The first factor was gender of the subjects. The second factor was presentation. A printed text presentation (control condition) was compared to a computer based multimedia presentation with redundant audio (experimental treatment). The experimental treatment was set up as a workbench to present guidelines to developers of computer equipment and software for the visually impaired. The guidelines were presented and then illustrated through pictures, sound, animation, and quicktime video. Each condition was measured for its effectiveness in increasing knowledge in the subject area and positively influencing attitudes toward the blind and disabled. The experiment was conducted as follows. To counter any possible gender/computer variables, forty subjects of similar knowledge, skills, and computer abilities were recruited. Subjects received three pretests in the order listed; an Attitude Toward Blindness (ABS) questionnaire, an Attitude Toward Disabled People (ATDP) questionnaire, and a pretest on the research material. Training subjects then completed either the printed text or the multimedia with redundant audio presentation. Following the presentation of the study material the subjects completed three posttests in the order listed; a posttest on the research material, an ATDP questionnaire, and an ABS questionnaire. It was hypothesized that subjects would spend a significantly longer time studying the multimedia material because of interest and motivation. It was also hypothesized that the multimedia condition would produce significantly higher results in the knowledge test and significantly improve attitudes toward the visually impaired and disabled. The knowledge scores and the study times were recorded, analysis of variance was used to analyze the results. The analysis showed that there were no significant effects for either gender or presentation for knowledge posttest scores, although the difference between pretest and posttest for all groups was significant, indicating effective training. Females took significantly less time to complete the second attitude pretest and two attitude posttest questionnaires. Subjects who were exposed to the multimedia presentation finished the posttest significantly faster. And multimedia subjects spent significantly longer studying the material and completing the experiment. The attitude questionnaires were scored, treated as nonparametric data, and analyzed using a Kruskal-Wallis test. No significant pretest to posttest changes in attitude resulted, although both groups of females (printed text and multimedia) held more favorable posttest attitudes toward the disabled in general than did males exposed to the printed text presentation.

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## INTRODUCTION

The goal of this research work was to develop and test the training efficacy of a computer based multimedia "accessibility workbench" to be used by people who design systems for the visually impaired and blind. The workbench demonstrated, through the use of examples, the implementation of generic design guidelines and dispensed fundamental knowledge about visual impairment and blindness.

The availability and use of computer hardware and software have progressed at a tremendous rate. This is evidenced by the growth in computers both at work and in the home, and the increase in public terminals such as automatic teller machines, public telephones, airline and rail arrival-departure displays, ticketing machines, information-retrieval systems, and order-entry terminals (such as at restaurants). The growth has been both a blessing and a curse as many of the systems incorporate graphics and touchscreens. The positive aspect has been a greater accessibility by the general population to computers that are easier to use. The ease of use is specifically related to the development of the Graphical User Interface (GUI). Unfortunately, this poses an accessibility problem for two distinct, yet related, populations; the aged/elderly (those over 65 years of age) and the visually impaired and blind.

This new and continued design direction has impacted negatively on the visually impaired and blind population. In the early days of the text based DOS system of computers, with software applications generally limited to word-processing, there existed rudimentary speech and screen reading software that allowed the visually impaired and blind user to hear the screen presentation. With the advent of intricate icon/object oriented displays created by GUI software the visually impaired and blind are again suffering setbacks. These setbacks affect the individual's quality of life in both pleasure and employment.

For whom is this a problem? It is first a problem for the age group 65 years and older. It is a population that will grow tremendously in just the next 10 years. With an increase in age comes a decrease in sensory function, particularly vision. This is a sensory requirement that strongly affects the ability of the elderly to maintain independent productive lifestyles as they pursue the activities of daily living. A second group is the visually impaired of working age and school age. In the normal working environment there is an immense reliance on computers to complete tasks. There exists a need then for designers to dedicate effort and resources to develop user friendly software and hardware for both the aged, and visually impaired populations. It is hoped that by introducing designers to a computer based "accessibility workbench" that presents accessibility guidelines through actual experience, designers will be led to a better understanding of the unique design requirements for a visually impaired user. However, despite the proliferation of multimedia there exists only a small body of evidence to support the claims of increased rates of learning transfer through use of multimedia.

This research compared differences between a printed text presentation, and a generic multimedia presentation of an "accessibility workbench" that presents generic guidelines for the effective design of products and computers for the disabled. The multimedia presentation made extensive use of a sound presentation concept known as redundant audio. The comparison was made by determining whether significant gains were obtained in original learning of general knowledge of both verbal and intellectual skills through the use of a pretest and a posttest. As a secondary measure, data was collected to determine if gains could be achieved in motivating users to become more positive in their attitude toward the blind.

The expected result of the treatment conditions is an increase in knowledge as measured by performance on a posttest. As a corollary, it is expected that there will be an increase in positive attitude as indicated by scores obtained from a standard attitude measurement scale.

**Key Words:** Accessibility, Blind, Design Guidelines, Disabled, Multimedia, Multimedia Guidelines, Multimedia Workbench, Redundant Audio, Vision, Visually Impaired.

## BACKGROUND

### Vision

Vision - Importance. Vision is very important to all our daily lives, particularly to the older generations as they pursue the activities of their daily living (ADL's). A key subset of the ADL's is listed as an Index of Independence in Activities of Daily Living; bathing, dressing, toileting, transferring, continence, feeding, communication, grooming, visual capability, walking, and the use of the upper extremities (combined list from Katz, Downs, Cash, and Grotz, 1970, and Ham, 1991). Aging individuals fear loss of sight more than the decline of other body functions. Visual capability is considered a minimum capability for independence in the activities of daily living. Keeping one's sight is equated with continuing independence and interaction with one's environment, enjoyment of life, and communication with others (Faye, 1986, and Nagler, 1993). Yet, diminished eye function is an inevitable consequence of aging, although age-related changes are not uniform nor do they proceed at the same rate. The most common problems are seen in Table 1 below.

Table 1.  
Areas of Visual Impairment  
(Faye, 1986)

1. **Reduced Contrast and Image Resolution:** Conditions that reduce contrast are those affecting the optical media; corneal disease, iris abnormalities, lens and vitreous opacities. These conditions affect light transmission adversely causing scatter and veiling glare. Contrast is reduced resulting in blurring of overall detail. Patients complain of poor contrast and glare.
2. **Central Field Defects:** Macular degeneration accounts for more than 60 percent of referrals for low vision evaluation. When the specialized function of the fovea and macula are disrupted by degeneration of photoreceptors, by hemorrhage or by scar formation, the ability to see detail is permanently impaired. Typically patients cannot read or write fluently, can't see signs or distinguish features. Colors may appear faded. Fortunately, peripheral vision is retained.
3. **Peripheral Field Defects:** Older persons with glaucoma, optic neuritis, stroke affecting the eye have difficulty getting around. Persons with intact central fields are able to read, but may become too laborious to remain an important mode of information gathering.

There are biological, psychological and social changes that occur with age and have an impact on the older person's ability to function but do not necessarily result in disability (National Research Council, 1987), but can lead cumulatively to significant visual deterioration in older people. Consequently, most of us can expect to experience one or more of the following moderate changes in our vision (Nagler, 1993, and National Research Council, 1987), as seen in Table 2:

Table 2.  
Changes in Vision Associated with Aging

1. Reduction in pupil size.
2. Decrease in focusing ability (loss of accommodation).
3. Increased sensitivity to glare.
4. Decline/Decreased ability to see objects clearly (visual acuity).
5. Need for greater illumination.
6. Difficulty adapting to darkness and brightness.
7. Restricted/Narrowing field of vision.
8. Deficient gaze stability.
9. Decline in color vision/color discrimination.
10. Color contrast sensitivity.
11. Slower speed in visual processing.
12. Decreased perception.
13. Difficulty reading, particularly small print.

While 13 percent of older adults have some vision impairment, only 3 percent of all Americans 65 and over are totally blind. However, the rate of severe visual impairment increases steadily and dramatically with age. See Figure 1 below.

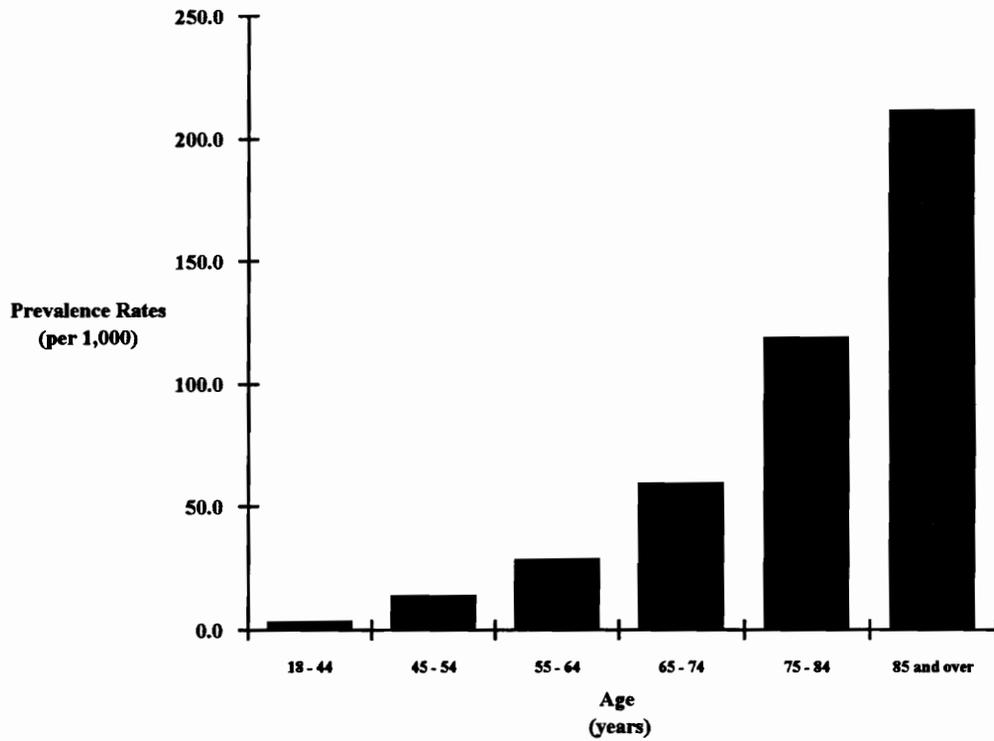


Figure 1.  
Severe Visual Impairment  
(PirkI, 1994)

**Vision - Numbers Affected.** The estimates of the number of persons with visual problems vary from 1.3 to 8.6 million (Vanderheiden and Vanderheiden, 1991). Despite the disparity in the prevalence estimates, there is general agreement that, the incidence and prevalence of visual impairment increase with age. For the first time in history, there are more Americans over 65 than under 25. Moreover, the median age in the United States, now 33, is expected to rise to about 44 by the year 2080. Today, 50 million middle-aged baby boomers are approaching the threshold of senior citizenship. Between 2010 and 2030, they will join the ranks of "the elderly", over age 65, and swell our country's older population from about 12 percent today to 20 percent when they reach retirement age (Pirkl, 1994, and Rosenthal, 1986) with the greatest amount of growth in the age group of 85 years and older (Rosenthal, 1986). Figures 2 and 3 give an indication of these projected figures.

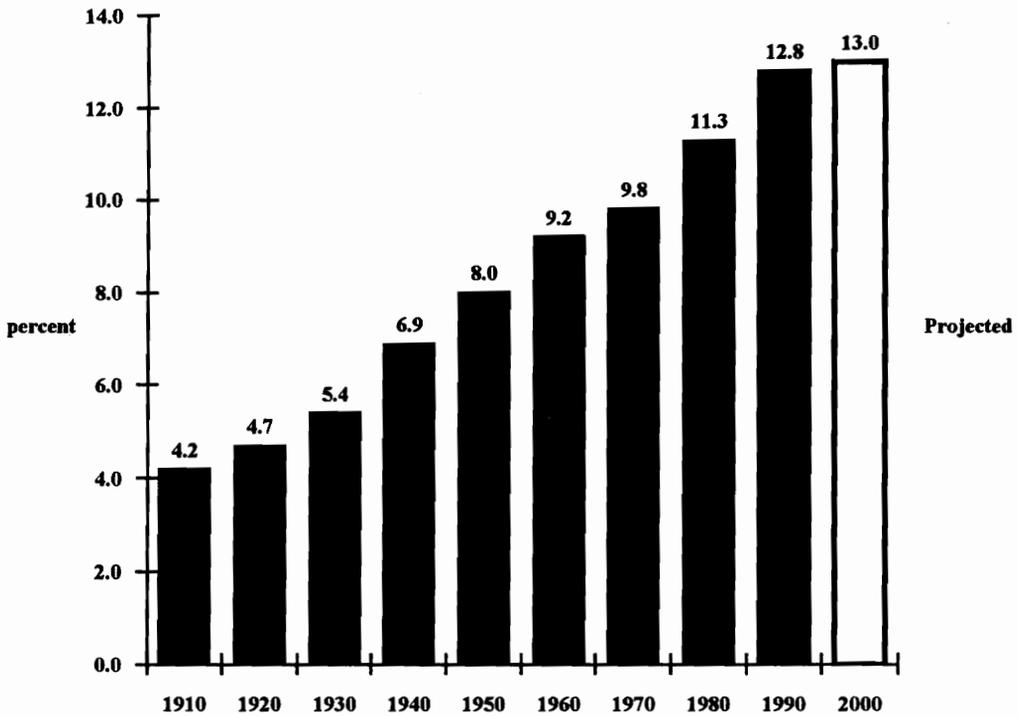


Figure 2.  
Percent of Total U.S. Population Age 65 and Older  
(Pirkl, 1994)

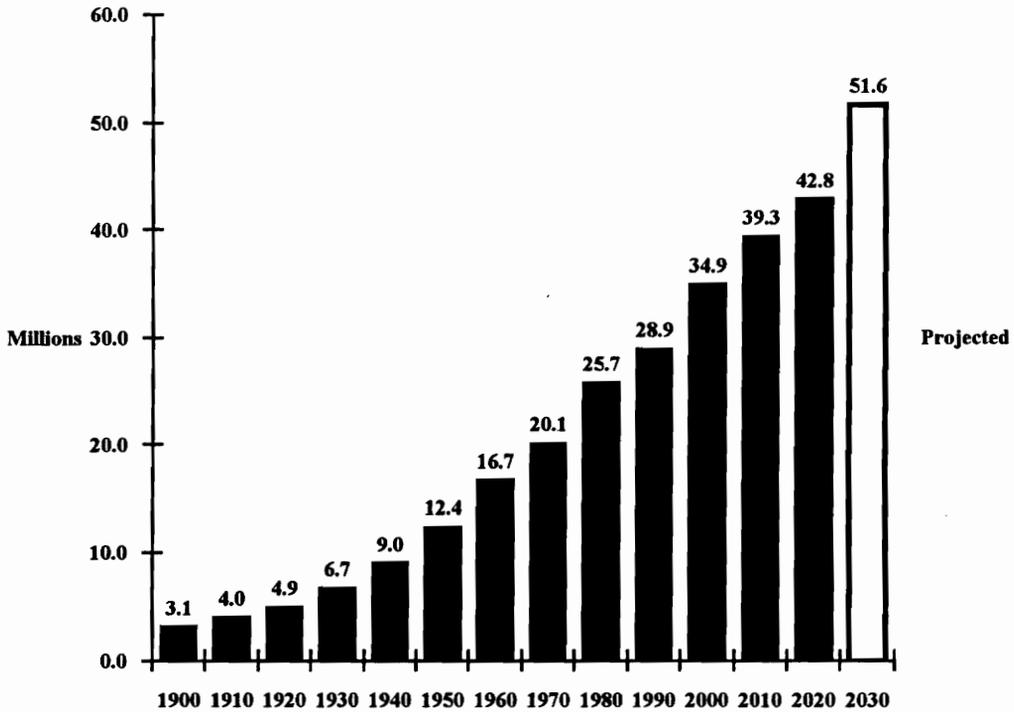


Figure 3.  
Population Age 65 and Older  
(Pirkl, 1994)

Not only are the numbers of older people increasing but the American population is also living longer as life expectancy increases dramatically (Nelson and Dimitrova, 1993). According to the National Center for Health Statistics, a newborn infant has a life expectancy of 75.6 years. In the year 2000, it will be 77.0 years. See Figure 4 below.

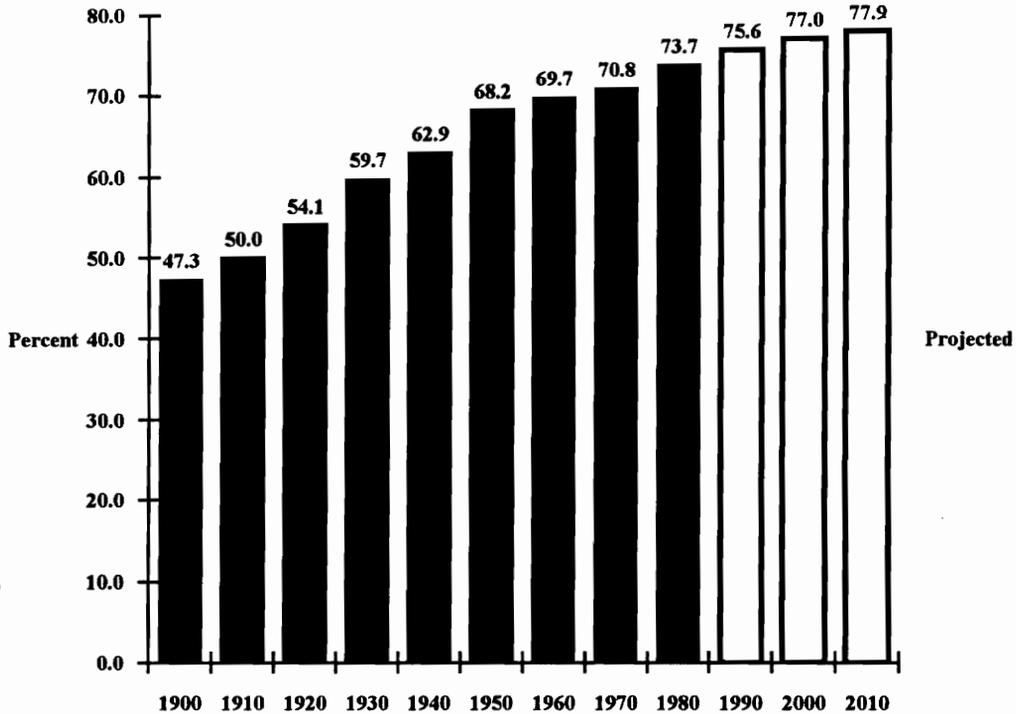


Figure 4.  
Life Expectancy at Birth  
(Pirkl, 1994)

Vision - Definitions. Most people think in terms of absolutes and in the minds of many individuals blindness is synonymous with blackness or the complete absence of light, and view the term "blind" as total disability (Dobree and Boulter, 1982). In reality this is a relative term and most people legally labeled "blind" have some sight. In general, less than one in ten of those officially listed as "blind" live in a state of complete darkness, and while 13 percent of older adults have some vision impairment, only 3 percent of all Americans 65 and over are totally blind (Dobree and Boulter, 1982). The majority remains able to perceive light and even large objects. So blindness may deprive its victims of sight, but not necessarily of light (Dobree and Boulter, 1982).

The National Society to Prevent Blindness (NSPB) reports its data in terms of visual impairments and legal blindness. Legal blindness is the most severe vision impairment category and is generally universally accepted as including persons whose degree of corrected vision in the better eye is 20/200 or poorer or a severely restricted field of vision of 20 degrees or less in the better eye (Rosenthal, 1986).

The standardization of the definitions used to describe persons with reduced vision has been an issue for a number of years. Using words such as "visually impaired" and "visually handicapped" interchangeably to describe persons with visual problems can lead to confusion in planning rehabilitation programs for persons with visual disabilities and in assessing their readiness to return to work (Scheer, 1990). Scheer, (1990), most elegantly details definitions for vision and offers the following definitions in Table 3.:

Table 3.  
Vision Definitions  
(Scheer, 1990)

1. **Visual disorder:** a specific pathologic condition or deviation from typical or normal eye structure caused by an injury, disease, or congenital condition.
2. **Visual impairment:** a limitation in the overall function of the eye. See Table 4 for levels of visual impairment that may be obtained from measures of the ocular system.
3. **Visual disability:** a limitation in an individual's ability to perform certain tasks that require either detailed or gross vision (e.g., reading, writing, orientation, or mobility).
4. **Visual handicap:** a visual condition that places the affected individual at a disadvantage because of the social, cultural, or physical environment in which the individual lives.

A visual disability becomes a visual handicap when it limits or prevents role fulfillment or performance that is normal for that individual. In spite of the efforts of the individual to compensate for the visual disability, factors beyond his or her control may transform the problem into a visual handicap. See Table 4 for a summary.

Table 4.  
Levels of Visual Disability  
(Scheer, 1990)

<b>Visual Disability</b>	<b>Effect</b>
<b>No</b>	
<b>Slight</b>	Can perform visual tasks without special aids (may require reduced reading distance, reading adds up to 4 D).
<b>Moderate</b>	Can reach near-normal performance with special aids (magnifiers, reading adds over 4 D).
<b>Severe</b>	Can perform visual tasks with aids but at reduced level (reading speed, reading endurance reduced).
<b>Profound</b>	Cannot perform most detailed visual tasks (reading), experiences difficulty with gross visual tasks (mobility), increased reliance on other senses.
<b>Near-total</b>	Vision unreliable; relies mainly on other senses.
<b>Total</b>	No vision; relies on other senses entirely.

Corn's three dimensional model (Figure 5) attempts to address the many factors needed for visual function. Although the dimensions of the model may vary for different individuals, minimum volume levels are needed to perform specific tasks (Scholl, 1986). It gives individuals the knowledge that despite an existing visual disability there are many factors that account for the use of sight, and therefore, there may remain several factors that can be addressed to make remaining sight usable.

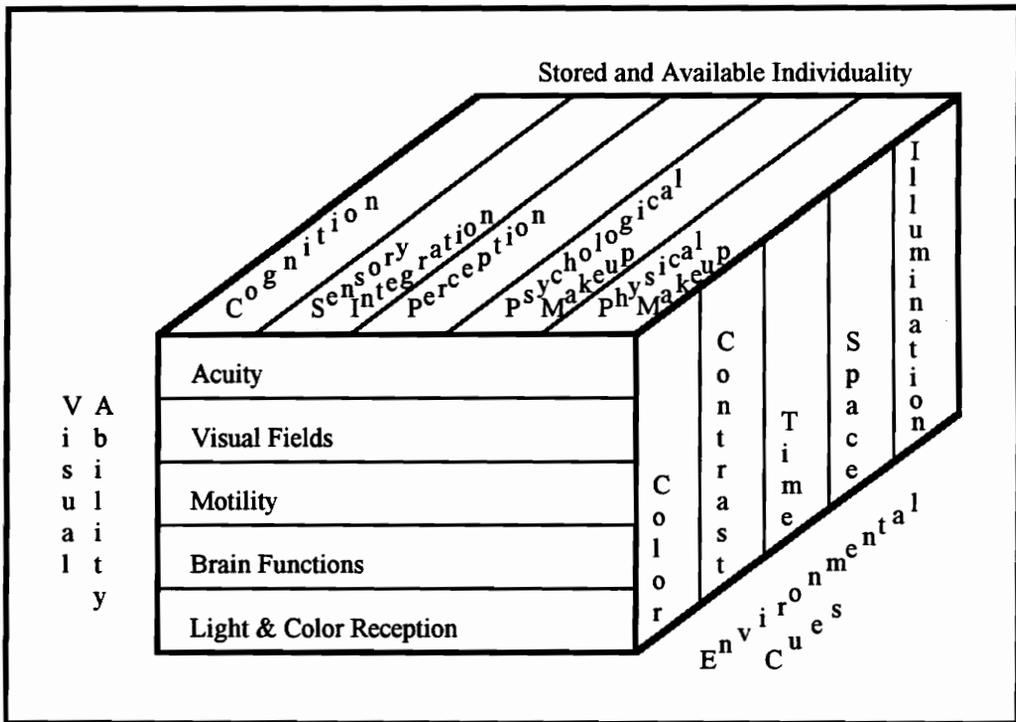


Figure 5.  
Corn's Model of Visual Functioning  
(Scholl, 1986)

Vision - Causes of Blindness. The four most common sites for afflictions leading to legal blindness are the retina, the eyeball as a whole, the lens, and the optic nerve and pathways. Although some people are born blind, (Dobree, and Boulter, 1982), in most cases blindness is the culmination of a lengthy period of gradual sight loss resulting from the progression of an eye disease (Scholl, 1986). And blindness as the result of an accident/injuries and poisonings, represents only a small proportion of the total number (Scholl, 1986).

Across all age groups, the leading causes of blindness are glaucoma, macular degeneration, senile cataract, optic nerve atrophy, and diabetic retinopathy (Scholl, 1986). These findings are summarized in Table 5 below.

Table 5.  
Leading Causes of Legal Blindness  
(Scheer, 1990)

Age Range	Leading Causes of Legal Blindness
20 - 44	<ol style="list-style-type: none"> <li>1. diabetic retinopathy,</li> <li>2. optic nerve atrophy,</li> <li>3. retinitis pigmentosa,</li> <li>4. optic neuritis, and</li> <li>5. macular degeneration.</li> </ol>
45 - 64	<ol style="list-style-type: none"> <li>1. diabetic retinopathy,</li> <li>2. glaucoma,</li> <li>3. senile cataract,</li> <li>4. macular degeneration,</li> <li>5. retinitis pigmentosa, and</li> <li>6. optic nerve atrophy.</li> </ol>

**Vision - Employment.** Blind and low vision individuals are successfully employed at every occupational level --for example, as scientists, engineers, secretaries, teacher, managers of businesses, laborers, and household workers. Nevertheless, many figures, (Kirchner, 1985, The Bureau of the Census, 1987, Nagler, 1993) show that there is a low level of participation in the labor force participation among the adult blind of employment age. Only one-third (33.6%) of working age visually impaired persons were in the labor force, the comparable figure for the United States population as a whole was 75%. This tells us that the problems associated with blindness in our society today are disproportionately concentrated among elderly persons, and among working age persons who are no longer in the labor force (Kirchner, 1985).

However, educators, business people, and legislators alike, are becoming increasingly aware of the need to bring persons with disabilities into the economic and social mainstream of American life (Brown, 1992). Many companies now acknowledge the validity of target-market "understanding", and make it part of their marketing. Hiatt (1987), predicts that "designs that accommodate and overcome sensory (and physical) impairments will become more acceptable".

The ADA is now a federal law that "prohibits discrimination on the basis of disability in places of public accommodation" and requires that all new places of public accommodation and commercial facilities be designed and constructed so as to be accessible to and usable by persons with disabilities (Pirkl, 1994). The Americans with

Disabilities Act of 1990 (ADA), Public Law 101-336, (ADA Handbook, 1990) is designed to ensure the integration of persons with disabilities into the mainstream of American society. This legislation prohibits discrimination against persons with disabilities in four major areas affecting the private sector: (1) employment, (2) telecommunications, (3) transportation, and (4) public services and accommodations.

And with particular dedication to the computer user, in 1986, Congress reauthorized the Rehabilitation Act (RA) of 1973, as amended, (Public Law 99-506) adding Section 508 on electronic equipment accessibility "to ensure that handicapped individuals may use electronic office equipment with or without special peripherals" (Brown, 1992).

The cost of support for people with disabilities is staggering. The United States spends \$119.9 billion a year through a variety of federal, state, and private support structures. That support comes in the form of Social Security Disability Income, Food Stamps, Medicaid, Medicare, Workman's Compensation, insurance company payments, and direct payments from companies. While Americans spend almost \$120 billion a year on support, we spend only \$3 billion a year on rehabilitation. Less than 3 percent of the money spent on people with disabilities goes toward creating independence and self-support structure for them (Castorina, 1994).

Vision - Making Changes. The key to appropriate development and use of technologies lies in finding a compromise fit between: (1) the needs, desires, and capabilities of users and other relevant parties, and (2) the costs, risks, and benefits of technologies (Office of Technology Assessment, 1982).

Pirkl (1994) suggests that the key issue is how designers, manufacturers, and care providers can best (1) help us remain active and independent as we grow older, (2) provide an environment that adapts to our changing sensory and physical needs, and (3) enable us to choose the means by which we accomplish our activities of daily living (ADL). Pirkl, (1994) offers four options to accomplish the goal. His fourth option, design at the outset for use by a transgenerational population, promises the availability of products and environments flexible enough to extend our independence supporting the changing physical and sensory needs we encounter as we grow older.

## **Visual Disability Guidelines**

**Guidelines - Making Changes.** Since Pirkel, (1994) offers an option of what can be done the question remains as to how best educate others to pursue such design. There are three principle categories of disabilities (Denno, Isle, Ju, Koch, Metz, Penner, Wang, and Ward, 1992):

1. Physical/motor limitations that impair an individual's ability to reach and manipulate controls.
2. Sensory limitations that impair an individual's ability to receive information and feedback.
3. Cognitive limitations that impair an individual's ability to process information.

This thesis generally addresses the second category and in particular concentrates on visual sensory limitations. There are unique challenges to the engineering and design of controls and displays for people with disabilities, for people with sensory limitations, adequate displays and feedback from devices are needed (Denno, et al, 1992). However, devices can be made user friendly for the elderly and those with disabilities by applying good human factors design principles. Extremely general guidelines such as the following present a rudimentary starting point for designers:

1. Use a minimized set of unique controls or keys and avoid the use of the same controls or keys for different functions.
2. Reduce the number of potential operating parameters while providing powerful functionality. For example, use the fewest and simplest set of steps necessary to accomplish a function and avoid unnecessary options.
3. Design operating procedures to be fault tolerant. For example allow entry of a sequence of inputs in any order.
4. Strive for standard operating procedures across dissimilar devices to promote consistency.

However, the above list highlights one of the problems with guidelines. Two characteristics of existing guidelines make the design of acceptable information displays for use by the disabled difficult are: (1) Guidelines are too narrow in focus, and (2) general human factors guidelines have been developed without due concern for the needs and abilities of the disabled (Ward, 1990). This has resulted in two philosophies of design, the design for the mean and ignore the extreme, and design for all (Ward, 1990). The design for the mean and ignore the extreme approach always leaves somebody out, and the design for all approach often results in products no one wants. This is the key to the thesis. Knowledge of the guidelines will be tested after training to determine the better training system.

It must be remembered that the guidelines are intended to ensure that the products designed, selected, and built by various manufacturers will be safe, convenient, and easy to use. They are not intended to establish specific and inflexible standards for device design; rather, to promote good design practice, and allow a variety of effective solutions to each design requirement.

Laws, such as the ADA, establish guidelines for access to electronic equipment in the federal workplace. But more must be done, the prevailing computer culture must be changed (Glinert, 1992). And this is where this thesis focuses its attention. There are many individuals and groups that through research have extended and refined guidelines. Their guidelines and general suggestions are enclosed in Appendix A. This represents the heart of the training system, but additional information will be gathered from the original sources by Vanderheiden, 1989, Vanderheiden, and Vanderheiden, 1992, Pirkl, 1994, and Denno, et al, 1992.

One might ask why is computer access or access to text information so important. Consider that all of the following often use text and graphics alone, often of very small size: computers, touch screen computers, phone systems with screen information, automatic ticketing machines in airlines, subways, and railways, automated teller machines at banks, on-line services, VCR's, microwave ovens, etc. The need for information is pervasive in our lives.

And although significant advances have been made in creating electronic devices to increase blind persons' access to text materials, some trends have the potential to decrease this new found accessibility. These trends include the growing use of graphical user interfaces (GUI's) and touchscreens. All the elements of the GUI are designed to provide a consistent interface with the computer and to minimize keystrokes by sighted users. However, they significantly complicate the screen review that is critical to blind persons (Dixon and Mandelbaum, 1990). The GUI has two components that greatly complicate the review of information on a computer screen: the icon and selection tools. The icon, a graphical representation of a concept, is a type of mnemonic device to minimize the user's reliance on memorized strings of commands. Selection tools that are not command driven, such as pull-down menus, scroll bars, and overlapping windows, are also designed to assist sighted users. In addition, most GUI's are designed for the use of "point-and-click" selection with a mouse (Dixon and Mandelbaum, 1990).

Touchscreens, a specially configured computer screen, translates the pressure of a finger on a particular part of the screen into specific commands. Although the touchscreen concept has limited flexibility, it is often used on computers in public locations to provide information to less computer-literate sighted users (Dixon and Mandelbaum, 1990).

The graphical user interface is a powerful new interface for mainstream computer users and a source of serious concern for those who cannot see. However, it is possible to design nonvisual interfaces to windows, menu bars, and pixel-based text. And it has also been demonstrated that tactile displays, combined with speech output, can provide direct access to simple graphics, charts, and diagrams (Boyd, Boyd, and Vanderheiden, 1990).

Guidelines - Cognitive Apprenticeships. Since accessibility guidelines exist but the knowledge of their existence and use is rare, it is apparent that instruction of designers is required. Wilson, and Cole (1991), present a training model they call the cognitive apprenticeship model. They compare this model among four differently oriented multimedia programs: (1) problem solving versus skill orientation, (2) detailed versus broad cognitive task analysis, (3) learner versus system control, and (4) error- restricted versus error-driven instruction.

They feel there are two reasons for the need of cognitive apprenticeships:

1. **"Lost apprenticeship"**: the need for high levels of expertise in supervising and using automated work systems is growing, while the need for entry levels of expertise is declining.
2. **Training opportunities**: fewer on-the-job training opportunities exist for entry-level workers. There is little or no chance for beginning workers to acclimatize themselves to the job, and workers are expected to perform like seasoned professionals very quickly.

### Learning and Multimedia (MM)

Learning and MM - Dimensions Incorporated. Given that there is instruction required to pass on the information contained in the guidelines it is important to discuss briefly multimedia has been selected as a training system. Gautsch quotes Marshall McLuhan's daunting phrase "The Medium is the Message" where he warns: "this is a 'new environmental implosion' transforming people whose senses are working overload with the modern electronic media". Each new wave of educational technology advancement has raised hopes for the promotion of higher levels of achievement in student learning (Carlson, 1991). Carlson goes on to mention that in 1940, Johnson wrote about the exemplary effect moving pictures would have in history instruction and that later, programmed learning and computer-assisted instruction promised individualized instruction for students. Today, interactive multimedia (IMM), which combines videodisc with its moving sequences and still visuals with two audio tracks and a computer, is proposed as the solution to many learning problems (Carlson, 1991).

According to Schroeder, (1991), hypermedia provides at least three distinct advantages to the learner; (1) its abilities to adapt to individual differences, (2) to allow the learner to control the path of his/her study where the learner can either be directed or wander through information, and (3) the system can provide customized interfaces for

each user with varying levels of guidance. Another broad based advantage which also echoes characteristics that are cited by others as advantages is forwarded by Oblinger, (1992): "By providing information in a variety of modalities, providing a context for the information, and allowing multiple paths through this knowledge, the system allows the learner to select information in the format or formats best suited to his/her learning style, ability level, and information needs through one unified system of access. All of this will increase the learner's engagement with the learning situation as he/she elaborates on current knowledge". Learning styles, modalities, and motivation are activated by different delivery mechanisms available in multimedia programs (Litchfield, 1993), and these are addressed to varying degrees in the body of this paper. The interactive multiple-channel and multiple-screen approach of multimedia allows a user to adapt the presentation to his or her learning style (Cronin, 1993).

According to La Follette, (1993), multimedia learning incorporates three significant dimensions of learning resources:

1. **Sensory Dimension:** includes structural media attributes and incorporates an imposed communication variable, message treatment.
2. **Processing Dimension:** relates more closely to the functional attributes of media. This dimension is approached primarily from the perspective of what the learner brings to the media.
3. **Control Dimension:** represented by a continuum from total control exercised by the program designer to the ability of the learner to manage the learning situation completely free of program control.

These can be seen in representational form in Figure 6 below.

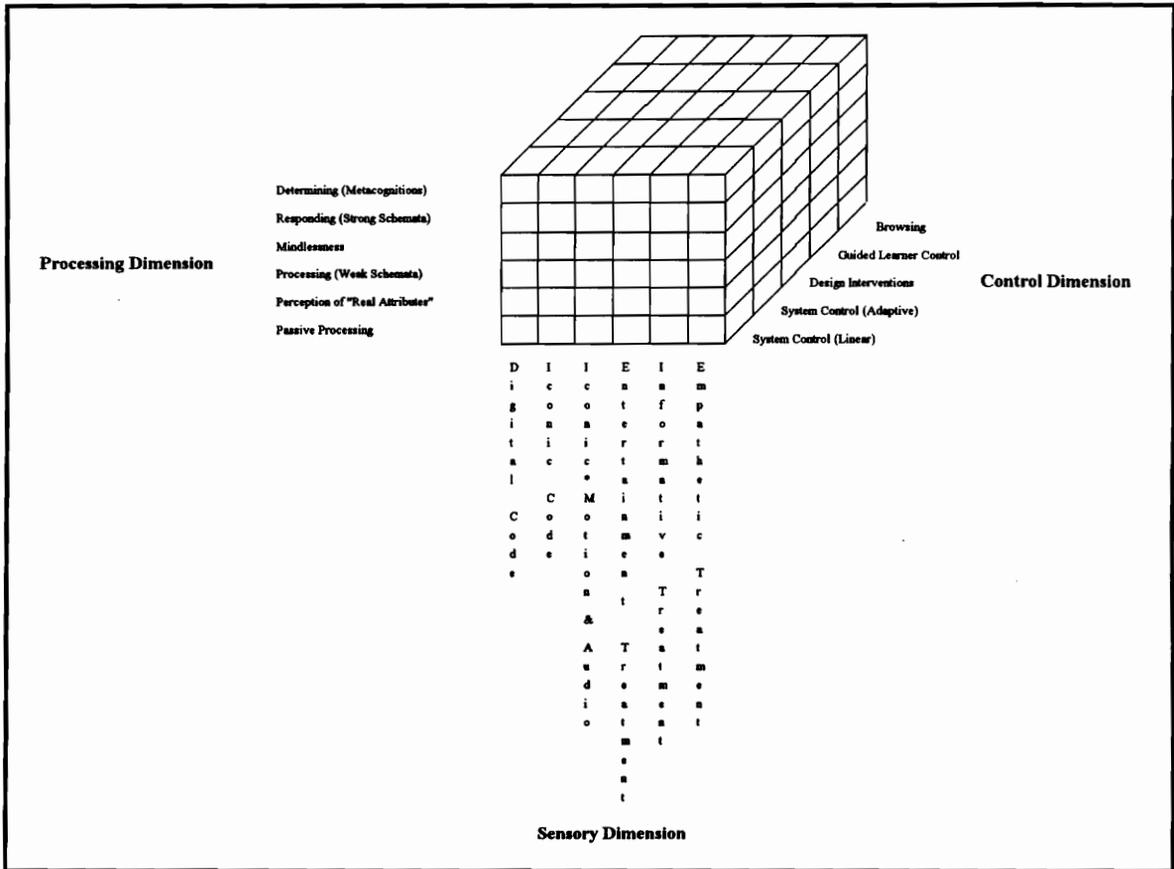


Figure 6.  
 Learning Dimensions Incorporated by Multimedia  
 (La Follette, 1993)

According to Jonassen, (1991), hypertext can be considered to be consistent theoretically and operationally with instructional design in that both share theoretical foundations in cognitive and systems theory and practical elements of learning environment design. However, the ability to tailor and extend the functionality of hypertext systems makes them powerful environments for authoring, designing, and displaying most instructional designs (Jonassen, 1991). Combining learner-control of major topics with program-control within the topic allows users to adapt the program to their learning needs while also ensuring that they will follow the designed lesson sequence.(Cronin, 1993).

Learning and MM - Problem Solving. Duffield (1992), defines problem solving as a directed cognitive learning process that makes use of previously learned knowledge and cognitive strategies. It is cognitive because it occurs internally and therefore must be inferred from behavior, it is a process because it involves the use or manipulation of prior knowledge, it involves learning in that the product of the process is new knowledge and/or strategies (Gagné, 1985). Once the learner has learned to solve a class or type of problem, solving further problems of that class would be considered rule using rather than problem solving, since no further learning is taking place (Gagné, 1985).

Information-processing models are an attempt to describe the cognitive and neurological processes that occur inside the human learner (Gagné, 1985). General models include components that represent short-term memory, long-term memory, and working memory, see Figure 7 from Gordon, (1994).

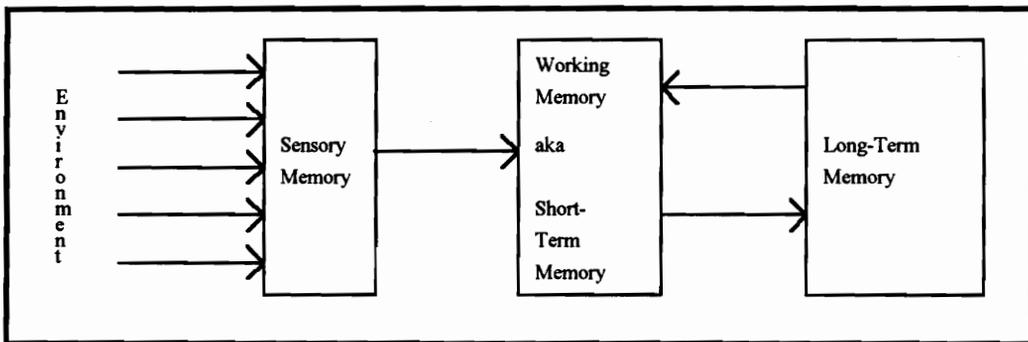


Figure 7.  
Information Processing Model of Memory  
(Gordon, 1994)

Researchers disagree as to how problem-solving abilities develop. Some feel that as an individual's knowledge base expands, new higher order rules are created (Gagné, 1985) and the individual becomes more aware of the conditions and constraints associated with the use of those rules (Glaser, 1984). Consequently, Greeno, (1980) argues that the foundation of all problem solving is knowledge. Organizational structures, or schema, allow knowledge to be acquired and preserved (Glaser, 1984). Experts can solve problems better than novices in part due to the structure of their knowledge (Glaser, 1984). Studies of novices and experts have shown that the knowledge structures of experts are organized around abstractions and principles, whereas the knowledge structures of novices are organized around literal or physical characteristics (Adelson, 1981).

Learning and MM - Tests. Modern, systematic instruction is characterized by (1) clear and relevant objectives, (2) effective instruction based on those objectives, and (3) tests which are highly integrated both with those objectives and with instruction (Dick and Carey, 1990).

Three uses of tests are (1) practice, (2) formative evaluation (feedback), and (3) summative evaluation. To satisfy these three needs, a large number of high-quality test items is needed (Haladyna, 1991). But, the content of many instructional programs appears to be at a very low level, namely recall of facts, concepts, principles, or procedures (Haladyna, 1991). Haladyna, (1991) details an item set as a related set of test items that follows the presentation of instructional material: (1) pictorial form, which includes as the instructional material pictures, photographs, maps, graphs, tables of data, figures, line drawings, works of art, or other visual material. (2) Interlinear form, which includes a single written passage and denotations (marked places) that provide for multiple-choice options. This format is typically used to measure objectively such writing skills as capitalization, spelling, punctuation, abbreviation, and grammar. (3) Interpretive exercise form, which includes a single written passage and related questions and is intended to measure reading comprehension of the passage. (4) Problem-solving form, which includes a scenario and related questions and is intended to measure one's ability to solve a problem, conduct an analysis, make an evaluation, or predict an outcome.

Learning and MM - Hypertext vs. Instructional Design. While hypertext documents and systems are comparatively unstructured, instructional systems are tightly structured by the assumptions of the given design model (Jonassen, 1991). And, Jonassen, (1991), continues, unique problems occur in using hypertext systems, such as difficulties in navigation (getting lost in the unstructured knowledge base), difficulties in integrating information into personal knowledge structure and synthesizing and tuning that knowledge and cognitive overload. A learner's interactions with hypertext are not predictable, while most instructional design and development models stress the predictability of learner outcomes from instructional interactions, and user interactions with hypertext systems are less deterministic than those resulting from traditional instructional designs and design models, because they are not based upon convergent, objective-referenced purposes (Jonassen, 1991). They are minimally intervening and are predicated upon cognitive activity instead of the behavioral outcomes that drive instruction design processes (Jonassen, 1991).

Hypertext knowledge bases typically are structured to reflect the organization of knowledge or the content domain, whereas instructional systems are designed to reflect a task (learning outcome) functionality. Hypertext systems are based upon random access and collaborative construction of the knowledge base, which require nonlinear thinking. Traditional instructional systems are based upon more linear and procedural sequences of operations (e.g., task analysis, producing instructional materials) as well as linear sequences of instruction (presentation-practice-feedback) as well as an objectivistic conception of knowledge (Jonassen, 1991).

Regardless of specific design factors, learning seems to be affected more by relevant cognitive activity than by particular instructional systems. In other words: good instructional design is good instructional design whatever the platform. Designers should not concentrate on what is needed to design specifically a particular multimedia program and neglect components of good instruction (Litchfield, 1993).

### **Multimedia (MM)**

**MM - Advantages/Disadvantages.** With respect to learning it generally appears that multimedia is an appropriate platform for instruction. However, there are other elements of multimedia which must be briefly examined. Oblinger, (1992), presents a concise and conscientious summary (see Table 6), which offers an extensive list as to reasons why multimedia appears to be an effective form of instruction.

Table 6.  
Benefits of Multimedia Use  
(Oblinger, 1992)

1. **Information is easier to access.** Multimedia mirrors the way in which the human mind thinks, learns and remembers by moving easily from words to images to sound, stopping along the way for interpretation, analysis and in-depth exploration.
2. **Learning becomes more interesting.** The combination of media elements in a multimedia lesson enables students to learn more spontaneously and naturally, using whatever sensory modes they prefer. For example, some people learn best by seeing, others learned best by seeing and hearing, still others learn best through manipulation or even kinesthetic exercises (the sense of touch).
3. **Independent and discovery learning is fostered.** Combining media elements with well-designed, interactive exercises means that students are able to extend their experience -- to discover on their own so that they are no longer passive while information is "fed" to them. Although active learning is possible with any delivery mode, it often does not occur. By taking an active part in their learning and using their senses to experience new situations, students can begin to gain a broader, more in-depth understanding.
4. **Feedback.** Programs may include immediate feedback to help clarify misconceptions (before students become confused) and to provide reinforcement for correct responses.
5. **Learning is self-paced.** While there seems to be a limit on the number of times a student will raise his or her hand to ask a question, many multimedia programs are designed to let students stop and explore as often as they like. Students report that they often want to repeat a segment or go to another part of the program that offers a different kind of a segment or go to another part of the program that offers a different kind of explanation, like a glossary, graphic, map or hypermedia function for cross-referencing to related information. Multimedia makes this type of digression easy for individuals without limiting the progress of the remainder of the students.
6. **Reading comprehension.** With today's concern about literacy, multimedia brings another advantage. By combining words with pictures and graphics and audio, multimedia programs enable people with varying levels of reading skill to learn by using their multiple senses of sight, hearing and even touch. Some evidence suggests that using multimedia segments to set the context for students significantly aids their reading comprehension.
7. **Problem solving.** Instructional technologies often help people to learn how to problem-solve by working in teams, which supports the development of teamwork and interpersonal skills.
8. **Effective instruction.** With an assistant in the form of a multimedia program, instructors can provide more individualized attention to students when they need it most. Instructors have time to focus on activities that demand participation while students are able to learn on their own.

There are also several problems with hypermedia as it is currently conceived. Hypermedia systems can be both confusing and disorienting, especially for the less able student. Another major problem is that current user interfaces are not "friendly" enough for the average user and too inconsistent across systems. Disorientation and distraction can be caused by jumping around throughout the database. Some systems may be sacrificing depth of learning for breadth (Schroeder, 1991).

MM - Effectiveness - Positive Evaluation. Despite all its professed advantages and very few disadvantages one must still determine if multimedia is effective. Oblinger, (1992) reports that it is well documented that we have short-term retention of about 20 percent of what we hear, 40 percent of what we see and hear and 75 percent of what we see, hear, and do. Which intuitively supports an expectation that multimedia has a positive effect on learning.

This expectation is primarily explained by Keane, Norman, and Vickers, (1991) who state that it is thought that Computer Assisted Instruction (CAI) is at least as effective as traditional means in helping students learn specific knowledge and develop problem-solving skills. And this is due to enjoyable features that can be attributed to CAI's greater capacity to: (1) make problem-based learning easier through risk-free (and thus less inhibiting) yet otherwise more realistic clinical simulations, and (2) provide more personalized instruction, for example, learner-centered, learner-paced, and learner-controlled. In addition, Oblinger, (1992), optimistically reports that study after study confirms the utility of interactions using sight, sound and simulated experiences in learning. In conclusion Oblinger, (1992), summarizes that in broad terms, computer-based instruction works: "it offers a 10 to 20 percent improvement in performance over conventional teaching methods while reaching competency levels of up to 50 percent higher". Also, Weber, (1992), states that research into the development and use of computer-based interactive technologies for instruction has revealed increasing evidence of effectiveness.

Although there have been many positive evaluations on the effectiveness of multimedia in general there has been little work done in the evaluation of this media as an instructional tool or on its efficacy with differing school populations (Backer and Yabu, 1993). Consequently, others have not reported positive effective learning results attributed to multimedia. Carlson, (1991) reported that the content scores in his research were not significantly different. Invariably, the opposing resources are too dissimilar to permit meaningful comparison of factors influencing learning. (Keane, Norman, Vickers, 1991). Additionally, Schank and Rowe, (1993), directly compared learning effects between paper and computerized delivery media. They noted that their research, in addition to prior research, has found little effect on learning due to instructional configuration (e.g., computer-versus textbook-based).

Despite Oblinger's, (1992), optimism that learners spend one third of the time learning with multimedia platforms others are not so optimistic. Keane, Norman, and Vickers, (1991), observed that a difference between CAI and non-CAI learners, is that even if equal at the beginning of the observation period, they are invariably unequal in one critical respect by the end: CAI users devote more time (if not more attention) than their peers to attaining the common learning goal. And Bridges, Reid, Cutts, Hazelwood, Sharp, and Mitchell, (1993), reported that the average time spent by individuals using their

multimedia presentation, AI/LEARN/Rheumatology, was similar to the time spent in lectures, approximately (3 hours).

Keane, Norman, and Vickers, (1991) state that after their review of the available research that the literature provides little guidance concerning (1) whether learning gains associated with CAI use can be attributed to computer-dependent features of the CAI resource, and (2) whether important (as distinct from statistically significant) learning gains are attainable. They state in consideration, perhaps with jaundiced eye, but nevertheless astute observation, that for example, the capacity to present information clearly, concisely, and coherently is not unique to the computer environment.

MM - Sound. Multimedia/Hypermedia displays can be the best examples of what Blattner refers to as the seductive interface:

"To be seductive, an interface ideally engages both the mind and the emotions of the user. Seductive interfaces temporarily disengage us mentally from the "real world" by presenting the mind with alternate, engaging activity. Seductive interfaces involve drama and suspense as well. A truly seductive interface is self-teaching and highly conducive to learning because intellectual challenge must take place if the user's interest is to be maintained:

1. **Entice:** draw to the interface by curiosity and appeal.
2. **Engage:** engage with challenging tasks and feedback.
3. **Enrich:** provide a rich sensory environment".

As discussed, seductive interfaces are a required element of multimedia and sound can be a very provocative element. Auditory signals are detected more quickly than visual signals and produce an alerting or orienting effect (Wenzel, 1992). The literature researched by Blattner, implies a trend towards increased use of interactive multimedia technologies for instruction and one of the best ways to develop this seductive interface is through auditory displays. To this point we have only generally discussed auditory displays. They can consist of several different elements; auditory icons, earcons, and speech.

Auditory icons use environmental sounds that have a semantic link with objects they represent. They have been shown to be an effective form of presenting information in sound (Brewster, Wright, and Edwards, 1993). But it is difficult to create and manipulate sounds along dimensions that specify events in the world (Gaver, 1993).

Earcons are abstract, synthetic tones that can be used in structured combinations to create sound messages to represent parts of an interface that are more useful than blips and bleeps (Blattner). Earcons are composed of motives, which are short, rhythmic sequences of pitches or tones with dynamics (variable intensity/loudness), timbre and

register (Brewster, Wright, and Edwards, 1993, and Blattner). The advantage is that these musical parameters can be easily manipulated (Blattner). They are easily constructed on almost any type of workstation or personal computer. The sounds do not have to correspond to the objects they represent, so objects that either make no sound or an unpleasant sound still can be represented by earcons with further explanation (Blattner).

Currently, there are three methods employed to produce computerized speech: (1) text-to-speech synthesis, (2) linear predictive coding, and (3) digitized sound (Blattner). However, the best quality of computerized speech is produced by digitizing with a technique similar to that used for creating digital audio recordings on compact discs. This technology is extremely realistic and natural sounding, and its educational potential is enormous (Blattner). Digitized sounds are recorded and stored as files on either a computer disk or compact disc. The primary problem is that the process of storing digitized sounds requires an enormous amount of disk space (Blattner), and all information must be prerecorded.

**MM - Metaphors.** Human-computer communication has always needed to use some kind of already-familiar devices or experiences as metaphors to help users understand and remember data and functions: i.e., Graphical User Interfaces (GUIs): desktops, folders, paper documents, cards, pushpins, trashcans (Marcus, 1993). Analogies/metaphors of fundamental terms, images, and concepts that are easily recognized, understood, and remembered can help build more accurate or more complete mental models (Genter, 1983, and Marcus, 1993). The metaphors are represented by labels and images in icons, objects portrayed in the screen displays, and the terms used in the primary menus or dialogue boxes (Marcus, 1993)

Users often encounter problems navigating around large data structures. As data structures increase in size and complexity, the possibilities of getting lost, or of failing to find desired information or facilities, will multiply (Hammond and Allinson, 1987). An analogy which perfectly represents comparison relationships can be extremely useful in visualizing, internalizing and developing an understanding of a target concept (Galloway, 1993). Metaphors help users understand and remember things (Marcus, 1993). However, metaphors do not explain everything about the system and not all features of the metaphor map to the system (Hammond and Allinson, 1987). While it seems obvious that a good analogy would be preferred over poor, the most important concern, to facilitate conceptual development for students' understanding, does not require the best possible analogies (Galloway, 1993). The learning process lies in analyzing relationships and attributes in the target and comparison domains. Analogies are useful so long as they facilitate that process (Galloway, 1993)

Marcus, (1993), describes two broad-based systems upon which metaphor design can be based:

1. **Noun-Object and Collection Metaphors:** In designing metaphors, it is useful to recall some of the terms, images, and concepts used to refer to collections of data or objects. They are the "nouns" of the visual-verbal communication in the user interface. That is, Television: programs, channels, networks, commercials, and
2. **Verb or Action Metaphors:** Some of the typical ways verbs of interaction are made concrete are the following. That is, Delete: throw away, destroy, lose, recycle, shred.

MM - Learner Control. In multimedia programs, learner control is a design feature of Computer Based Instruction (CBI) that enables the learner to choose the amount of latitude over direction/path, rate/pace, content, nature of feedback in instruction, and depth of investigation (Litchfield, 1993, and Park and Reeves, 1991). This degree of control can be preset by the program to afford the learner limited or total control (see Figure 8 below). However, learner control is contrasted with "program control", i.e., design features that determine the path, rate, content, and feedback in instruction for the learner (Park and Reeves, 1991).

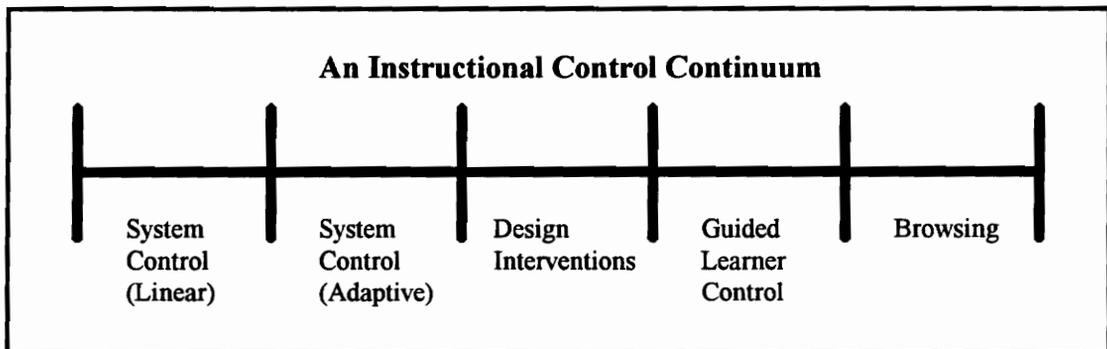


Figure 8.  
An Instructional Control Continuum  
(La Follette, 1993)

Learner control may refer to a number of things. According to (Schwier, 1992) learners may be granted or may require control over:

1. Content of instruction.
2. Context of learning.
3. Presentation method of the content.
4. Provision of optional content.
5. Sequence of material to be learned.
6. Amount of practice.
7. Level of difficulty.
8. Level of advisement.

A review of studies on learner control in CBI finds that the learner is not always the best judge of the instruction needed for effective learning (Litchfield, 1993). Consequently, Litchfield, (1993), reports that the best results in learner controlled situations have come from those programs using advisement, specifically adaptive advisement which was found to be beneficial to students in effectiveness, appeal, and efficiency.

**MM - Feedback.** Feedback, like control is an important variable that is often ignored in CAI. Researchers have reported that feedback increases learner performance and reduces program errors (Kulhavy, 1977). Some researchers have suggested that the "mere illusion of control" significantly improves motivation and performance (Perlmutter and Monty, 1977). Others have concluded "there is little support from the research literature that offering students control will lead to increased learning (Carrier, 1984).

Feedback is a unit of information with two components, (1) verification and (2) elaboration (Kulhavy, and Stock, 1989). Verification is the simple, dichotomous judgment that an initial response was right or wrong. Elaboration consists of all substantive information contained in the feedback message. Performance is significantly higher for elaboration feedback than verification feedback regardless of the type of control provided (Pridemore and Klein, 1991). According to Pridemore and Klein, (1991), this is consistent with other research which indicates that elaboration, rather than verification, produces greater effects in learning (Pridemore and Klein, 1991).

**MM - Nodes & Links.** The basic building blocks of most hypertext/hypermedia systems are nodes and links. The node elements are data fragments (text, graphics, video) that comprise the basic unit of information, and links join the nodes together (Parunak, 1989). Below in Figure 9 is a generalized example showing the multiple interconnectivity of links and nodes. Ideally, all links should be two-way:

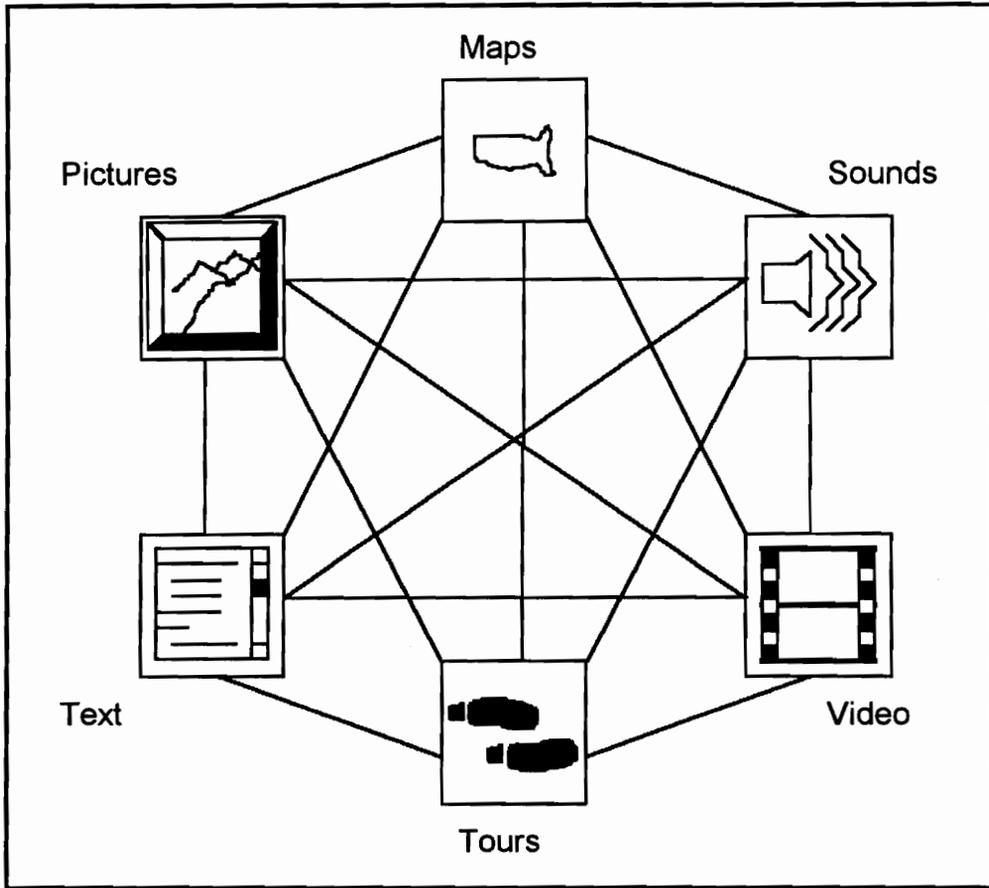


Figure 9.  
Two-Way Links Connect Information of all Media Types.  
(Laurel, Oren, and Don, 1990)

The hypertext model does have navigation problems. First, as the number of items in the hypertext grows, the potential connections also expand. The prospective paths from a given item quickly exceeds the optimal "seven plus or minus two" choices to present to a user at a given time (Laurel, Oren, and Don, 1990). The second hypertext problem is disorientation due to a rapid succession of jumps between items which may appear widely disparate to the naive user (Laurel, Oren, and Don, 1990). Both extended-menu-selection and map-browsing subproblems increase the user's cognitive load since events are experienced as unfolding in time rather than as a fixed set of articles that exists in an information space (Laurel, Oren, and Don, 1990). Therefore, a temporal metaphor such as that embodied by narrative may be a better match for the user's experience.

Hammond and Allinson, (1989) lists five problems encountered with navigation of hypermedia presentations:

1. Users get lost,
2. Users may find it difficult to gain an overview of the material, or see how parts of the knowledge base are related and even miss relevant sessions entirely.
3. Even if users know specific information is present they may have difficulty finding it.
4. Learners may ramble through the knowledge base in an unmotivated and instructionally inefficient fashion.
5. Coming to grips with the interface for controlling the various facilities may interfere with the primary task of exploring and learning about the materials.

However, despite the problems, literature review by Schank and Rowe, (1993), of prior research suggest no main effect of navigation method on learning (Recker and Pirolli, 1992).

### **Attitudes**

Attitude - General Discussion. Krandall and Biscoe, (1981), considered a curriculum of six key points for librarians that would educate them on the needs and requirements of disabled users of library services. Two of those key points have been adapted and are addressed in this thesis:

1. What knowledge, attitudes, and competencies should computer programmers have to meet these needs?
2. What is the "ideal" educational program for training computer programmers to serve handicapped individuals?

An attitude cannot be observed directly. No single act or statement of opinion can define an underlying structure of cognition, frame of reference, evaluation, and affect. We infer an attitude from an individual's behavior, his words and deeds. Specifically, attitudes are inferred from characteristic or consistent patterns of behavior or expressions of opinion toward objects or, more usually, classes of objects (Sherif, Sherif, and Nebergall, 1965, and Crespi, 1965). One must remember that verbal opinions stated by the individual are data for attitude research. They may or may not accurately reflect an attitude (Sherif, Sherif, and Nebergall, 1965). Regardless attitudes are important. According to Pratkanis, Breckler, and Greenwald, (1989), attitudes are important for four reasons:

1. Attitudes are persuasive.
2. Attitudes are a selective force in perception and memory.
3. Attitudes serve various psychic functions.
4. Attitudes predict behavior toward their objects.

**Attitude - Definitions.** Crespi (1965), defines attitudes as "predispositions to behave in specific ways to specific stimuli. Whereas, Sherif, Sherif, and Nebergall, (1965) define social attitude, which may be defined as a set of evaluative categorizations formed toward an object or class of objects as the individual learns, in interaction with others, about his environment, including evaluations of other persons.

However, I have chosen to incorporate Louis Thurstone's, the social psychologist credited with first formalizing and popularizing an attitude-measurement methodology, definition of attitude as quoted by Mueller (1986): "Attitude is the affect for or against a psychological object". Mueller further adapts the definition as follows: Attitude is (1) affect for or against, (2) evaluation of, (3) like or dislike of, or (4) positiveness or negativeness toward a psychological object.

**Attitude - Classed Attitudes.** Yuker of Hofstra University in volume 1 of the White House Conference on Handicapped Individuals in Krandall and Biscoe, (1981). Summarizes the study of the attitudes and the measurement of attitudes toward disabled persons as follows. There are five classes summarized in Table 7 below.

Table 7.  
Classed Attitudes Towards Disabled  
(adapted from Yuker in Krandall and Biscoe, 1981)

First Class	Consists of people who have comparatively minor disabilities (those who are partially sighted or speech-impaired or hard of hearing, those with heart disease, or those with ulcers).
Second Class	Consists of persons who have lost one or more of their extremities.
Third Class	Includes people who have completely lost a major sense (vision or hearing).
Fourth Class	Includes people who are mentally ill.
Fifth Class	Includes people who have acute and chronic brain injuries such as cerebral palsy, epilepsy, or mental retardation.

Yuker has concluded that attitudes of able-bodied people are more positive toward persons with disabilities at the top of the list. He also concluded that attitudes toward disabled persons at the top of the list are easier to change than are attitudes toward persons at the bottom of the list.

**Attitude - Measurement.** Five different ways of studying attitudes have typified most of the research studies in the area. Description, Measurement, Polls, Theories, and Experiments (Oskamp, 1977). Mueller lists several reasons for choosing Louis Thurstone's definition amongst many, but the main reason is that Mueller feels that the

description of items in the definition of attitude is what is measured in the popularly used attitude scales. These instruments, either by design or by default, have used the very simple, one-dimensional definition proffered by Thurstone.

Measuring someone's attitude is an attempt to locate his position on an affective continuum ranging from "very positive" to very negative" toward an attitudinal object. In the Likert scaling technique this quantification is accomplished by tallying respondents' affirmation of positive and negative belief statements about the attitudinal object (Mueller, 1986). The major difficulty with cumulative scales, ordered along a dimension of favorability/unfavorability, is that they are unable to define the neutral or "zero point" at which attitude is neither favorable nor unfavorable to the object in question. Therefore, one can only rank-order individuals on a dimension of favorability/unfavorability, and thus there is no means of locating the neutral position on this scale (Lemon, 1973).

Henerson, Morris, and Fitz-Gibbon, (1978) offer the following advantages for the use of questionnaires and attitude rating scales in Table 8:

Table 8.  
Attitude Measurement Scales  
Advantages/Disadvantages/Precautions  
(adapted from Henerson, Morris, and Fitz-Gibbon, 1978)

<b>Advantages</b>	<ol style="list-style-type: none"><li>1. They permit anonymity. If you arrange it so that the responses are given anonymously, you will increase your chances of receiving responses that genuinely represent a person's beliefs or feelings.</li><li>2. They permit a person a considerable amount of time to think about his answers before responding.</li><li>3. They can be given to many people simultaneously.</li><li>4. They provide greater uniformity across measurement situations than do the interviews. Each person responds to exactly the same questions.</li><li>5. In general, the data they provide can be more easily analyzed and interpreted than the data received from oral responses.</li><li>6. They can be mailed as well as administered directly to a group of people, although you may find that you will have to work hard to get a good return rate.</li></ol>
<b>Disadvantages</b>	<ol style="list-style-type: none"><li>1. They do not provide the flexibility of interviews.</li><li>2. People are generally better able to express their views orally than in writing.</li></ol>
<b>Precautions</b>	<ol style="list-style-type: none"><li>1. When we measure attitudes, we must rely on inference, since it is impossible to measure attitudes directly.</li><li>2. Behaviors, beliefs, and feelings will not always match, even when we correctly assume that they reflect a single attitude. So to focus on only one manifestation of an attitude may tend to distort our picture of the situation and mislead us.</li><li>3. We have no guarantee that the attitude we want to assess will "stand still" long enough for a one-time measurement to be reliable. A volatile or fluctuating attitude cannot be revealed by information gathered on one occasion.</li><li>4. When we study certain attitudes, we do so without universal agreement on their nature.</li></ol>

**Attitude - Measurement - Reliability.** Reliability and validity are the benchmark criteria for assessing the quality of all measurement devices and procedures. If a measurement instrument is valid, it is measuring the right thing -- what it is supposed to be measuring. If it is reliable, its measurement is consistent and accurate, rather than random. As a general rule, when the scores of individuals are being compared, reliability must be very high. When group means are being compared, substantially lower reliability is acceptable (Mueller, 1986). A well-constructed attitude scale, for instance, may have a reliability coefficient of 0.80 or even 0.90 (Mueller, 1986).

If a measurement instrument produces highly reliable scores, then each respondent's score can be believed; it can be depended upon in drawing conclusion's and making decisions; it is trustworthy. There are four procedures for calculating the reliability of a psychological measure, such as an attitude scale: test-retest, alternate forms, split-half, and internal consistency (Mueller, 1986).

Attitude - Measurement - Validity. There are three major validity models that may be applied to attitude scales and other psychological measures: content validity, predictive validity, and construct validity (Mueller, 1986). Reliability is a precondition for validity. If an instrument is not measuring anything consistently (reliability), then it can't possibly be measuring the right thing (validity). The upper limit for a validity coefficient is expressed as follows:  $\text{Validity} = \sqrt{\text{Reliability}}$  (Mueller, 1986). There are several threats to the validity of an attitude measurement scale that the experimenter must be aware of, as seen in Table 9:

Table 9.  
Threats to Validity  
(Mueller, 1986)

- |  |
|--|
| <ol style="list-style-type: none"><li>1. The inevitably weak link between attitudes and behavior.</li><li>2. Response bias, or evaluation apprehension.</li><li>3. Lack of comprehension, or self-awareness.</li><li>4. Lack of objectivity in administration.</li><li>5. Too few items.</li></ol> |
|--|

Attitude - Handicapped - Gender. Earlier reasons were given as to why measurement of attitudes was important. Now attitude and the handicapped/visually impaired and its relationship to the experiment are examined. Horne (1985), states the following: "the attitudes handicapped students hold toward themselves can affect their social, psychological, and academic growth and ultimately their functioning in society. Those attitudes are greatly influenced by the attitudes and opinions others hold. Whereas, at one time, the attitudes of handicapped students were mainly influenced by the family and the few school personnel and peers with whom they interacted, the possible influence of others in the environment has now greatly increased".

Data on teacher attitudes toward handicapped students suggest males and females may have different attitudes toward handicapped students. Generally, findings indicate that females held significantly more favorable attitudes toward handicapped persons than their male counterparts (Horne, 1985, and Fielder and Simpson, 1987). Female teachers may be more accepting of handicaps adds Horne; that is they are more willing to work with, talk to, play with, etc., a handicapped person. Whether or not they will be more positive toward handicapped females than handicapped males is not clear. Horne also

relays information that consistent with findings in studies of adult attitudes toward handicapped persons there is a growing body of evidence that females demonstrate more positive attitudes toward their handicapped peers (Horne, 1985).

Attitude - Handicapped - Changing Attitude Towards. The existence of negative and stereotypic attitudes toward handicapped individuals is well documented. Fielder and Simpson (1987), categorize school-based attempts at modifying such attitudes have fallen into two general categories; (1) efforts aimed at attitude change through increased exposure to and contact with handicapped individuals, and (2) curricular interventions (informational presentations about handicapped individuals). Most of the existing attitude-change curricula have been efficacious in positively modifying non-handicapped students' attitudes. Categorical curricula, disseminating information of a cognitive nature - definitions, causes, and characteristics of disabling conditions, have proven effective in positively modifying non-handicapped students' attitudes toward handicapped individuals (Fielder and Simpson, 1987). A categorical curriculum would be a presentation of standard definitions, common characteristics, possible causes, and simulations of the limitations imposed by the disability. That is, today we are going to learn about people who are visually impaired, etc.. Appendix B shows the determinants and conditions required to change attitude.

Attitude - Handicapped - Scales Used. Pretest and Posttest attitudes were measured with two scales. The first by Cowen, Underberg, and Verrillo (1958) is the Attitude to Blindness Scale (ABS). See Appendix C to examine the scale in its entirety. Shaw and Wright (1967) state that the scale has adequate reliability but insufficient evidence of validity. Nevertheless, it is the standard scale that is still used today.

The other scale that was used for this study was the Attitude Toward Disabled People (ATDP) scale. See Appendices D, and E for a reproduction of this scale. Yunker, Block, and Campbell (1960) developed two equivalent 30-item forms. Each statement suggest that disabled persons are either the same as or different from physically normal people. Approximately half of the items refer to similarities or difference in personality characteristics, whereas the other half deal with the question of special treatment for the disabled. The ATDP scale has reasonably good content validity, and additional evidence is provided by correlation of ATDP scores with other scales. Shaw and Wright, (1967) report that the authors of the scale have done a considerable amount of work on it, and the supporting data are better than for most scales. There is still some question concerning its validity, but it seems adequate for research purposes.

A serious weakness in disability technology research is a lack of the user's perspectives (Brooks, 1991). Scientists and engineers (and I add computer scientists) are an excellent group for study because they hold the kinds of social positions becoming increasingly available to people with disabilities. Technology use occurs within a social context; so the informed, positive attitudes of rehabilitation professionals, educators,

family, and employers are as relevant to device application as is user acceptance (Brooks, 1991). And in conclusion, Brooks (1991) states that too often, professionals see devices as cures rather than as components of the total rehabilitation process.

### **Gender and Computers**

**Gender and Computers - General.** Sex differences in computer interest and use are well documented. At least part of the differential attitudes of men and women about computers is due to society's process of sexual stereotyping. Computers are considered a male sphere of influence and are avoided by women because of pre-existing habits of sex segregation (Lockheed and Frakt, 1984). Females have different opinions from males about their experience with and ability to use computers. An important aspect of understanding these inequities is the recognition that human-computer interaction (HCI) does not occur in a social vacuum, the stereotypes and expectations of others, and even the mere presence of others, has been shown to affect the quality of HCI, (Huff and Cooper, 1987). Huff, Fleming, and Cooper, have research that confirms recognizable differences in the ways that males and females approach the task of computing, and more surprisingly, difference in the ways in which computer software approaches men and women. They also found that students using software designed for the other gender reported more situational stress than when using gender appropriate software Huff, Fleming, and Cooper.

Fortunately, research has shown that many of these effects are found only in those who were doing their computing in public and who had little experience with computers (Huff, Fleming, and Cooper, and Huff and Cooper, 1987). When the software was used in private there were no differences in situational stress levels (Huff, Fleming, and Cooper). Respondents with the most positive attitudes were those having the most reported contact with a computer (Aman, 1992). Fennema, (1980), suggested that educationally significant sex-related difference in mathematics performance would disappear if the time that both males and females spent studying the subject could be equalized. Fennema, (1980) further opined that the implication for computer class participation is apparent; teacher interactions aside, equality of computer experience would provide a mechanism for alleviating or eliminating gender-related computer inequity. And this has been shown to be the case, as many gender differences disappear the hours of computer use and the effect of computing experience are accounted for (Huff, Fleming, and Cooper, and Aman, 1992). Therefore, according to Aman the most reliable prediction of computer attitude is based upon knowing the quantity of an individual's past and present computer experiences, both overall, and task specific.

## **Summary**

**Summary - Pertinent Points of Literature Review.** The purpose of this research was to provide instruction on guidelines for designing for computer accessibility through comparison of traditional printed text to a multimedia presentation with complete redundant audio to determine if multimedia is a more effective means of information transmission. Effectiveness was compared on the basis of the result of the amount of original learning of each treatment condition. As a secondary indicator of effectiveness the amount of attitude change that occurs was also examined. The preceding literature review can therefore, be summarized as follows:

1. Vision is extremely important to one's Activities of Daily Living (ADL's), especially as individuals age and undergo inevitable sensory changes. The importance of vision is therefore particularly true for the elderly. The elderly as a population group must be understood and accommodated, since within the next 20 years, 20 percent of the population will be age 65 and older. And the fastest growing group is age 85 years and older.
2. Powerful legislation in the form of the ADA has required society to become cognizant of the impaired and make effort to create changes. However, the public is also beginning to realize a financial burden for maintaining the status quo. And the private sector is beginning to appreciate a consumer base with special needs that is growing.
3. Learning is a multi-faceted area of research that is not made best effective with one approach but with many. However, in traditional instruction only one approach is used generally and only reaches certain types of learners optimally. Multimedia, with its free flowing, flexible structure, and multitude of possible presentations of text, video, and graphics, can be many types of instruction to many types of learners. It was therefore, expected that multimedia would be highly effective in producing larger changes in original learning as compared to traditional printed text.
4. One of the main areas this research hoped to affect was the future application of Vanderheiden's guidelines to make computer access available to the visually impaired. With respect to the type of problem solving involved in the application of those principles, multimedia appeared well suited.
5. The enthusiastic advent of multimedia has many proponents advocating multimedia's many advantages. And at the same time documented disadvantages other than getting lost and disoriented in the data base are few and far between. Yet, overwhelming, and definitive results championing multimedia's effectiveness are inconclusive. The use of basic multimedia has yet to be declared definitively better than traditional instruction by many.
6. A part of this inconclusiveness is potentially attributable to the reality that many multimedia programs are not truly multimedia programs or have been so poorly designed as to be detrimental to learning. For this reason guidelines have begun to emerge to guide the use of color, placement, metaphors, navigation, links and nodes, sound, feedback, and control. These guidelines will be practically used in the development of the multimedia presentation used in this thesis.

7. User control for the multimedia presentation was illusory, since for purposes of measuring the effect of multimedia on knowledge it was required to control access to the core material.
8. A weakness by many who try to make changes for the disabled is a lack of knowledge about the user's perspectives and knowledge. Positive attitudes toward the disabled can play a major part in sensitizing the abled to make better, and informed design decisions. Thus, before positive change can be made, positive attitudes need to be present.
9. Understanding the many limitations of trying to measure an unobservable behavior Likert scale attitude measurement instruments were used. They offer a greater number of advantages than disadvantages.
10. Some of the more important variables in changing attitude are: attention, comprehension, and acceptance. One of the expectations of this research was that multimedia would be an effective tool for creating an effective environment for attitude change.
11. A true experimental design was used to control threats to validity.
12. Gender has several facets with regard to this research. Since multimedia is a computer based platform it was important to recognize the effect gender could play in determining results. Females in general have exhibited greater frustration and anxiety when using computers. Fortunately, these indicators of performance are eliminated with time, experience, and exposure to computers. For this reason, subjects will be culled from the computer science department. This will minimize this underlying variable and allow the research to concentrate on the apparent attitude differences between males and females that are reported in the literature.

Summary - Experimental Hypotheses. The following represent the experimental hypotheses that this research hopes to show support for:

- H<sub>1</sub>:** Subjects who receive the multimedia treatment condition will produce scores on posttest that exhibit a significantly greater amount of learning than the posttest scores obtained by the subjects exposed to the printed text treatment condition.
- H<sub>2</sub>:** Subjects who receive the multimedia treatment condition will produce net-gain scores from pretest to posttest that exhibit significantly greater gains in learning than the net-gain scores obtained by the subjects exposed to the printed text treatment condition.
- H<sub>3</sub>:** Subjects exposed to the multimedia treatment condition will spend a significantly longer period of time learning the instructional material than the subjects exposed to the printed text treatment condition.
- H<sub>4</sub>:** Subjects who are exposed to the multimedia treatment condition will exhibit, on attitude posttest, significantly more favorable attitudes toward the visually impaired and disabled than the subjects exposed to the printed text treatment condition.
- H<sub>5</sub>:** Subjects who are exposed to the multimedia treatment condition will exhibit net-gain attitude scores that are significantly more favorable toward the visually impaired and disabled than the net-gain scores of subjects exposed to the printed text treatment condition.

## EXPERIMENTAL METHOD

### Procedures

Procedures - Subjects. The experiment was conducted as outlined in Table 10 below:

Table 10.  
Procedure for Conducting Experiment

<ol style="list-style-type: none"><li>1. Subjects:<ol style="list-style-type: none"><li>a. Scheduled subject.</li><li>b. Randomly assigned subject.</li><li>c. Welcomed subject.</li></ol></li><li>2. Introduction:<ol style="list-style-type: none"><li>a. Subject read informed consent form.</li><li>b. Subject read participant's permission and instruction form.</li></ol></li><li>3. Pretesting:<ol style="list-style-type: none"><li>a. Subject completed ABS Scale (Appendix C).</li><li>b. Subject completed ATDP Scale - Form A (Appendix D).</li><li>c. Subject completed pretest.</li></ol></li><li>4. Training:<ol style="list-style-type: none"><li>a. Subject received printed text training (P1), or</li><li>b. Subject received multimedia training (P2).</li></ol></li><li>5. Posttesting:<ol style="list-style-type: none"><li>a. Subject completed posttest.</li><li>b. Subject completed ATDP Scale - Form B (Appendix E).</li><li>c. Subject completed ABS Scale (Appendix C).</li><li>d. MM training subjects also completed MM evaluation (Appendix F).</li></ol></li><li>6. Conclusion:<ol style="list-style-type: none"><li>a. Subject was debriefed.</li><li>b. Subject signed for and receives remuneration.</li><li>c. Subject was thanked for participating.</li></ol></li></ol>
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The experiment began by scheduling the subject. Notice of invitation to participate was by e-mail to select lists, and paper bulletin board notices. The intended target population was the computer science students of Virginia Tech, or any other qualifying student, of approximately age 18 to 24, who had completed two freshman computer courses. From this population, 40 suitable, and randomly selected subjects, 20 female and 20 male, would comprise the tested subjects. Participants were paid \$5.00 per hour. Based on the development of the literature review, and selection of independent and dependent variables, a screening of potential subjects was required. It was a brief screening, that was conducted by telephone at the time that the potential subject called to volunteer and be scheduled. The screening questions are enclosed at Appendix G.

Upon successfully completing screening, assignment to a training condition was made on a random basis in accordance with Table 11. The first subject was labeled subject 11 and proceeded to subject 50. As the males and females randomly arrived they were assigned to a presentation condition in accordance with the following table which was randomly generated with the Excel 4.0 random number generator. If  $0.00 < x < 0.49$  then the subject received presentation P<sub>1</sub>, and if  $0.50 < x < 1.00$  then the subject received presentation P<sub>2</sub>. The form that recorded the arrival and placement of subjects is included and can be viewed in Appendix H.

Table 11.  
Random Order of Treatment Conditions

M	1	2	3	4	5	6	7	8	9	10
	0.71	.015	0.62	0.83	0.33	0.80	0.54	0.35	0.71	0.00
	P2 (1)	P1 (1)	P2 (2)	P2 (3)	P1 (2)	P2 (4)	P2 (5)	P1 (3)	P2 (6)	P1 (4)
M	11	12	13	14	15	16	17	18	19	20
	0.22	0.76	0.94	0.06	0.89	0.41	0.85	0.49	0.27	0.04
	P1 (5)	P2 (7)	P2 (8)	P1 (6)	P2 (9)	P1 (7)	P2 (10)	P1 (8)	P1 (9)	P1 (10)
F	1	2	3	4	5	6	7	8	9	10
	0.86	0.32	0.22	0.77	0.00	0.21	0.25	0.78	0.17	0.63
	P2 (1)	P1 (1)	P1 (2)	P2 (2)	P1 (3)	P1 (4)	P1 (5)	P2 (3)	P1 (6)	P2 (4)
F	11	12	13	14	15	16	17	18	19	20
	0.99	0.74	0.35	0.11	0.68	0.23	0.64	0.50	0.06	0.64
	P2 (5)	P2 (6)	P1 (7)	P1 (8)	P2 (7)	P1 (9)	P2 (8)	P2 (9)	P1 (10)	P2 (10)

**Key:** M = Male, F = Female, P1 = Printed Text Presentation, P2 = Multimedia Presentation.

**Procedures - Informed Consent/Permission/Instructions.** Once welcomed the subjects were accompanied into the testing room. They were then instructed to listen to a multimedia presentation of the informed consent form. This document contained in Appendix I. On completion the subject was asked if they had any questions. The subject was then given a multimedia presentation of the participant's permission and instructions once the investigator departed (these are located in Appendix J). The investigator then departed and observed the rest of the proceedings from outside the testing room.

**Procedures - Apparatus.** The experiment was conducted in room 530B of the Virginia Tech Human Computer Interaction lab. The room was set up with one table and chair. The table was bare except for the required print materials for both the printed text and multimedia treatment conditions. There was also a MacIntosh 840AV for the multimedia presentation and presentation of the pretest and posttest questions. There was a video camera set up for observation of the participants and the signal was sent video monitoring and recording station set up outside of room 530B. In addition an intercom

was set up for communication with the subject. Lighting for both treatment conditions was fixed throughout the experiment.

Training Development - Printed Text Condition. As indicated in Table 10, pretesting consisted of three tests, (1) the ABS (Appendix C), (2) the ATDP scale (Appendix D, and Appendix E), and (3) a knowledge pretest. Development of the knowledge test was the result of a systems approach.

The best way at present to create a strong instructional program was to follow a systematic approach as advocated by Dick and Carey (1990). This overall system is seen in Figure 10. However, it can also be represented in phases with three components: (1) Specification of Training Requirements, (2) Development of Training Program, and (3) Evaluation of Training Effectiveness (see Appendix K).

From examination of Appendix K the systems approach to design has three distinct phases; (1) specification of training requirements, (2) development of training program, and (3) evaluation of training effectiveness. The training requirements phase consists of two sections: (1) training needs, and (2) training objectives. The training needs for this instructional program arose out of a detailed literature review. Two of the major points encountered were that: (1) good design of accessible products for the visually impaired requires an experienced perspective that can only be garnered through increased knowledge, and (2) a positive attitude is likely to increase both the knowledge garnered and the perspective viewed.

These conditions lead to the statement of two instructional goals. (1) The learner will be able to identify answers, list words, describe terms, and accurately resolve problem scenarios associated with design for the visually disabled. This is actually a demonstration of both intellectual skills and verbal information, but for the purpose of this research, they will be combined as a performance measure labeled "knowledge". (2) the learner's increased knowledge and decisions about designs that are accessible to the visually disabled will also be indicative of a positive attitude as determined by existing measurement scales.

This led to the training objectives, or to the behavioral objectives as they are sometimes referred. This is a detailed description of what the students will be able to do when they complete a unit of instruction (Dick, and Carey, 1990). A behavioral objective has three components: (1) a behavior, (2) a condition, and (3) a criterion. The most difficult aspect of defining the behavioral objective was to define objective criteria in order to evaluate objectively the performance. The behavioral objectives are listed in Appendix L. From these behavioral objectives the pretest/posttest items and marking key (see Appendix M), and instructional content were derived (see Appendix N). Note that the pretest and posttest knowledge test were identical in form.

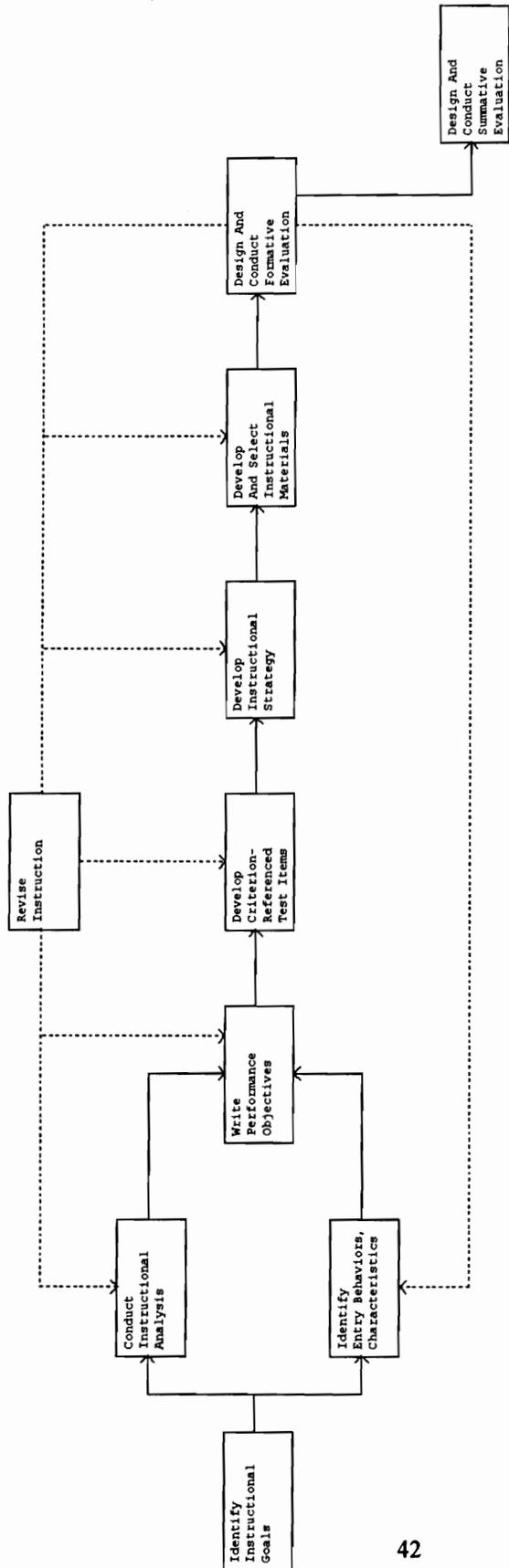


Figure 10.  
Systematic Design of Instruction  
(Dick, and Carey, 1990)

Training Development - Multimedia Condition. The systems approach works particularly well for what is considered conventional instruction. However, there are additional considerations when creating multimedia instruction. Therefore, development of the multimedia instruction will be examined.

Developers of multimedia usually rely on at least three sources of information; (1) educational research and theory, (2) actual design experience (either their own or as reported in case studies), and (3) creative intuition Kinzie, (1991). For the uninitiated, additional direction, in the form of guidelines, principles, and other information, is required to produce a competent generic multimedia presentation. Many programs profess to be multimedia and multimedia instruction, but in fact are not. The addition of simple multimedia characteristics, such as audio, animation, and quicktime video, to a weak instructional design, does not suddenly create a strong instructional package. The basic instructional foundation must be strong.

As with any emerging field, progress is made in fits and starts with the bad idea eventually being weeded out and the good incorporated into a usable form of guidelines. Ogawa, (1993), analyzed the role of design guidelines in improving interface designs by conducting an experimental task with and without guidelines. The results indicated that there was no significant difference in the number of improvements, but the average quality of proposals was quite different. The designers who did not use the guidelines, not only suggested good proposals, but also bad ones because the proposals could not be confirmed as being appropriate. The guidelines act as a filter to eliminate bad proposals. Therefore, guidelines will be used in addition to the systems approach to tailor a solid multimedia program. The guidelines that will be utilized have been gathered from an extensive array of authors and are summarized in Appendix O. Topics include; general principles, hypertext structure guidelines, system guidelines, digital audio, redundant audio, use of speech, learner control, cognitive apprenticeship features, interaction and events, navigation, links and nodes,

In addition to guidelines, a multimedia systems approach to design also serves multimedia designers well. Weber, (1992) summarized aspects of expert opinions, collected during information surveys, into a diagram that allows for a systems analysis approach to multimedia design, see Figure 11 below:

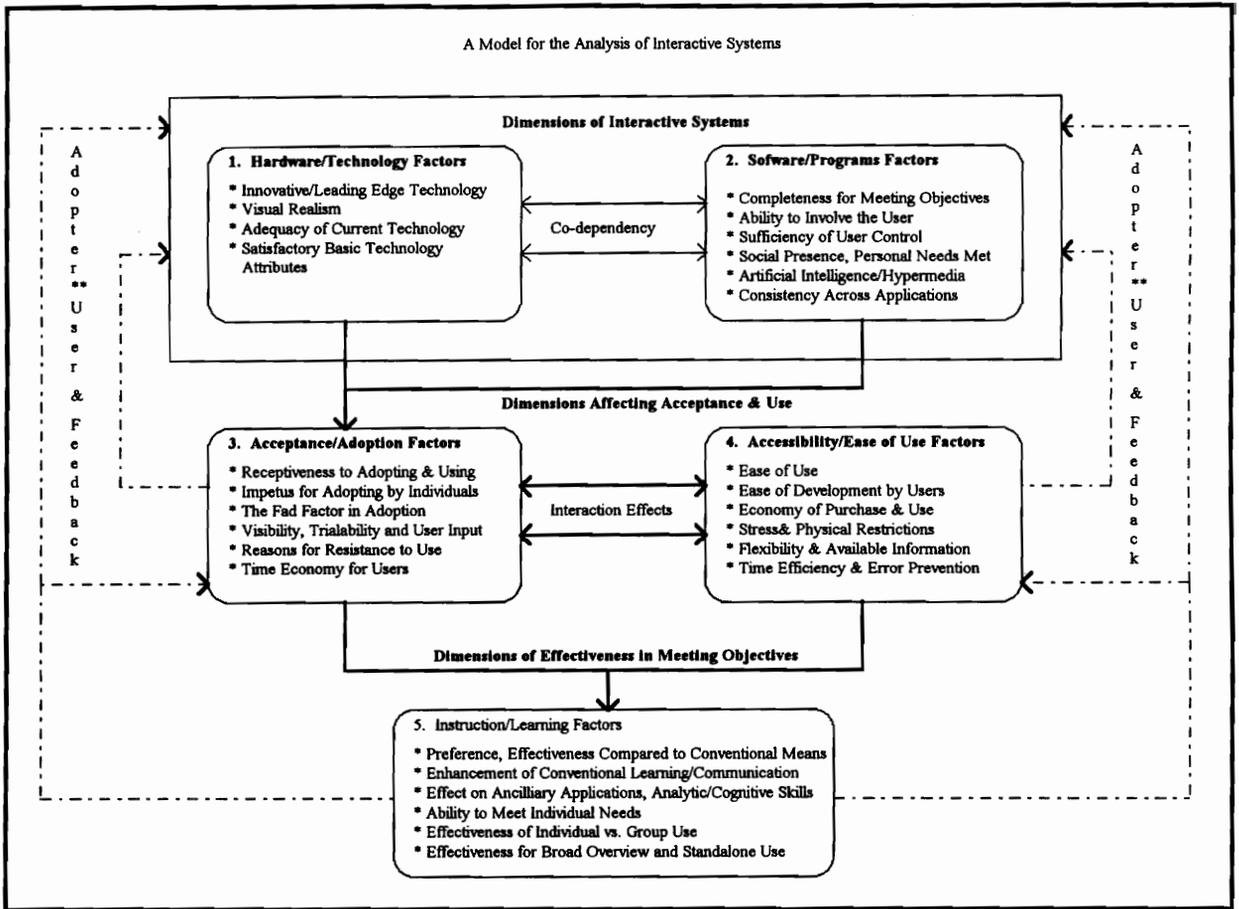


Figure 11.  
A Model for the Analysis of Interactive Systems  
(Weber, 1992)

Finally, Conklin, (1987) describes four classes of hypertext systems: (1) browsing systems, (2) problem exportation tools, (3) macro-literary systems, and (4) general-purpose hypertext.

1. Browsing systems enable user to navigate and explore information knowledge bases.
2. Problem exploration tools are work-related systems that facilitate specific task domains. Hypertext enables learners to construct, organize, and convey personal knowledge. Learners acquire and retain knowledge better when they actively participate in its construction than when they merely use it.
3. Macro-literary systems do not represent a single document or system, but rather a collection of materials that are linked together by the hypertext.

4. General-purpose hypertext systems are not designed to facilitate a specific kind of processing, but to be general-purpose information systems that can be tailored to a variety of needs (Jonassen, 1991).

The focus of this multimedia program was based on a macro-literacy system.

Training Content - Multimedia/Printed Text Differences. The training content for the experimental conditions was derived from material within the thesis. The final training material was based upon the behavioral objectives and is presented in Appendix N in the format given to printed text subjects. The printed text condition and the multimedia condition contained an identical core of information in the form of text.

There was only one difference between the core material of the multimedia condition and the printed text condition. That difference was that the multimedia condition had a machine paced, nonvoluntary, redundant audio component.

However, there was one other difference. By way of hypertext links the multimedia condition had additional data, diagrams, scenarios, video clips, and animation. These additional links were known as Extra Learning Opportunities (ELO's). The ELO's were accessed voluntarily and could either be examined or ignored. It is important to note that the ELO's did not present any new information, rather, they amplified the core material. The following represent examples of ELO's: (1) for the Activities of Daily Living, an ELO for bathing showed a person in a bathtub, (2) for the vision changes associated with aging, the ELO for decreased visual acuity compared a normal view and a blurred view of an object to highlight the deterioration of vision, (3) the statement that blindness can vary widely in degree was accompanied by a quicktime video clip ELO of an individual stating exactly that, (4) other ELO's used animation to provide additional meaning to a black and white statement, and (5) sound was used in some ELO's to illustrate the possibility of using sound in designs for the visually impaired.

In all, 78 ELO's were available for examination. Some of these 78 ELO's were identical, since one animation/picture often could be used to represent more than one design concept. Appendix N, which represents the printed text condition in its entirety, has asterisks by those items or statements in which the multimedia presentation also included a link to an ELO. Note, the asterisks were not on the copy that printed text subjects used during the experiment. The ELO's were selected for the following reasons: the personal choice of the developer, the developer's imagination and drawing ability, and also, available diagrams, photographs, and video clips that appropriately depicted the design guidelines, principles, or statements.

Any of the additional information sought out via ELO's relied on the quality of the multimedia in achieving a seductive interface which proponents assert make multimedia superior to other forms of instruction. The themes pursued were that multimedia would increase motivation to learn because it generated interest, appealed to different styles of learners and consequently resulted in improved performance as measured by knowledge. For this reason, the software was constructed to maintain a record of the number of ELO's examined by the subjects.

**Pre-Testing - Evaluation - Formative.** There are two phases to the evaluation of an instructional program as can be seen in Appendix K. Formative evaluation, the collection of data and information during the development of instruction which can be used to improve the effectiveness of the instruction, This was conducted by pretesting the material with four students. Conduct of the evaluation of the printed text material was in accordance with the guidance of Dick and Carey, (1990).

As for the multimedia presentation, Shneiderman, (1987), offers two rating scale forms to assist the developer in evaluating the design of the multimedia presentation. The short form (see Appendix F) was the form used. The short form is a generic user evaluation questionnaire for interactive systems. Information obtained from this form after administering the pretest was incorporated into the design. The multimedia subjects had the option of completing the evaluation questionnaire. Their data is incorporated into Appendix F.

### **Experimental Design (X-Design)**

**X-Design.** The experimental design selected for this project was a two factor, between subjects design with the following structural model:

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + \gamma_{k(ij)} + \alpha\beta_{ij} + \varepsilon_{l(ijkl)}$$

Where:

- Y = Observation
- $\mu$  = Population mean
- $\alpha$  = Presentation factor (fixed)
- $\beta$  = Gender factor (fixed)
- $\gamma$  = Subjects (random)
- $\varepsilon$  = Random error

The two independent factors selected for this experiment were:

1. Presentation (P): It had two levels:
  - a. P1 - printed text, and
  - b. P2 - multimedia.
  
2. Gender (G): It of course had two levels:
  - a. G1 - males
  - b. G2 - females

And the number of subjects per treatment condition was be 10. This resulted in the design layout in table 12:

Table 12.  
Layout of Experimental Design

<u>Gender</u>	<u>Presentation</u>			
	<u>P1</u> (Printed Text)		<u>P2</u> (Multimedia)	
<b>G1</b> (Males)	GPS <sub>111</sub>	GPS <sub>116</sub>	GPS <sub>121</sub>	GPS <sub>126</sub>
	GPS <sub>112</sub>	GPS <sub>117</sub>	GPS <sub>122</sub>	GPS <sub>127</sub>
	GPS <sub>113</sub>	GPS <sub>118</sub>	GPS <sub>123</sub>	GPS <sub>128</sub>
	GPS <sub>114</sub>	GPS <sub>119</sub>	GPS <sub>124</sub>	GPS <sub>129</sub>
	GPS <sub>115</sub>	GPS <sub>1110</sub>	GPS <sub>125</sub>	GPS <sub>1210</sub>
<b>G2</b> (Females)	GPS <sub>211</sub>	GPS <sub>216</sub>	GPS <sub>221</sub>	GPS <sub>226</sub>
	GPS <sub>212</sub>	GPS <sub>217</sub>	GPS <sub>222</sub>	GPS <sub>227</sub>
	GPS <sub>213</sub>	GPS <sub>218</sub>	GPS <sub>223</sub>	GPS <sub>228</sub>
	GPS <sub>214</sub>	GPS <sub>219</sub>	GPS <sub>224</sub>	GPS <sub>229</sub>
	GPS <sub>215</sub>	GPS <sub>2110</sub>	GPS <sub>225</sub>	GPS <sub>2210</sub>

X-Design - Independent Factors. This experiment attempted to determine if a multimedia presentation with redundant audio was more effective than printed text with respect to the selected dependent variables. The printed text, therefore, was the control condition. The literature review has shown many different results with multimedia, some positive and some neutral. Therefore, the aim of this research was to compare directly a well crafted, generic multimedia presentation to the printed text. Thus, the multimedia presentation in particular will make no attempt to place conditions on the presentation, such as matching learning style. This should allow greater generalizability in the final analysis.

Gender was included as an independent factor because of expected results with respect to one secondary dependent variable, attitude. The literature review indicated strongly a greater probability of females to holding a positive attitude toward the disabled than males. There were also indications that a positive attitude provided greater motivation to the learner and consequently an inclination to learn more which would show up in measurement of the primary performance variable, knowledge.

X-Design - Dependent Variables. Three dependent variables were selected for measurement.

1. **Knowledge:** This was measured pretest and posttest and is really a measure of change in original learning. The values considered were as follows: The pretest measures were examined to verify no appreciable differences in the sampling pool. The values were examined posttest for significance, and net gain values (posttest - pretest) were also examined for changes in knowledge.
2. **Time:** The total time spent on task was examined. This was the time voluntarily spent by the subject learning the subject matter. Essentially, the printed text and multimedia presentation contained the same core material. But the multimedia presentation was to have enticed the learner to spend more time learning.
3. **Attitude:** This was measured pretest and posttest. The values were considered as follows: The pretest measures were examined to verify no appreciable differences in the sampling pool, and no subjects were eliminated. The values were examined posttest for significance, and net gain values (posttest - pretest) were also examined for significance.

### Analysis

Analysis - Types. The two dependent factors knowledge and time were analyzed using parametric analysis. The dependent factor attitude was analyzed using nonparametric analysis since no data could be found to support the information obtained sufficiently meets the requirements of interval measurement data.

Analysis - Nonparametric. The results of the attitude questionnaires were analyzed using nonparametric analysis. A Kruskal-Wallis one way ANOVA was used to see if any of there were any differences in experimental conditions (Male/Printed - G1P1, Male/Multimedia - G1P2, Female/Printed - G2P1, or Female/Multimedia - G2P2) were significant.

Analysis - Correlation. A Spearman rank order correlation coefficient was calculated for some aspects of attitude and knowledge data. It was expected that a high attitude level would correspond to a high knowledge score. This is because it is presumed that a positive attitude would lead the subject to be a motivated learner and consequently score higher on the knowledge tests.

## EXPERIMENTAL RESULTS

### Experimental Results - Overview

Data were collected from three main sources: (1) embedded data from the computer, (2) evaluation data from the multimedia condition, and (3) data collected directly from the subjects. The embedded data included the number of extra learning opportunities (ELO's) examined by the subjects who received the multimedia presentation and the times spent by every subject completing the various sections of the experiment, such as instructions, ABS - Pretest, ATDP Form A - Pretest, Pretest, Study Material, Posttest, ATDP Form B - Posttest, ABS - Posttest, Total Time. .

The raw data of all times and scores were reduced to simple, organized tables contained in Appendix P. Graphs were created to provide a visual perspective of the data. One series of graphs, contained in Appendix Q, present all the individual data points as listed in the raw data tables. A second series of graphs only depicting the means is contained in Appendix R.

For purposes of a reference criterion the following information is given for scoring and time:

1. **Knowledge:** One fully correct answer for each question of the knowledge test will score 811 points. The lowest and highest scores for each sample on pretest were as follows: M/Print - 25 and 210, M/Multimedia - 73 and 281, F/Print - 77 and 218, and F/Multimedia - 90 and 221. The lowest and highest scores for each sample on posttest were as follows: M/Print - 104 and 471, M/Multimedia - 204 and 666, F/Print - 195 and 649, and F/Multimedia - 162 and 563.
2. **Attitude:** For the Attitude to Blindness Scale the range of possible scores is 30 to 120, with a lower score indicating a more favorable attitude. The lowest and highest scores for each sample on pretest were as follows: M/Print - 32 and 74, M/Multimedia - 39 and 69, F/Print - 36 and 53, and F/Multimedia - 33 and 54. The lowest and highest scores for each sample on posttest were as follows: M/Print - 30 and 72, M/Multimedia - 37 and 59, F/Print - 35 and 59, and F/Multimedia - 30 and 50. For the Attitude Toward Disabled People Scale the range of possible scores is 0 to 180, with a higher score indicating a more favorable attitude. The lowest and highest scores for each sample on pretest were as follows: M/Print - 72 and 172, M/Multimedia - 80 and 156, F/Print - 117 and 161, and F/Multimedia - 119 and 169. The lowest and highest scores for each sample on posttest were as follows: M/Print - 91 and 174, M/Multimedia - 80 and 153, F/Print - 106 and 168, and F/Multimedia - 131 and 168.
3. **Time:** All the times can be found in Appendix P. However, for purposes of comparing the core material of the printed text and multimedia presentations

the following times are given in this overview: The mean time required by subjects to complete the printed text study material was 37.33 minutes. By comparison, there was one multimedia subject who examined no ELO's and therefore completed the multimedia core presentation in 71.58 minutes, the minimum time possible. This represents a 91.7% increase in study time. This increase is attributed to the complete redundant audio that was part of the multimedia presentation.

### **Experimental Results - ANOVA**

**General.** The original data was pretested for homogeneity of variance using the  $F_{\max}$  test developed by Hartley and another test developed by Cochran. No data set consistently violated both tests. Therefore, since samples were of equal size, a simple ANOVA was used.

**Time Analysis.** The following ANOVA tables contain significant results at the  $\alpha = .05$  level. The significant effect is indicated by an asterisk. Therefore, the significant time data were: ATDP Form A - Pretest (Gender - Females took less time), Study Material (Presentation - Multimedia subjects took more time), Posttest (Presentation - Multimedia subjects took less time), ATDP Form B - Posttest (Gender and Presentation - Females took less time and Multimedia subjects took less time), ABS - Posttest (Gender - Females took less time), Entire Experiment (Presentation - Multimedia subjects took more time). All of the ANOVA tables are listed in Appendix S.

Table 13.  
ANOVA: Time to Complete: ATDP Form A - Pretest  
(\* = significance at p = 0.05)

Source	df	SS	MS	F	p
Gender (G)	1	7.336	7.336	4.54	0.040*
Presentation (P)	1	3.243	3.243	2.01	0.165
G x P	1	0.464	0.464	0.29	0.595
S/GP	36	58.233	1.618		
Totals	39	69.277			
Means					
	Males/Printed		5.87 minutes		
	Males/Multimedia		5.09 minutes		
	Females/Printed		4.80 minutes		
	Females/Multimedia		4.45 minutes		

Table 14.  
ANOVA: Time to Complete: Study Material  
(\* = significance at p = 0.05)

Source	df	SS	MS	F	p
Gender (G)	1	2	2	0.01	0.929
Presentation (P)	1	32570	32570	150.82	0.000*
G x P	1	403	403	1.87	0.181
S/GP	36	7775	216		
Totals	39	40750			
Means					
	Males/Printed		40.71 minutes		
	Males/Multimedia		91.43 minutes		
	Females/Printed		33.94 minutes		
	Females/Multimedia		97.36 minutes		

Table 15.  
ANOVA: Time to Complete: Posttest  
(\* = significance at p = 0.05)

Source	df	SS	MS	F	p
Gender (G)	1	115.91	115.91	1.33	0.257
Presentation (P)	1	786.33	786.33	9.00	0.005*
G x P	1	16.47	16.47	0.19	0.667
S/GP	36	3143.97	87.33		
Totals	39	4062.68			
Means					
	Males/Printed		44.70 minutes		
	Males/Multimedia		37.11 minutes		
	Females/Printed		49.39 minutes		
	Females/Multimedia		39.23 minutes		

Table 16.  
ANOVA: Time to Complete: ATDP Form B - Posttest  
(\* = significance at p = 0.05)

Source	df	SS	MS	F	p
Gender (G)	1	5.4317	5.4317	8.94	0.005*
Presentation (P)	1	6.4160	6.4160	10.57	0.003*
G x P	1	1.5840	1.5840	2.61	0.115
S/GP	36	21.8621	0.6073		
Totals	39	35.2938			
Means					
	Males/Printed		5.11 minutes		
	Males/Multimedia		3.91 minutes		
	Females/Printed		3.98 minutes		
	Females/Multimedia		3.58 minutes		

Table 17.  
ANOVA: Time to Complete: ABS - Posttest  
(\* = significance at p = 0.05)

Source	df	SS	MS	F	p
Gender (G)	1	8.3266	8.3266	9.37	0.004*
Presentation (P)	1	0.1199	0.1199	0.13	0.716
G x P	1	2.8249	2.8249	3.18	0.083
S/GP	36	31.9944	0.8887		
Totals	39	43.2658			
Means		Males/Printed	4.17 minutes		
		Males/Multimedia	3.53 minutes		
		Females/Printed	2.73 minutes		
		Females/Multimedia	3.15 minutes		

Table 18.  
ANOVA: Time to Complete: Entire Experiment  
(\* = significance at p = 0.05)

Source	df	SS	MS	F	p
Gender (G)	1	1402	1402	1.35	0.253
Presentation (P)	1	18543	18543	17.85	0.000*
G x P	1	1421	1421	1.37	0.250
S/GP	36	37391	1039		
Totals	39	58757			
Means		Males/Printed	177.84 minutes		
		Males/Multimedia	208.99 minutes		
		Females/Printed	154.08 minutes		
		Females/Multimedia	209.07 minutes		

**Score Analysis.** The only scores that were analyzed using ANOVA methods were the knowledge scores obtained in pretesting and posttesting. Thus, in addition to some of the significant time data results, there was one knowledge score data set that produced significant results, the Pretest/Posttest comparison. This showed that the training was successful.

Table 19.  
ANOVA: Scores: Pretest/Posttest Comparison  
(\* = significance at p = 0.05)

Source	DF	SS	MS	F	P
Gender (G)	1	21386	21386	2.14	0.148
Presentation (P)	1	750781	750781	75.05	0.000*
G x P	1	911	911	0.09	0.764
S/GP	76	760299	10004		
Totals	79	1533378			
Means		Males/Pretest	139.20 of 811 points		
		Males/Posttest	326.20 of 811 points		
		Females/Pretest	165.15 of 811 points		
		Females/Posttest	365.65 of 811 points		

**Experimental Results - Kruskal-Wallis Analysis**

The numerical values obtained from the standardized attitude tests, the Attitude toward Blindness Scale (ABS) and the Attitude Towards Disabled People (ATDP) Scale (both Form A and Form B) were ordinal at best. This dictated the requirement to analyze the data using nonparametric statistics.

Two data sets contained scores that proved to be different significantly and were analyzed further through post-hoc testing. They were: (1) ATDP Form B - Posttest, and (2) ATDP Pretest/Posttest Comparison (see Tables 20 and 21). In Table 20 both the printed text and multimedia females (levels 7 and 8) scored significantly better than the printed text males (level 5). That is, on posttest scores females held a more favorable attitude toward the disabled than males who were exposed to the printed text condition. In Table 21, only the multimedia females (level 8) scored significantly better than the printed text males (level 5). All other Kruskal-Wallis tables can be found in Appendix T.

Table 20.  
Kruskal-Wallis: ATDP Form B - Posttest

Level	Number of Observations	Median	Average Rank	Z Value
M/Printed	10	115.0	11.2	-2.90
M/Multimedia	10	129.0	16.5	-1.23
F/Printed	10	148.5	25.5	1.56
F/Multimedia	10	151.5	28.8	2.58
Overall	40		20.5	
H = 14.28		d.f. = 3	p = 0.003	
H = 14.28		d.f. = 3	p = 0.003	(adjusted for ties)
Scoring Range	0 to 180		A higher score means a more favorable attitude toward the disabled.	

Table 21.  
Kruskal-Wallis: ATDP Form B - Pretest/Posttest Comparison

	Level	Number of Observations	Median	Average Rank	Z Value
Pretest	M/Printed	10	120.50	29.20	-1.64
	M/Multimedia	10	126.50	29.50	-1.61
	F/Printed	10	147.00	48.70	1.19
	F/Multimedia	10	146.00	51.10	1.54
Posttest	M/Printed	10	115.00	22.00	-2.69
	M/Multimedia	10	129.00	33.30	-1.05
	F/Printed	10	148.50	51.50	1.60
	F/Multimedia	10	151.50	58.70	2.65
	Overall	80		40.50	
H = 23.66		d.f. = 7	p = 0.001		
H = 23.67		d.f. = 7	p = 0.001	(adjusted for ties)	
Scoring Range	0 to 180		A higher score means a more favorable attitude toward the disabled.		

**Experimental Results - Correlation Results**

It had been hypothesized that individuals who spent more time exploring extra learning opportunities (ELO's) would: (1) spend more time studying the material, (2) score better on the knowledge posttest, and (3) exhibit a more favorable attitude on posttest attitude measures. Further, there had been expectations that the greater the time spent studying the better the results on all posttests. By examination of Table 22 below, it can be seen that two of these hypotheses were statistically supported (asterisk: significant at the 0.05 level). (1) the more ELO's examined by the multimedia subjects resulted in

them spending more time studying. (2) also, the more ELO's examined by multimedia subjects the higher the score on the posttest.

Table 22.  
Correlation Values  
(\* = significance at  $p = 0.05$ )

Correlation of				
Extra Learning Opportunities	To	Time - Study Material	0.63	*
Extra Learning Opportunities	To	Score - ABS Posttest	0.11	
Extra Learning Opportunities	To	Score - ATDP Posttest	-0.05	
Extra Learning Opportunities	To	Score - Posttest	0.53	*
Time To Study	To	Score - ABS Posttest	-0.20	
Time To Study	To	Score - ATDP Posttest	0.26	
Time To Study	To	Score - Posttest	0.25	

### **Experimental Results - User Evaluation Form**

The user evaluation form was only administered to the multimedia subjects. Completing the evaluation was voluntary. In all 15 of 20 multimedia subjects completed the evaluation. Their responses are summarized in Figure 12 below. The actual means and standard deviations for each question are found in Appendix F. Through examination of Figure 14 the questions that appeared most interesting were 11, 16, 17, 19, 20, 21, and 22. Due to the constraints of the Friedman Two-Way analysis only questions 11, 20, 21 and 22 can be studied further for significant results. This is because all cells must be filled and this is not the case as can be seen in Appendix U. The subjects did not answer all questions equally, whereas some answered all questions, others felt the question was N/A, thus the gaps observed in Appendix U.

The results of post-hoc analysis showed that question 11 (pace of the interaction) was significantly different from all other questions except 20, 21, and 22. And also, questions 20, 21, and 22 (which dealt with overall reactions, see Appendix F) were significantly different from question 15 (ease of learning the operation).

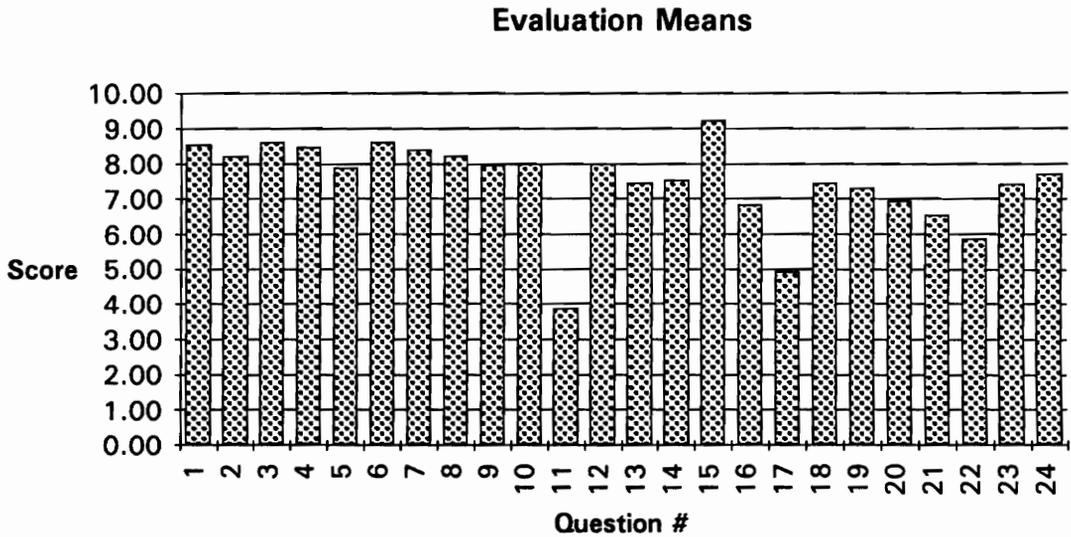


Figure 12.  
Results of Multimedia User Evaluation Survey

**Experimental Results - Study Material - Voluntary Review**

The redundant audio and screen transitions extended greatly the material study time. The length of multimedia study time was so lengthy, that even those subjects who did not pursue even a single extra learning opportunity took considerably longer than the longest of the printed text subjects for study time. This is even more alarming considering that only 2 of the 20 multimedia subjects did a review, which was cursory in nature, whereas, most of the printed text subjects were observed reviewing the subject material. Of the 2 multimedia subjects who did reviews, they ranked among the highest extra learning opportunities explored, and can be labeled as highly motivated.

## DISCUSSION

### Discussion - Overview

This research was intended to show that multimedia with redundant audio was a more effective teaching tool than printed text. The objective was to support this idea through the presentation of design guidelines for the visually disabled in the form of a multimedia workbench. Additionally, the hypothesis was put forward that attitudes toward the visually impaired and the disabled in general could be significantly altered. Specifically, the following null hypotheses were tested:

- H<sub>1</sub>:** Subjects who receive the multimedia treatment condition will produce scores on posttest that exhibit a significantly greater amount of learning than the posttest scores obtained by the subjects exposed to the printed text treatment condition.
- H<sub>2</sub>:** Subjects who receive the multimedia treatment condition will produce net-gain scores from pretest to posttest that exhibit significantly greater gains in learning than the net-gain scores obtained by the subjects exposed to the printed text treatment condition.
- H<sub>3</sub>:** Subjects exposed to the multimedia treatment condition will spend a significantly longer period of time learning the instructional material than the subjects exposed to the printed text treatment condition.
- H<sub>4</sub>:** Subjects who are exposed to the multimedia treatment condition will exhibit, on attitude posttest, significantly more favorable attitudes toward the visually impaired and disabled than the subjects exposed to the printed text treatment condition.
- H<sub>5</sub>:** Subjects who are exposed to the multimedia treatment condition will exhibit net-gain attitude scores that are significantly more favorable toward the visually impaired and disabled than the net-gain attitude scores of subjects exposed to the printed text treatment condition.

For this study many articles were reviewed, particularly in the area of multimedia. The emphasis of this research was the efficient design of multimedia and the effectiveness of multimedia with complete redundant audio. With respect to effectiveness, although multimedia is considered an effective format for instruction, there are both positive and negative evaluations as to its effectiveness as an instructional tool. This research found no significant learning effect with respect to multimedia. If analysis had supported the hypotheses, one could only state that multimedia seems to be a significantly better instructional tool than printed text. One could not state that it was due to the redundant audio.

The greatest finding of the experiment may well have been the discovery of Director 4.0 as a productive research tool. The ability to capture data covertly was only partially unearthed in this research through the collection of section times and number of extra learning opportunities explored. There is the capability to collect data with respect to keystrokes and search time. This is of inestimable value in researching multimedia issues.

### **Discussion - Knowledge Score**

Neither  $H_1$  nor  $H_2$  were supported. However, it is important not to minimize the results of this experiment but to examine carefully the results. Effective instruction can occur only with careful planning. Poorly planned instruction is no better just because it is multimedia instruction. Well planned traditional instruction is likely to perform, at a minimum, as well as "multimedia". Consequently, the design of the multimedia presentation was a combination of a systems approach to training with careful attention to multimedia design guidelines.

The first two phases of the systems approach, specification of training requirements and development of the training program, proved at a minimum to be successful. This is supported by the fact that the pretest/posttest comparison of knowledge scores showed a significant gain in knowledge by both the printed text and multimedia group. However, as previously stated  $H_1$  was not supported. This was the hypothesis that stated that although both groups would exhibit extensive original learning, the posttest multimedia group would score significantly higher than the posttest printed text group.

Explanation for failure of these two hypotheses to be supported is centered on the multimedia design itself. An extensive list of multimedia design guidelines were incorporated into the multimedia presentation. These efforts did result in a quality presentation when comparing the multimedia presentation to the "Common-Sense Checklist for CBT", (Jeiven, 1994). However, multimedia is supposed to be beneficial as a learning tool because information is easier to access, learning is more interesting, independent learning and discovery is fostered, there is feedback, learning is self-paced, and reading comprehension is enhanced.

However, these benefits did not occur. They did not occur for two reasons: (1) redundant audio, and (2) screen transitions. Although pretesting was carried out, neither of these issues was raised as a problem. In fact, subjects commented very favorably on the redundant audio and screen transitions, finding them interesting. Regardless, the redundant audio at least would have remained because the effort was to determine the effectiveness of a multimedia presentation with redundant audio. The screen transitions were for interest, and if the interest had not been there, they could have been removed. Nevertheless, both of these multimedia techniques conspired to make information harder

to access, reduced learning interest, stunted independent learning and discovery, removed self-pacing and suppressed reading comprehension. Examining screen transitions first, subjects commented that although the transitions were interesting at first, they soon became tiresome. They were tiresome because they slowed up the presentation and interfered with reading the information.

Literature that stated the benefits of redundant audio was too restrictive in its generalizations. Many studies used children as a subject pool, and the material the subjects, in all cases, were exposed to was very short in duration. In fact the longest exposure was only twenty minutes. As observed from the results of the user evaluation form, none of the subjects considered the amount of material covered trivial in nature. They generally found that human memory limitations were more overwhelmed than respected. This is not necessarily unsound, since the greater the difficulty of the material the less the chance of non-definitive results that could be attributed to the fact the material was too simplistic in nature.

Thus it was found that redundant audio produced a strong negative effect in most users, who felt it interfered with their internal reading speed. Also, the user could not advance further until the currently displayed material was read. This affected the subjects' feeling of learner control, an important aspect of multimedia. Additionally, there is research that raises the concern that redundant audio splits the subject's attention resulting in reduced ability to learn.

These observations are supported by the data collected in the multimedia user evaluation forms. Question 11 - Pace of the Interaction scored very low with respect to all other answers, scoring only a 3.75 of 10. In fact it was a significant difference. That is, subjects felt the presentation moved too slow, and there was nothing they could do about it. This was further observed by examining questions 20, 21, and 22 with respect to the subjects' overall reactions which varied as follows: Terrible - Wonderful: 6.44 of 10, Frustrating - Satisfying: 6.26 of 10, and Dull - Stimulating: 5.43 of 10.

### **Discussion - Times**

The redundant audio and screen transitions had further ripple effects. Although  $H_3$  was supported by analysis, it is contended that the support is weak at best. The following two times produced significant results that were entirely due to presentation: (1) Study Material (Presentation - Multimedia took longer), and (2) Entire Experiment (Presentation - Multimedia took longer). That is, the multimedia presentation of the study material took significantly longer than the printed text study material to assimilate and subsequently caused the multimedia subjects to take longer to complete the experiment.

One of the original goals of the research had been to determine the amount of additional time the multimedia subjects would willingly spend studying. That goal would have been measured in two ways: (1) comparing the core area study time, and (2)

accumulating the time spent exploring the extra learning opportunities. This would have confirmed statements that subjects are willing to spend more time studying due to the interest level and motivation to learn developed by the multimedia. Measurement would have been possible because the core content of the printed text presentation was identical to the multimedia presentation. Unfortunately, the redundant audio and screen transitions confounded any possibility to do so as explained in the results section.

That observation prevents any compelling statements from being made on the following significant time effects: Posttest (Presentation - Multimedia took less time), ATDP Form B - Posttest (Presentation - P2 took shorter). That is, did the multimedia people spend a shorter time on these sections because they were more confident of their responses because of better learning due to the multimedia or were they simply trying to finish the experiment quickly because of the length of time already spent?

Interestingly, other than during the first attitude test in which both males and females used a comparatively equal amount of time to complete, the females took a significantly shorter amount of time to complete the rest of the attitude questionnaires. That is, ATDP Form A - Pretest (Gender - G2 took shorter), ATDP Form B - Posttest (Gender - G2 took shorter), and ABS Posttest (Gender - G2 took shorter). It is possible that there was no difference on the first attitude questionnaire because both groups were determining their position on the material. As for the rest of the questionnaires did the females use a shorter amount of time because they were more confident or sure of their attitudes toward the disabled? Confidence of their attitudes is a possibility since there is a large body of data which supports the hypothesis that females hold more favorable attitudes toward the disabled.

### **Discussion - Attitudes**

Despite the result that females took less time than the males to complete the attitude questionnaires the overall result of attitude testing was discouraging.  $H_4$  was only partially supported, and  $H_5$  was not supported. As previously stated there is a wide consensus that females hold more favorable attitudes toward the disabled. Unfortunately this consensus was not supported in pretesting of the subjects. The reason may be the standard attitude tests that were used for data collection. These standard tests are still widely accepted for research, however, the tests may no longer possess the validity claimed. The tests were developed in the late 1950's. Some of the questions represent social attitudes particular to the era that perhaps are not nearly so prevalent today. Take the following questions for example: Disabled people usually do not make much of a contribution to society, It would be best if disabled persons would live and work with non-disabled persons, A blind person might as well accept the fact that blindness makes people pretty helpless, You should not expect too much from a blind person, The blind adult is not quite as mature or "grown-up" as the sighted adult. These kinds of questions are reminiscent of the time when the disabled and blind were institutionalized. One question that produced amazing answers was Attitude to Blindness Scale - question 12: "It makes

me feel a little guilty to know that I can see and others cannot". A large number of subjects expressed guilt.

The fact that posttest scores were not different significantly than pretest may have been due to conditioning as a result of both pretesting and posttesting the subjects with attitude scales. It may have been more advantageous to have developed an population attitude profile from a control group who were never exposed to treatment. Both groups held equally favorable attitudes toward the blind and the disabled. Additionally, these attitudes were quite favorable to begin with, thus leaving very little latitude for developing an even more favorable attitude. It is likely for this reason that no significant changes in attitude were noted other than both the F/Printed and F/Multimedia groups scored higher in attitude than the M/Printed group on the ATDP Form B - Posttest. That is, females who received multimedia training held a more favorable attitude at the end of the experiment toward the disabled in general than males who only received printed text training.

Regardless of the attitude scoring results, the simple fact that there are many precautions when measuring attitudes must be remembered. We must rely on inference, a fluctuating attitude cannot be revealed by information gathered on one occasion, and since direct measurement is impossible, behaviors, beliefs and feelings will not always match.

### **Discussion - Evaluation**

The third phase of an effective systems approach to training is evaluation of training effectiveness. Evaluation is comprised of formative and summative evaluation. The formative evaluation was weak in some areas. Pretesting was not extensive enough. Additionally, the pretest subject pool, department graduate students, did not represent the general subject pool that was eventually tested. The pretest subject pool may not have been objective enough. Particularly, pacing was not objected too. Also, time spent on the knowledge pretest, very short, was not indicative of the research subject pool. However, the pretesting did confirm that the material met objectives and was of high quality with respect to spelling mistakes and absence of software errors.

One other critical area that complete pretesting would have isolated for revamping, was the form of the pretest/posttest questions. Their form was too general in nature, allowing for a small set of generic answers to produce repeated correct results. For example, add audio, or make the computer talk was a valid answer in far too many questions. Additionally, pretesting may have primed the subjects too extensively. Stice, (1976), advocates that good instruction begins with providing the subjects with the instructional objectives or even the questions because it can focus a student's attention. Such an approach may be desirable for general instruction, however, in this instance, pretesting may well have confounded the results.

The summative evaluation was achieved through completing the experiment. The objective of a summative evaluation is to show that the training system developed is effective. In this regard it was successful, because the multimedia training was as effective as the printed text. However, as presented, it would not justify the time, money, or resources that went into developing it for one instructional session. In order for these efforts to be justified the multimedia presentation would have to be better significantly than traditional instructional methods.

### **Discussion - Future Research**

The first stage of future research would attempt to solve two fundamental areas where problems occurred. Solving these problems would bring about a solid foundation for future research. The first effort would be to redefine the testing questions. The objective being to require more focused and specific answers. Second would be the creation of an alternate program without the unnecessary screen transitions, redundant audio, and the extra learning opportunities. The equivalency of the core material between printed text and multimedia in terms of time could then be compared. And, the general effectiveness of generic multimedia could be determined.

Following this experiment, the multimedia could then be presented to include the extra learning opportunities. Since the general effectiveness of the program would largely be established, the ability of the program to induce exploration, raise interest and create motivation could be measured. This measurement would be indicated by how many of the extra learning opportunities were explored by the subjects, and the amount of time spent exploring.

Another parallel experiment using just the core study material could compare the forced use of redundant audio versus voluntary use of redundant audio. A elementary 2 x 3 experiment could be conducted. Gender having two levels and presentation having three levels: printed text, multimedia core, multimedia core with the preferred redundant audio presentation.

Although gender was used as a factor, and the results were inconclusive, further research with using this factor could be undertaken. This could be done in combination with matching/mismatching the subject with his/her preferred learning style. The "free-form" structure of multimedia with its alternative methods of presenting facts could prove to appeal to some types of learners more than traditional highly structured and linear instruction does.

And finally, a retention experiment could be performed, whereby, after receiving either traditional training or multimedia training, subjects would return at a specified later date to complete testing.

## CONCLUSIONS

Multimedia is a rapidly growing medium for instructional training. And many traditional training programs are quickly being transformed to multimedia by adding some sound, movement and color pictures. But if the original training was not well developed, transforming it into multimedia will not create good training. Additionally, just because there is sound, pictures, animation, and video does not make it multimedia. Good multimedia, is developed through the extensive use of design guidelines which are constantly being refined as new data emerges from experimentation in this quickly changing field. Pacing, computer/learner control balance, nodes and links, feedback, interaction, color coding, location coding, all of these critical issues must be planned for when developing multimedia. This is in addition to using a fundamental systems approach when designing training. These issues have conspired to create controversy about the effectiveness of multimedia, since some studies support its benefits, while others highlight drawbacks. Because of the general design vagaries of the multimedia used in the experiments of the literature review no direct comparison can be made between various studies. Using a core multimedia program that has been refined and can be used for several different studies by either turning on or turning off certain features presents the best possible future for research.

However, with those thoughts in mind it is believed that complete redundant audio as a component of multimedia is a definite drawback and probably interferes with the ability of subjects to learn more effectively than subjects exposed to traditional instruction. This research considered complete redundant audio with no options for adjusting reading speed, or turning the sound on or off. Therefore, as presented, the redundant audio severely restricted subject self-pacing, considered an important attribute of multimedia. Limited self-pacing combined with a restricted succession of access to core components of the program, impeded subjects from exploring fully the available knowledge base. Also, until the benefits/drawbacks of multimedia are more fully understood I believe it behooves researchers not to attempt to extend areas of research into areas like its effect on attitudes or similar social issues. It is important to first develop fully its potential as a tool for instruction before it is compared further or chosen as a tool in situations that may in the future dictate its use.

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## **APPENDICES**

## **APPENDIX A**

### **Design Guidelines for the Visually Disabled**

## **Generic Guidelines to Increase Access to the Disabled (Pirkl, 1994)**

1. Provide cross-sensory redundant cueing for all alarms, signals and controls (combine an audio signal with a visual indicator)
2. Offer redundant modes of operation utilizing the next larger set of motor movements (finger to hand; hand to arm ; arm to foot)
3. Establish consistent display/motion relationships left to right and forward/up to increase, backward/down to decrease)
4. Provide definitive feedback cues (control positions (detents) should "snap" into position)
5. Reduce the complexity of all operations (minimize the number of tasks)
6. Place critical, and frequently used controls within easiest reach (cluster controls on basis of priority)
7. Prevent accidental actuation of critical controls (relocate, recess, or provide a guard)
8. Provide adjustable product/user interfaces (horizontal/incline, vertical/incline, raise/lower, push/pull)
9. Design for use by a variety of populations (male/female, young/old, weak/strong, large/small)
10. Design to facilitate physical and cognitive function (encourage user to practice and improve by making operations easy and enjoyable)
11. Design beyond the basic physical/functional need (enhance the user's independence, self-respect, and quality of life)
12. Compensate for a range of accommodation levels (provide for some exercise through user interaction/participation)
13. Strive to make task movements simple and understandable (clockwise for "on" or "increase", counterclockwise for "off" or "decrease")

**Consumer Product Design Guidelines to Increase their Accessibility to People with Disabilities or Who are Aging**  
(Vanderheiden et al, 1992)

<p><b>Section 1 Output/Displays:</b> Includes all means of presenting information to the user.</p>	<p><b>Maximize the number of people who can/will ...</b></p> <p>O/D 1 - ... hear auditory output clearly enough.  O/D 2 - ... not miss important information if they can't hear.  O/D 3 - ... have line of sight to visual output and reach printed output.  O/D 4 - ... see visual output clearly enough.  O/D 5 - ... not miss important information if they can't see.  O/D 6 - ... understand the output (visual, auditory, other).  O/D 7 - ... view the output display without triggering a seizure.</p>
<p><b>Section 2 Input/Controls:</b> Includes keyboards and all other means of communicating to the device.</p>	<p><b>Maximize the number of people who can ...</b></p> <p>I/C 1 - ... reach the controls.  I/C 2 - ... find the individual controls/keys if they can't see them.  I/C 3 - ... read the labels on the controls/keys.  I/C 4 - ... determine the status or setting of the controls if they can't see them.  I/C 5 - ... physically operate controls and other input mechanisms.  I/C 6 - ... understand how to operate controls and other input mechanisms.  I/C 7 - ... connect special alternative input devices.</p>
<p><b>Section 3 Manipulations:</b> Includes all actions that must be directly performed by a person in concert with the device or for routine maintenance (e.g., inserting disk, loading tape, changing ink cartridge)</p>	<p><b>Maximize the number of people who can ...</b></p> <p>M 1 - ... physically insert and remove objects as required to operate a device.  M 2 - ... physically handle and/or open the product.  M 3 - ... remove, replace, or repositions often used detachable parts.  M 4 - ... understand how to carry out the manipulations necessary to use the product.</p>
<p><b>Section 4 Documentation:</b> Primarily operating instructions.</p>	<p><b>Maximize the number of people who can ...</b></p> <p>D 1 - ... access the documentation.  D 2 - ... understand the documentation.</p>
<p><b>Section 5 Safety:</b> Includes alarms and protection from harm.</p>	<p><b>Maximize the number of people who can ...</b></p> <p>S 1 - ... perceive hazard warnings.  S 2 - ... use the device without injury due to unperceived hazards or user's lack of motor control.</p>

## Summary of Nonvisual Display Techniques by Information Type (Vanderheiden, 1989)

Information Type	Description	Possible Solutions
<b>Running Text</b>	This includes any information that is displayed in straight ASCII characters. No formatting, underlining, or spatial relationship between words is included, other than that each word follows the one preceding it.	<ul style="list-style-type: none"> <li>• Braille (single character, 1-40 cell, or full page).</li> <li>• Speech</li> <li>• Tactile image (Optacon).</li> <li>• Morse code (auditory and tactile).</li> </ul>
<b>Text Attributes</b>	This includes any nonspatial attribute of the text, including boldface, superscript/subscript, underlining, italics, and shadow print.	<p><b>With Speech</b></p> <ul style="list-style-type: none"> <li>• Announcement</li> <li>• Background tone (presence, pitch, volume, apparent direction, short or continuous).</li> <li>• Speech attribute (timbre, voice, volume, pitch).</li> <li>• Environment (echo, tremelo).</li> </ul> <p><b>With Braille</b></p> <ul style="list-style-type: none"> <li>• See items listed under "With Speech"</li> <li>• Frequency of pin vibration.</li> <li>• Slow pulse of pins.</li> <li>• Extra pins at top or bottom of text.</li> <li>• Separate tactile or electrocutaneous stimulator.</li> </ul>
<b>Spatially Related (Text) Information</b>	This includes the information presented as the spatial relationship between two items of text, such as which words are placed specifically above, below, beside, in the same column, in the same row, etc., as other words.	<ul style="list-style-type: none"> <li>• Apparent source of speech.</li> <li>• Pitch.</li> <li>• Haptic sense (with haptic tablet or joystick).</li> <li>• Haptic with tone.</li> <li>• Tactile tablet (full or virtual) (with tones, speech).</li> <li>• Grids.</li> <li>• Temporary ridges.</li> <li>• Lockable tracking mechanism.</li> <li>• Driven cursor, (puck, mouse, joystick).</li> </ul>
<b>Pick From List</b>	This includes all instances in which the individual is presented with a series of choices from which he or she is to choose one or more items.	<ul style="list-style-type: none"> <li>• Direct request (voice or keyboard).</li> <li>• Best match(es).</li> <li>• High/low-speed scan.</li> <li>• Direct control scan (slider with indents or puck with ridges between choices).</li> <li>• Search/read as block of text.</li> </ul>

<b>Interruption or Alert</b>	This includes all instances in which information is abruptly presented to the individual at a time when he or she may not be expecting it (beeps, messages, etc.).	<ul style="list-style-type: none"> <li>• Concurrent sound (beep, tone, or sound).</li> <li>• Speech announcement.</li> <li>• Tactile stimulator (vibrator or electrocutaneous stimulator).</li> <li>• Olfactory.</li> </ul>
<b>Directing</b>	This includes all information presented to the user in order to direct his or her attention or activity to a particular point or action (e.g., an arrow that appears on the screen pointing to an object or an object that starts flashing). This also includes cursors that flash and draw the user's attention to the text insertion point.	<ul style="list-style-type: none"> <li>• Speech.</li> <li>• Tone and echo location.</li> <li>• Pitch and repetition rate of beep.</li> <li>• Pitch and timbre.</li> <li>• Virtual source.</li> <li>• Braille.</li> <li>• Tactile direction indication.</li> <li>• Haptic table with auditory or tactile cross hair (absolute position).</li> <li>• Driven mouse/puck (absolute position).</li> </ul>
<b>Icon Image</b>	Small images that always appear exactly the same (size may vary, but not shape/graphic description).	<ul style="list-style-type: none"> <li>• Recognized and announced (by number or name).</li> </ul>
<b>Stereotypic Image</b>	Images that vary but follow a specific predefined format (e.g., particular histograms, pie charts, etc.).	<ul style="list-style-type: none"> <li>• Image interpretation with verbal output (see above for text display approaches).</li> </ul>
<b>Pictographic Image</b>	This includes all information that is basically pictorial in nature and cannot be easily or completely expressed verbally.	<ul style="list-style-type: none"> <li>• High-resolution, full tactile tablet.</li> <li>• Pressure-sensitive full tactile tablet (with tones, speech).</li> <li>• Virtual tactile tablet (with tones, speech).</li> <li>• Driven puck, graphics, or tactile tablet (using guided or constrained movement).</li> <li>• Object drop-out.</li> <li>• Zoomed images.</li> <li>• Image interpretation.</li> </ul>
<b>Animated Image</b>	This includes all information that is presented through a dynamic, moving display.	<ul style="list-style-type: none"> <li>• Depends on information being presented.</li> </ul>
<b>Three-Dimensional Image</b>	This includes all displays of three-dimensional image information.	<ul style="list-style-type: none"> <li>• Methods are unknown.</li> </ul>

## **APPENDIX B**

### **Determinants of Attitude Formation**

(Oskamp, 1977)

<b>Function</b>	<b>Origin and Dynamics</b>	<b>Arousal Conditions</b>	<b>Change Conditions</b>
<b>Understanding</b>	Need for understanding, for meaningful cognitive organization, for consistency and clarity	1. Reinstatement of cues associated with old problem or of old problem itself	1. Ambiguity created by new information or change in environment 2. More meaningful information about problems
<b>Need Satisfaction</b>	Utility of attitudinal object in need satisfaction. Maximizing external rewards and minimizing punishments	1. Activation of needs 2. Salience of cues associated with need satisfaction	1. Need deprivation 2. Creation of new needs and new levels of aspiration 3. Shifting rewards and punishments 4. Emphasis on new and better paths for need satisfaction
<b>Ego Defense</b>	Protecting against internal conflicts and external dangers	1. Posing of threats 2. Appeals to hatred and repressed impulses 3. Rise in frustrations 4. Use of authoritarian suggestion	1. Removal of threats 2. Catharsis 3. Development of self-insight
<b>Value Expression</b>	Maintaining self identity; enhancing favorable self-image; self-expression and self-determination	1. Salience of cues associated with values 2. Appeals to individual to reassert self-image 3. Ambiguities which threaten self-concept	1. Some degree of dissatisfaction with self 2. Greater appropriateness of new attitude for the self 3. Control of all environmental supports to undermine old values

## **APPENDIX C**

### **Attitude to Blindness Scale (ABS)**

(Shaw and Wright, 1967)

The Attitude to Blindness Scale is a 30 item questionnaire in which ten items indicate a positive attitude and twenty items, a negative attitude. The negative items are marked with an asterisk, and the asterisk did not appear on the experimental version of the questionnaire. The responses are weighted 1, 2, 3, and 4, respectively, when the statement is positive, and exactly opposite when the statement is negative. The attitude score is the sum of item scores with the range of possible scores being 30 to 120. The lower the score the more favorable the attitude toward blindness. The split-half reliability was 0.83 before correction and 0.91 after correction.

Read each of the statements below and then rate them as follows:

<b>A</b>	<b>a</b>	<b>d</b>	<b>D</b>
Strongly Agree	Mildly Agree	Mildly Disagree	Strongly Disagree

Indicate your opinion by drawing a circle around the "A" if you strongly agree, around the "a" if you mildly agree, around the "d" if you mildly disagree, and around the "D" if you strongly disagree.

There are no right or wrong answers, so answer according to your own opinion. It is very important to the study that all questions be answered. Many of the statements will seem alike but all are necessary to show slight differences of opinion.

- 1.\* A blind person might as well accept the fact that blindness makes people pretty helpless.

**A**                      **a**                      **d**                      **D**

- 2.\* On the whole, blind children seem to be less intelligent than sighted children.

**A**                      **a**                      **d**                      **D**

- 3.\* Blinded people are used to failing in most of the things they do.

**A**                      **a**                      **d**                      **D**

- 4.\* A blind person should not have to meet the same standards as others.

**A**                      **a**                      **d**                      **D**

- 5.\* Blind people are constantly worried about the future.

**A**                      **a**                      **d**                      **D**

6. Blindness has little or no effect upon intelligence.

**A**                      **a**                      **d**                      **D**

7. A blind person is not afraid to express their feelings.

**A**                      **a**                      **d**                      **D**

- 8.\* A blind person can never really be happy.

**A**                      **a**                      **d**                      **D**

- 9.\* Most blind people are dissatisfied with themselves.  
A a d D
- 10.\* A blind person can't afford to talk back to people.  
A a d D
11. One can live in a competitive society and still compete successfully without sight.  
A a d D
- 12.\* It makes me feel a little guilty to know that I can see and others cannot.  
A a d D
- 13.\* You should not expect too much from a blind person.  
A a d D
- 14.\* Most blind people feel that they are worthless.  
A a d D
15. It is possible to know the beauty of the world without sight.  
A a d D
16. My attitude towards a blind person would be based more upon their personality than upon the fact that they are blind.  
A a d D
- 17.\* Blind people do not have as much initiative as sighted people.  
A a d D
- 18.\* It is very difficult to make a blind person change their mind once they have decided on something.  
A a d D
- 19.\* It must be bitterly degrading for a blind person to depend so much upon others.  
A a d D

20. Many blind people are economically independent.  
A a d D
- 21.\* Blind people are more easily upset than sighted people.  
A a d D
- 22.\* Most blind people think and act alike.  
A a d D
- 23.\* It's difficult to understand the blind because they keep so much to themselves.  
A a d D
24. There are things worse than being blind.  
A a d D
25. Acceptance of blindness is the same thing as acceptance of anything else in life.  
A a d D
- 26.\* The blind adult is not quite as mature or "grow-up" as the sighted adult.  
A a d D
27. Blindness does not change the person any more than any other physical handicap.  
A a d D
28. The blind have as many interests as the sighted have.  
A a d D
- 29.\* I feel that blindness is as hard to bear as complete paralysis.  
A a d D
- 30.\* A blind person is constantly worried about what might happen to them.  
A a d D

## **APPENDIX D**

### **Attitude Toward Disabled People (ATDP) Scale - Form A**

(Shaw and Wright, 1967)

For the Attitude Toward Disabled People (ATDP) Scale - Form A, subjects are given a six-point response scale: I agree very much, I agree pretty much, I agree a little, I disagree a little, I disagree pretty much, and I disagree very much. These alternatives are weighted +3, +2, +1, -1, -2, -3, respectively. The subject responds to each item by either entering the appropriate weight in a space provided to the left of each item or by circling the appropriate weight on an answer sheet.

Forms A and B of the ATDP scale are scored as follows: (1) Change the signs of the weights of positive items (Form A [Appendix D] items, 5, 9, 12, 14, 17, 19, 21, 22, 23, 24, 25, and 29; Form B [Appendix E] items 1, 3, 4, 6, 7, 10, 12, 13, 22, 26, 28), these items are marked with an asterisk which did not appear on the experimental copy; (2) Add all the responses algebraically; (3) Change the sign of the algebraic resultant; and (4) Add 90. The range of possible scores is 0 to 180. For non-disabled subjects, high scores are interpreted to represent acceptance of disabled persons, i.e., a favorable attitude toward disabled persons. Split-half reliabilities range from 0.78 (N=72) to 0.84 (N=110).

### Attitude Toward Disabled People (ATDP) Scale

Mark each statement in the left margin according to how much you agree or disagree with it. Please mark every one. Write +1, +2, +3; or -1, -2, -3; depending on how you feel in each case.

**+3: I agree very much**  
**+2: I agree pretty much**  
**+1: I agree a little**

**-1: I disagree a little**  
**-2: I disagree pretty much**  
**-3: I disagree very much**

#### Form A

1.  Disabled people are often unfriendly.
2.  Disabled people should not have to compete for jobs with physically normal persons.
3.  Disabled people are more emotional than other people.
4.  Most disabled persons are more self-conscious than other people.
- 5.\*  We should expect just as much from disabled as from non-disabled persons.
6.  Disabled workers cannot be as successful as other workers.
7.  Disabled people usually do not make much of a contribution to society.
8.  Most non-disabled people would not want to marry anyone who is physically disabled.
- 9.\*  Disabled people show as much enthusiasm as other people.
10.  Disabled persons are usually more sensitive than other people.
11.  Severely disabled persons are usually untidy.
- 12.\*  Most disabled people feel that they are as good as other people.
13.  The driving test given to a disabled person should be more severe than the one given to the non-disabled.
- 14.\*  Disabled people are usually sociable.
15.  Disabled persons usually are not as conscientious as physically normal persons.
16.  Severely disabled persons probably worry more about their health than those who have minor disabilities.
- 17.\*  Most disabled persons are not dissatisfied with themselves.

- 18.  There are more misfits among disabled persons than among non-disabled persons.
- 19.\*  Most disabled persons do not get discouraged easily.
- 20.  Most disabled persons resent physically normal people.
- 21.\*  Disabled children should compete with physically normal children.
- 22.\*  Most disabled persons can take care of themselves.
- 23.\*  It would be best if disabled persons would live and work with non-disabled persons.
- 24.\*  Most severely disabled people are just as ambitious as physically normal persons.
- 25.\*  Disabled people are just as self-confident as other people.
- 26.  Most disabled persons want more affection and praise than other people.
- 27.  Physically disabled persons are often less intelligent than non-disabled people.
- 28.  Most disabled people are different from non-disabled people.
- 29.\*  Disabled persons don't want any more sympathy than other people.
- 30.  The way disabled people act is irritating.

## **APPENDIX E**

### **Attitude Toward Disabled People (ATDP) Scale - Form B**

(Shaw and Wright, 1967)

For the Attitude Toward Disabled People (ATDP) Scale - Form A, subjects are given a six-point response scale: I agree very much, I agree pretty much, I agree a little, I disagree a little, I disagree pretty much, and I disagree very much. These alternatives are weighted +3, +2, +1, -1, -2, -3, respectively. The subject responds to each item by either entering the appropriate weight in a space provided to the left of each item or by circling the appropriate weight on an answer sheet.

Forms A and B of the ATDP scale are scored as follows: (1) Change the signs of the weights of positive items (Form A [Appendix D] items, 5, 9, 12, 14, 17, 19, 21, 22, 23, 24, 25, and 29; Form B [Appendix E] items 1, 3, 4, 6, 7, 10, 12, 13, 22, 26, 28), these items are marked with an asterisk which did not appear on the experimental copy; (2) Add all the responses algebraically; (3) Change the sign of the algebraic resultant; and (4) Add 90. The range of possible scores is 0 to 180. For non-disabled subjects, high scores are interpreted to represent acceptance of disabled persons, i.e., a favorable attitude toward disabled persons. Split-half reliabilities range from 0.78 (N=72) to 0.84 (N=110).

**Attitude Toward Disabled People (ATDP) Scale**

Mark each statement in the left margin according to how much you agree or disagree with it. Please mark every one. Write +1, +2, +3; or -1, -2, -3; depending on how you feel in each case.

**+3: I agree very much**  
**+2: I agree pretty much**  
**+1: I agree a little**

**-1: I disagree a little**  
**-2: I disagree pretty much**  
**-3: I disagree very much**

**Form B**

- |      |                          |   |
|------|--------------------------|---|
| 1.*  | <input type="checkbox"/> | Disabled persons are usually friendly.  |
| 2.   | <input type="checkbox"/> | People who are disabled should not have to pay income taxes.                                  |
| 3.*  | <input type="checkbox"/> | Disabled people are no more emotional than other people.                                      |
| 4.*  | <input type="checkbox"/> | Disabled people can have a normal social life.  |
| 5.   | <input type="checkbox"/> | Most physically disabled persons have a chip on their shoulder.                               |
| 6.*  | <input type="checkbox"/> | Disabled workers can be as successful as other workers.                                       |
| 7.*  | <input type="checkbox"/> | Very few disabled persons are ashamed of their disabilities.                                  |
| 8.   | <input type="checkbox"/> | Most people feel uncomfortable when they associate with disabled people.                      |
| 9.   | <input type="checkbox"/> | Disabled people show less enthusiasm than non-disabled people.                                |
| 10.* | <input type="checkbox"/> | Disabled people do not become upset any more easily than non-disabled people.                 |
| 11.  | <input type="checkbox"/> | Disabled people are often less aggressive than normal people.                                 |
| 12.* | <input type="checkbox"/> | Most disabled persons get married and have children.  |
| 13.* | <input type="checkbox"/> | Most disabled persons do not worry any more than anyone else.                                 |
| 14.  | <input type="checkbox"/> | Employers should not be allowed to fire disabled employees.                                   |
| 15.  | <input type="checkbox"/> | Disabled people are not as happy as non-disabled ones.  |
| 16.  | <input type="checkbox"/> | Severely disabled people are harder to get along with than are those with minor disabilities. |
| 17.  | <input type="checkbox"/> | Most disabled people expect special treatment.  |

18.  Disabled persons should not expect to lead normal lives.
19.  Most disabled people tend to get discouraged easily.
20.  The worst thing that could happen to a person would be for them to be very severely injured.
21.  Disabled children should not have to compete with non-disabled children.
- 22.\*  Most disabled people do not feel sorry for themselves.
23.  Most disabled people prefer to work with other disabled people.
24.  Most severely disabled persons are not as ambitious as other people.
25.  Disabled persons are not as self-confident as physically normal people.
- 26.\*  Most disabled persons don't want more affection and praise than other people.
27.  It would be best if a disabled person would marry another disabled person.
- 28.\*  Most disabled people do not need special attention.
29.  Disabled persons want sympathy more than other people.
30.  Most physically disabled persons have different personalities than normal persons.

## **APPENDIX F**

### **User Evaluation of Interactive Computer Systems (Short Form)**

(Shneiderman, 1987)



9. Display layouts simplify tasks

Never										Always									
	1	2	3	4	5	6	7	8	9	10	Mean	7.93	StDev	1.94					

10. Sequence of displays

Confusing										Clear									
	1	2	3	4	5	6	7	8	9	10	Mean	8.00	StDev	1.60					

11. Pace of the interaction

Too Slow										Fast Enough									
	1	2	3	4	5	6	7	8	9	10	Mean	3.87	StDev	1.88					

12. Error messages are helpful

Never										Always									
	1	2	3	4	5	6	7	8	9	10	Mean	8.00	StDev	1.55					

13. Error correction is

Confusing										Clear									
	1	2	3	4	5	6	7	8	9	10	Mean	7.43	StDev	2.30					

14. Online help

Confusing										Clear									
	1	2	3	4	5	6	7	8	9	10	Mean	7.50	StDev	2.07					

15. Learning the operation

Difficult										Easy									
	1	2	3	4	5	6	7	8	9	10	Mean	9.20	StDev	1.11					

16. Use by different levels of experience

Not Accommodated										Accommodated									
	1	2	3	4	5	6	7	8	9	10	Mean	6.85	StDev	2.76					

17. Human memory limitations

Overwhelmed										Are Respected									
	1	2	3	4	5	6	7	8	9	10	Mean	4.93	StDev	2.09					

18. Supplemental reference materials

<b>Confusing</b>											<b>Clear</b>									
	1	2	3	4	5	6	7	8	9	10	Mean	7.45	StDev	1.92						

19. Exploration of features

<b>Discouraged</b>											<b>Encouraged</b>									
	1	2	3	4	5	6	7	8	9	10	Mean	7.29	StDev	2.13						

20. Overall reactions

<b>Terrible</b>											<b>Wonderful</b>									
	1	2	3	4	5	6	7	8	9	10	Mean	6.93	StDev	1.83						

21. Overall reactions

<b>Frustrating</b>											<b>Satisfying</b>									
	1	2	3	4	5	6	7	8	9	10	Mean	6.53	StDev	1.85						

22. Overall reactions

<b>Dull</b>											<b>Stimulating</b>									
	1	2	3	4	5	6	7	8	9	10	Mean	5.87	StDev	2.77						

23. Overall reactions

<b>Difficult</b>											<b>Easy</b>									
	1	2	3	4	5	6	7	8	9	10	Mean	7.40	StDev	1.96						

24. Overall reactions

<b>Inadequate Power</b>											<b>Adequate Power</b>									
	1	2	3	4	5	6	7	8	9	10	Mean	7.70	StDev	2.21						

## **APPENDIX G**

### **Subject Screening Form**

The subject must answer "yes" to first three questions:

	<b>YES</b>	<b>NO</b>
1. Are you a computer science/engineering student?	<input type="checkbox"/>	<input type="checkbox"/>
2. Have you completed two freshman computer courses?	<input type="checkbox"/>	<input type="checkbox"/>
3. Have you used e-mail, the internet, or the WWW?	<input type="checkbox"/>	<input type="checkbox"/>

The subject must answer "no" to questions four and five:

	<b>YES</b>	<b>NO</b>
4. Do you have any disabled family members?	<input type="checkbox"/>	<input type="checkbox"/>
5. Do you have any disabled acquaintances?	<input type="checkbox"/>	<input type="checkbox"/>

## **APPENDIX H**

### **Record Form for Treatment Conditions**

Determining Effectiveness of Visual Disability Guidelines Presented on a Multimedia Workbench

Subject	Label	Males - G1		Females - G2		
		Printed (P1)	Multimedia (P2)	Printed (P1)	Multimedia (P2)	
1	11		X			X
2	12				X	X
3	13	X				X
4	14		X			X
5	15		X			X
6	16	X				X
7	17		X			X
8	18		X			X
9	19	X				X
10	20		X			X
11	21			X		X
12	22			X		X
13	23	X				X
14	24	X				X
15	25		X			X
16	26		X			X
17	27	X				X
18	28		X			X
19	29	X				X
20	30		X			X
21	31	X				X
22	32				X	X
23	33			X		X
24	34			X		X
25	35			X		X
26	36				X	X
27	37			X		X
28	38				X	X
29	39				X	X
30	40				X	X
31	41			X		X
32	42	X				X
33	43			X		X
34	44				X	X
35	45			X		X
36	46	X				X
37	47				X	X
38	48				X	X
39	49			X		X
40	50				X	X
	Totals	10/10	10/10	10/10	10/10	40/40

## **APPENDIX I**

### **Informed Consent Form**

## **INFORMED CONSENT FORM**

As a participant in this research study, you have certain rights as explained below. The following is a listing of those rights and should be read and understood before consenting to participate in this study. Please read your rights and additional material carefully as well as the attached sheet and sign your name.

### **Your Rights as a Subject:**

1. You have the right to withdraw from participating in the study at any time and for any reason. If you wish to terminate your participation, inform the researcher.
2. You have the right to inspect your data and withdraw them from the study at any time and for any reason. Please inform the researcher immediately of this decision. Shortly after you have completed the experiment, your name will be separated from your data and handled anonymously and it will not be possible to track your individual data once the experimental session is completed. All data collected in this experiment will be treated with confidentiality and data will also be processed and analyzed with anonymity.
3. You have the right to be informed of the overall results of this study. If you wish to receive a synopsis of the results, include your address with your signature below.
4. You have the right to be informed of any risks or discomforts in this research. No risk or discomfort is involved in this study beyond what might be experienced while using a computer.
5. Any of the research team members will answer any questions that you may have, to the extent that the answer will not bias the research results. If an answer can not be provided before data collection is completed, the researcher will inform you and will provide you the answer after the experiment. You should not sign this consent form until you understand fully all of the terms involved.

### **Compensation**

I understand that for my participation I will receive payment in the amount of \$5.00 for each hour completed, which will be contingent upon completion of the entire set of experiments. This will total approximately \$15.00.

## **Recording**

I understand that the results of my efforts will be recorded and that I may be photographed, filmed, or videotaped. I consent to the use of this information for scientific or training purposes and understand that any records of my participation in this study may be disclosed only according to federal law, including the Federal Privacy Act, and its implementing regulations. This means that personal information will not be released to any unauthorized third party without my consent. In any event, all records will be destroyed four weeks after the completion of the project.

## **Silence**

To avoid biasing other potential participants of this study, you are requested not to discuss this study with anyone until one year from now.

## **Approval of Research**

This research project has been approved, as required, by the Institutional Review Board for projects involving human subjects at Virginia Polytechnic Institute and State University, by the Department of Industrial and Systems Engineering.

## **Closing**

If you have any additional questions concerning the research, you may contact Tim J. Al-Molky or Dr. R.C. Williges at the telephone number that will be provided to you at the end of the experiment. If you have any further comments or question about your rights as a participant, these can be addressed to Chairman of the Institutional Review Board for Research Involving Human Subjects at the address and telephone number listed below:

Dr. Ernest R. Stout  
Chairman of Research Division  
Virginia Polytechnic Institute and State University  
306 Burrus Hall  
Blacksburg, Virginia, 24061-0244  
(703) 231-9359

## INFORMED CONSENT FORM

Your signature below will indicate that you have read this entire document, and understand your rights as a participant, and that you consent to participate.

I have read and understood the informed consent and conditions of this study. I am aware of my rights as a participant and I have no other questions at this time. I hereby give my voluntary consent for participation in this study. If I participate, I may withdraw at any time.

\_\_\_\_\_

Participant's Signature

\_\_\_\_\_ D / M / Y \_\_\_\_\_

Date

\_\_\_\_\_

Print Name

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(Print address if you wish to receive a synopsis of the experimental results)

## **APPENDIX J**

### **Participant's Permission and Instructions**

## **PARTICIPANT'S PERMISSION AND INSTRUCTIONS**

### **Title of Project:**

Determining Effectiveness of Visual Disability Guidelines Presented on a Multimedia Workbench.

### **Principal Investigator:**

Dr. R.C. Williges

### **Purpose of Project:**

Welcome and thank you for agreeing to participate in this experiment. At this time you will have read the informed consent form and will be aware of your rights as a subject.

This study is being conducted in the Human Computer Interaction Laboratory of the Human Factors Center at Virginia Tech. The experiment is being conducted by Tim Al-Molky under the supervision of Dr. Robert Williges, a professor in the Industrial and Systems Engineering department.

The purpose of this study is to compare the effectiveness of two different instructional systems and whether learners will benefit from the instruction. As an experimental subject you will be a learner engaged in independent instruction. The subject material you will be taught will consist of background material related to visual disability and guidelines for the development of equipment that can be used by the visually disabled.

The experiment will take approximately 180 minutes and you will be paid \$15.00 for your participation contingent upon completing the experiment in its entirety.

### **Benefits:**

The benefits derived from this experiment will be realized by the scientific body of knowledge. There are no known direct benefits to you as a participant. You may however, come away from the experiment with a greater awareness of yourself and others.

**Extent of Anonymity and Confidentiality:**

A code number will be assigned to each subject to maintain anonymity. Any information you provide will have your name removed and only a subject number will identify you during analyses and any written reports of the research. I understand that the results of my efforts will be recorded and that I may be photographed, filmed, or videotaped. I consent to the use of this information for scientific or training purposes and understand that any records of my participation in this study may be disclosed only according to federal law, including the Federal Privacy Act, and its implementing regulations. This means that personal information will not be released to any unauthorized third party without my consent. In any event, all records will be destroyed four weeks after the completion of the thesis.

**General Instructions**

Next to you on the table you will find a binder. It will inform you as to which training condition you have been randomly assigned. And it also contains all information to guide you from the beginning of the experiment to the end.

You will begin with a series of pretests. The first two tests are rating scales. There are no wrong or right answers and no one will ever know of your anonymous responses. So feel free to answer honestly. The third test will examine your current level of knowledge in the subject area. This test will be carried out using the computer. An experimenter will be available to answer questions during the experiment. However, not all questions may be answered. This is to ensure that all participant's are treated equally and the objectivity of the experiment is maintained.

Once you have completed the training you will then begin a series of three posttests. Upon their completion you will be debriefed and any additional questions you have can be answered. Then you will sign the date, your SSN, and your signature and receive payment and be thanked for your participation.

**Closing:**

I have been debriefed about the entire study and understand the scope of the research. I have no other questions at this time. I am aware of my rights as a participant including that I may inspect my data or withdraw them from the study if I choose to do so. I hereby give my voluntary consent to use data collected on me for this study with the understanding that all data will be processed with confidentiality and wherever possible, anonymity will be preserved.

\_\_\_\_\_

Participant's Signature

\_\_\_\_\_

Print Name

\_\_\_\_\_ D / M / Y \_\_\_\_\_

Date

## PARTICIPANT'S PERMISSION

I have been debriefed about the entire study and understand the scope of the research. I have no other questions at this time. I am aware of my rights as a participant including that I may inspect my data or withdraw them from the study if I choose to do so. I hereby give my voluntary consent to use data collected on me for this study with the understanding that all data will be processed with confidentiality and wherever possible, anonymity will also be preserved.

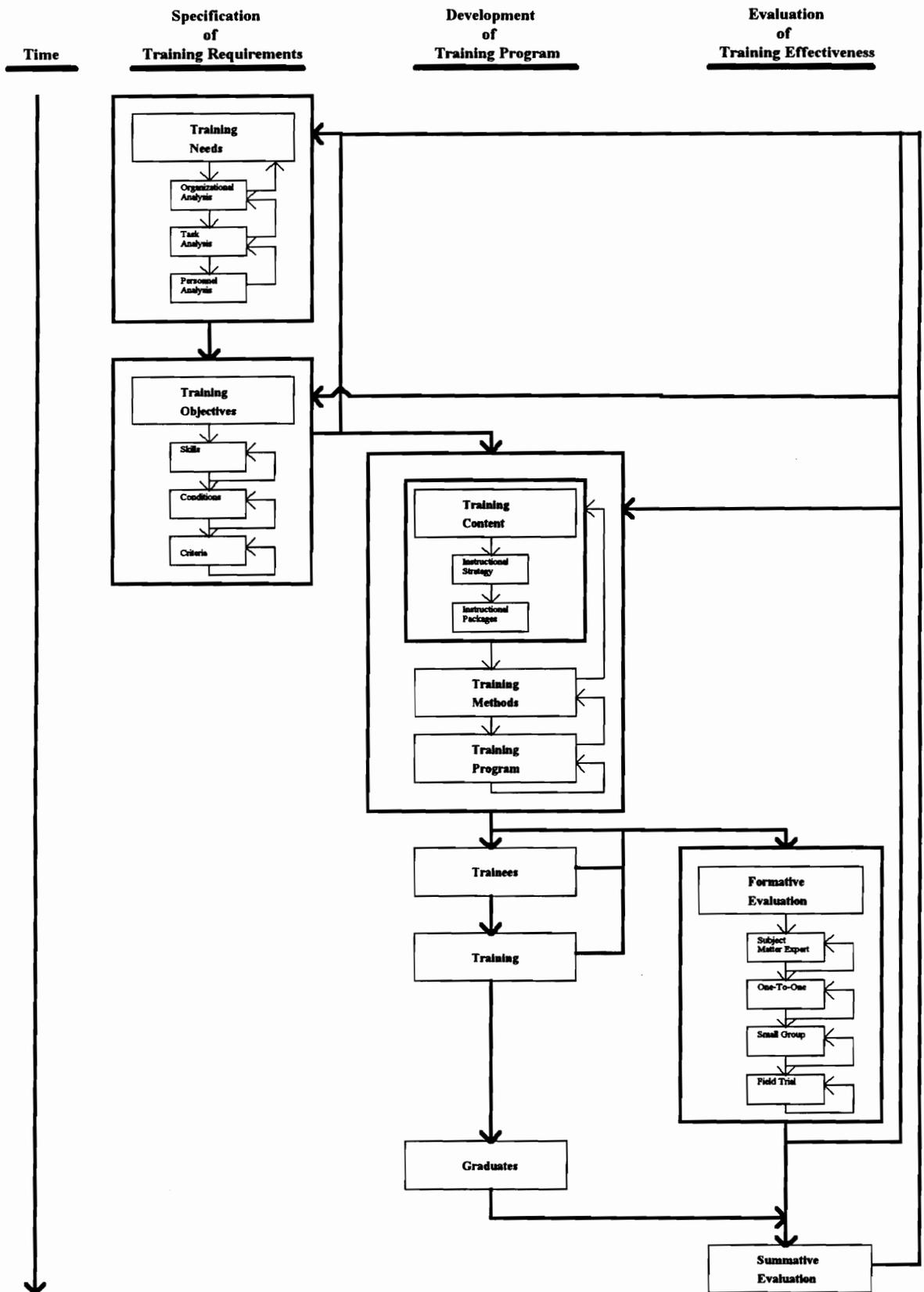
Should I have any questions about this research or its conduct, I will contact:

<b>Tim J. Al-Molky</b> Principal Investigator Graduate student in the Department of Industrial and Systems Engineering, Virginia Tech, Blacksburg, Virginia, 24061	<b>(703) 953 1088</b> Telephone
<b>Dr. R.C. Williges</b> Faculty Advisor Director of the Human Computer Interaction Laboratory, Department of Industrial and Systems Engineering, Virginia Tech, Blacksburg, Virginia, 24061	<b>(703) 231-6270</b> Telephone
<b>Dr. E.R. Stout</b> Chair, Institutional Review Board Research Division, Virginia Tech, 306 Burrus Hall, Blacksburg, Virginia, 24061-0244	<b>(703) 231-9359</b> Telephone

**You will receive a copy of this page on the completion of the experiment.  
Thank you!**

## **APPENDIX K**

### **Systems Approach to Instructional Design**



## **APPENDIX L**

### **Behavioral Objectives**

1. Given the term Activities of Daily Living (ADL's) list as many of the terms as possible in accordance with the training instruction.
2. Be able to list as many of the expected changes in vision associated with aging in accordance with the training instruction.
3. Be able to list a leading cause of visual impairment in accordance with the training instruction.
4. Be able to list as many of the four most common sites for afflictions leading to blindness in accordance with the training instruction.
5. Given the term "blind", be able to broadly describe the term, that is, in a manner indicative of its wide range of possibilities.
6. Name any reason for worrying about the social effects of visual disability in accordance with the training instruction.
7. Given a year, indicate the expected size of the senior citizen population, in accordance with the figures given in training (plus/minus 10%).
8. Given the term "generic guidelines" be able to indicate the most important generic guideline with the training instruction.
9. Given the term "accessible product design" be able to list any of the approaches, in accordance with the training instruction.
10. Given the term "accessible product design" be able to list the best approach, in accordance with the training instruction.
11. Given the term "direct accessibility" be able to explain a side benefit, in accordance with the training instruction.
12. Given the term "consumer product design guidelines" be able to list the main sections of the guidelines, as presented in the training material.
13. Given a section of the accessible consumer design guidelines be able to list any of the subcategories, as presented in the training instruction.
14. Given a visual scenario of "accessible product design" that is a variant of the information contained within the training instruction, be able to indicate the type of accessibility approach, in accordance with the training instruction.
15. Given the term "nonvisual display techniques" be able to list as many of the 11 information types as possible, in accordance with the training instruction.
16. Given a scenario of a computer display, be able to indicate what information type is being well employed, which information types could be employed, and what the possible visual condition is, in accordance with the training instruction.

## **APPENDIX M**

### **Marking Key for Pretest/Posttest**

## Marking Key Pretest/Posttest

For purposes of a criterion, one fully correct answer per question will score a total of 811 points.

1. Name the Activities of Daily Living (ADL's):

Three points each, one if close.

- |   |                                      |    |                     |
|---|--------------------------------------|----|---------------------|
| 1 | <u>Communication</u>                 | 7  | <u>Dressing</u>     |
| 2 | <u>Grooming</u>                      | 8  | <u>Toileting</u>    |
| 3 | <u>Visual Capability</u>             | 9  | <u>Transferring</u> |
| 4 | <u>Walking</u>                       | 10 | <u>Continence</u>   |
| 5 | <u>Movement of Upper Extremities</u> | 11 | <u>Feeding</u>      |
| 6 | <u>Bathing</u>                       |    |                     |

2. List the expected changes in vision associated with aging:

Three points each, one if close.

- |   |  |    |  |
|---|--|----|--|
| 1 | <u>Reduction in pupil size</u>           | 8  | <u>Deficient gaze stability</u>          |
| 2 | <u>Decrease in focusing ability</u>      | 9  | <u>Decline in color vision</u>           |
| 3 | <u>Increased sensitivity to glare</u>    | 10 | <u>Contrast sensitivity</u>              |
| 4 | <u>Decreased visual acuity</u>           | 11 | <u>Slower speed in visual processing</u> |
| 5 | <u>Need for greater illumination</u>     | 12 | <u>Decreased perception</u>              |
| 6 | <u>Difficulty adapting to light/dark</u> | 13 | <u>Difficulty reading small print</u>    |
| 7 | <u>Restricted field of view</u>          |    |  |

3. Name the five leading causes of visual impairment:

Three points each, one if close

- |   |                             |
|---|-----------------------------|
| 1 | <u>Glaucoma</u>             |
| 2 | <u>Macular degeneration</u> |
| 3 | <u>Senile cataract</u>      |
| 4 | <u>Retinitis pigmentosa</u> |
| 5 | <u>Diabetic retinopathy</u> |

4. List the four common sites for afflictions associated with blindness:

Three points each, one if close

- 1 Retina
- 2 Eyeball
- 3 Lens
- 4 Optic nerve

5. Broadly describe what the term blindness means to you:

Three points if any statement indicates that blindness can be more than complete darkness.

Blindness can vary widely in degree

6. Name three reasons why society should be concerned with visual disability:

Three points each, one if close.

- 1 Rapid growth of older population
- 2 Only one third of the visually impaired work
- 3 Cost of supporting the visually impaired is staggering

7. What is the expected size of the U.S. senior citizen population in 2030 (+/- 10%)?:

Three points.

20% or 52,000,000

8. With respect to visual disability, what is the most important "Generic Guideline"?:

Three points, one if close.

Cross-sensory redundant cueing

9. List the four approaches to "Accessible Product Guidelines":

Three points each, one if close.

- 1 Direct accessibility
- 2 Accessibility via standard options/accessories from the manufacturer
- 3 Compatibility with third party assistive devices
- 4 Facilitation of custom modifications

10. Which "Accessible Product Guideline" approach is considered the best approach?:

Three points, one if close.

Direct accessibility

11. With respect to "Accessible Product Guidelines", what is a side benefit of the "xxxxxx xxxxxxxxxxxxxxxx" (see computer screen)?

Three points for full answer (F), one if close, one for partial answer (P).

F-Benefits users without disabilities, P-Low cost

12. You will now view three separate scenarios/pictures related to the "Accessible Product Guidelines". You will be required to state which approach best applies to each scenario/picture.

12a. The picture presented below illustrates which approach to "Accessible Product Guidelines"?:

Three points, one if close.

Direct accessibility

12b. The scenario presented below best illustrates which approach to "Accessible Product Guidelines"?:

Three points, one if close.

Accessibility via standard options/accessories from the manufacturer

12c. The scenario presented below best illustrates which approach to "Accessible Product Guidelines"?:

Three points, one if close.

Compatibility with third party assistive devices

13. Name the five major sections of the "Consumer Product Design Guidelines":

Three points each, one if close.

1 Output/Displays

2 Input/Controls

3 Manipulations

4 Documentation

5 Safety

14. You will now view 16 separate scenarios/pictures related to "Consumer Product Design Guidelines". Your task will be to indicate which of the five (5) section(s) best describes each scenario/picture and which options are available to the designer to improve the scenario/picture.

For all section 14 answers the scoring is as follows: the correct section answer scores F-10 points, P-6 points if close. The improvement answer scores F-10 points, P-6 or P-3 points for every correct or close answer that is applicable to the scenario. If both the section and improvement answer are correct then there are bonus points awarded as follows bonus (B), B-5 if the section answer scored F-10, else B-3 if it scored P-6

The applicable answers are given in shorthand and can be cross-referenced in Appendix N.

14a. Consider the bar chart below, what section of the "Consumer Product Design Guidelines" does it represent?

Documentation

How could it be improved for someone who is color blind?

F-D1-4

14b. Consider the keypad below, what section(s) of the "Consumer Product Design Guidelines" does it represent?

Output/Displays and/or Input/Controls

How could it be improved for the visually impaired?

F-OD4-4a, F-IC3-3, P-OD4-1a, 2a, P-IC3-1, 4, 5, 6, 7, P-IC2-1, 3

14c. Consider the range top and dials below, what section of the "Consumer Product Design Guidelines" does it represent?

Input/Controls

How could it be improved for the visually impaired?

F-IC2-5, P-IC2-3, 4, P-IC3-1, 3, 5, 7, P-IC4-1, 4, 5, 6, P-IC7-1, 3

14d. Watch the scenario unfold below, what section of the "Consumer Product Design Guidelines" does it represent?

Output/Displays

How could it be improved for the visually impaired?

OD5-1, 2, 3

14e. Watch the flat panel relative position keypad below, what section of the "Consumer Product Design Guidelines" does it represent?

F-Input/Controls, P-Output/Displays

How could it be improved for the visually impaired?

F-IC4-2, P-IC4-1, 3, 4, 5, 6, P-IC7-1, P-IC3-3, 5, P-OD5-1, 2, 3

14f. Watch the scenario unfold below, what section of the "Consumer Product Design Guidelines" does it represent?

Output/Displays

---

How could it be improved for the visually impaired?

F-OD5-1, 2, 3 and plus/minus, P-OD4-1a, 2a, 3a

14g. Look at the picture below, what section of the "Consumer Product Design Guidelines" does it represent?

Input/Controls

---

How could it be improved for the visually impaired?

F-IC2-6

14h. Look at the picture below, what section of the "Consumer Product Design Guidelines" does it represent?

Output/Displays

---

How could it be improved for the visually impaired?

F-OD4-1c, P-OD4-1a, 1b, 3a, 3b, P-OD5-1, 2, 3

14i. Watch the scenario unfold below, what section of the "Consumer Product Design Guidelines" does it represent?

Input/Controls

---

How could it be improved for the visually impaired?

F-IC4-2, 3, P-IC4-4, 5, 6, P-IC3-1, 7, P-IC7-1, 3

14j. Look at the picture below, what section of the "Consumer Product Design Guidelines" does it represent?

Documentation

How could it be improved for the visually impaired?

F-D1-6, P-D1-1, 2, 3, 7

14k. I'll give you the previous answer. It was xxxxxxxxxxxxxxxx (see computer screen), (don't go back and change your answer now!). Specifically, it deals with making sure documentation is OCR/Scanner friendly. Point out some flaws of this presentation:

Three points each, one if close.

Highly stylized font

Screened picture

Text/Background low contrast

Are there any other OCR/Scanner unfriendly presentations that should be avoided?  
If so, what?

Five points each, two if close

Text is not in straight columns

Text flows around graphics

What could be done to make the presentation OCR/Scanner friendly?

Three points each, one if close.

Take away screening, use black on white

Use Helvetica font

14l. Watch the scenario unfold below, what section of the "Consumer Product Design Guidelines" does it represent?

Manipulation

How could it be improved for the visually impaired?

F-M1-1a, 1c, P-M1-1b, 1d

14m. Look at the picture below, what section of the "Consumer Product Design Guidelines" does it represent?

Input/Controls

---

How could it be improved for the visually impaired?

F-IC3-1, 2, 4, 5, 6, 7, P-IC2-3, P-IC4-4, 6, P-IC7-1, 3

14n. Look at the picture below, what section of the "Consumer Product Design Guidelines" does it represent?

Output/Displays

---

How could it be improved for the visually impaired?

F-OD4-1b, P-OD4-1a, 1c, 3a, 3b, P-OD5-1, 2, 3

14o. Watch the scenario unfold below, what section of the "Consumer Product Design Guidelines" does it represent?

Input/Controls

---

14p. Look at the picture below, what section of the "Consumer Product Design Guidelines" does it represent?

Output/Displays

---

How could it be improved for the visually impaired?

F-OD4-4a, 2a, P-OD4-1a, 1b, 1c, 2b, 3a, 3b

15. Name the eleven information types of the "Computer Screen Guidelines":

Three points each, one if close.

- 1 Running text
- 2 Text attributes
- 3 Spatially related text information
- 4 Pick from list
- 5 Interruption or alert
- 6 Directing

- 7 Icon image
- 8 Stereotypic image
- 9 Pictographic image
- 10 animated image
- 11 3D image

16. You will now view 9 separate scenarios/pictures related to "Computer Screen Guidelines"

Your task will be to indicate which of the eleven (11) information types best describes each scenario/picture and what options are available to the designer to improve the scenario/picture.

For all section 16 answers the scoring is as follows: the correct section answer scores F-10 points, P-6 points if close. The improvement answer scores F-10 points, P-6 or P-3 points for every correct or close answer that is applicable to the scenario. If both the section and improvement answer are correct then there are bonus points awarded as follows bonus (B), B-5 if the section answer scored F-10, else B-3 if it scored P-6

The applicable answers can be found in Appendix N under the appropriate non-visual display technique.

16a. Examine the following picture. What information type of the "Computer Screen Guidelines" does it represent?

Spatially related text information

How could it be represented or improved for the visually impaired? Appendix N

16b. Examine the following picture. What information type of the "Computer Screen Guidelines" does it represent?

Stereotypic image

How could it be represented or improved for the visually impaired? Appendix N

16c. Examine the following scenario. What information type of the "Computer Screen Guidelines" does it represent?

Pick from list

How could it be represented or improved for the visually impaired? Appendix N

16d. Examine the following scenario. What information type of the "Computer Screen Guidelines" does it represent?

Running text

How could it be represented or improved for the visually impaired? Appendix N

16e. Examine the following scenario. What information type of the "Computer Screen Guidelines" does it represent?

Interruption or alert

How could it be represented or improved for the visually impaired? Appendix N

16f. Examine the following picture. What information type of the "Computer Screen Guidelines" does it represent?

Pictographic image

How could it be represented or improved for the visually impaired? Appendix N

16g. Examine the following scenario. What information type of the "Computer Screen Guidelines" does it represent?

Icon image

How could it be represented or improved for the visually impaired? Appendix N

16h. Examine the following scenario. What information type of the "Computer Screen Guidelines" does it represent?

Directing

How could it be represented or improved for the visually impaired? Appendix N

16i. Examine the following scenario. What information type of the "Computer Screen Guidelines" does it represent?

Text attributes

How could it be represented or improved for the visually impaired? Appendix N

## **APPENDIX N**

### **Printed Text Study Material**

The pages that follow represent the printed text study material. It also represents the core of the multimedia study material. As explained previously the multimedia presentation contained Extra Learning Opportunities (ELO's). At those points where the multimedia presentation offered a hypertext link to an ELO, the printed text study material displays an asterisk. These asterisks were not part of the experimental material the subjects received. There were 78 ELO's in total, and 74 asterisks can be counted on the pages that follow. The four additional ELO's that were part of the multimedia presentation were short introductory video clips that displayed general information. This information was not tested in any form.

## INTRODUCTION

Vision is very important to all of our daily lives. We all pursue Activities of Daily Living (ADL's) that are an index of our independence. The ADL's are listed below:

- |                             |                   |
|-----------------------------|-------------------|
| * Communication,            | * Dressing,       |
| * Grooming,                 | * Toileting,      |
| * Visual Capability,        | * Transferring,   |
| * Walking,                  | * Contenance, and |
| * Use of Upper Extremities, | * Feeding.        |
| * Bathing.                  |                   |

We can easily see that Visual Capability is considered a minimum ADL for independence in living. Why is vision so personally important? Aging individuals fear the loss of sight more than the decline of any other body functions. As we age, we can expect any or all of the following changes to occur with our vision:

- |  |
|--|
| * Reduction in pupil size  |
| * Decrease in focusing ability (loss of accommodation)             |
| * Increased sensitivity to glare                                   |
| * Decline/Decreased ability to see objects clearly (visual acuity) |
| * Need for greater illumination                                    |
| * Difficulty adapting to darkness and brightness                   |
| * Restricted/Narrowing field of vision                             |
| * Deficient gaze stability   |
| * Decline in color vision/color discrimination                     |
| * Contrast sensitivity   |
| * Slower speed in visual processing                                |
| * Decreased perception   |
| * Difficulty reading, particularly small print.                    |

In addition to the body's expected and normal progression toward decreased visual ability there is also the threat of disease. The leading causes of visual impairment across all age groups are glaucoma, macular degeneration, senile cataract, retinitis pigmentosa, and diabetic retinopathy (Appendix A discusses some of these terms). These affect any of the four most common sites for afflictions leading to blindness: \* the retina, the eyeball, the lens, and the optic nerve.

What does visual disability mean? Most people think in terms of absolutes and in the minds of many individuals blindness is synonymous with blackness or the complete absence of light, and view the term "blind" as total disability. In reality this is a relative term and not necessarily so, and the attitude of the sighted toward blind people might change if it were more fully understood that \* blindness can vary widely in degree. In general, less than one in ten of those officially listed as "blind" live in a state of complete blindness. The majority remains able to perceive light and even large objects. However, it is important to realize that the rate of severe visual impairment increases steadily and dramatically with age.

The term legal blindness relates to the most severe vision impairment category and is generally universally accepted as including persons whose degree of corrected vision in the better eye is 20/200 or poorer or a severely restricted field of vision of 20 degrees or less in the better eye. Although legal blindness is a described term there are further categories of visual problems:

Visual Disorder:	A specific pathologic condition or deviation from typical or normal eye structure caused by an injury, disease, or congenital condition.
Visual Impairment:	A limitation in the overall function of the eye.
Visual Disability:	A limitation in an individual's ability to perform certain tasks that require detailed or gross vision (e.g., reading, writing, orientation, or mobility).
Visual Handicap:	A visual condition that places the affected individual at a disadvantage because of the social, cultural, or physical environment in which the individual lives.

### **Societal Effects**

Given that there are many individual effects why are we interested in visual impairment as a society?

1. The rapid growth and eventual size of an older population. By the year 2030, the population age 65 and older will be approximately 52,000,000 or 20% of the current population. And within this group the fastest growing group is age 85 and older. This is a definite problem since the prevalence of severe visual impairment is greatest in the age 85 and older group.
2. In addition to the number of visually impaired older citizens there is a discouraging number of unemployed individual's of working age due to their visual disability. Only one-third of working age visually impaired persons are part of the labor force.
3. The cost of supporting individual's with disabilities of all types is staggering. The United States spends \$120 billion dollars a year to support individual's with disabilities through a variety of federal, state, and private support structures. The support structures are in the form of Social Security Disability Income, Food Stamps, Medicaid, Medicare, Workman's Compensation, insurance company payments, and direct payments from companies.

## **COMPUTERS, INFORMATION, AND GUIDELINES**

Earlier we spoke of the Activities of Daily Living and listed vision one of the crucial indices of independence. Why does it seem that vision is more important than ever? It has a lot to do with the technological advances of society. Consider that all of the following often use text and graphics, often of very small size: computers, touch screen computers, phone systems with screen information, automatic ticketing machines in airlines, subways, and railways, automated teller machines at banks, on-line services, VCR's, microwave ovens, etc. The need for information is pervasive in our lives.

At one point it was easy for computers to relay by voice the information contained in the old DOS text systems. But the elements of the Graphical User Interface (GUI) are designed to provide a consistent interface with the computer and to minimize keystrokes by sighted users. But the GUI has two components that greatly complicate the review of information on a computer screen by the visually impaired: the icon, and the selection tools. The icon, a graphical representation of a concept, is a type of mnemonic device to minimize the user's reliance on memorized strings of commands. Selection tools that are not command driven, such as pull-down menus, scroll bars, and overlapping window, are also designed to assist the sighted user.

What can be done about this? This is where the computer industry and computer software designer can play an important role. There are many guidelines available that can guide the designer in developing software that is not only accessible to the visually disabled individual but is also likely to benefit the sighted individual. "Accessible Design" is the term used for the process of extending mass market product design to include people who find themselves on the low end of some dimension of performance (e.g., visually impaired).

## GENERIC GUIDELINES

The following statements represent twelve generic guidelines for designing items that best meet the needs of the disabled and also benefit the general population.

### Generic Guidelines to Increase Access to the Disabled

- \*
  1. Provide cross-sensory redundant cueing for all alarms, signals and controls (combine an audio signal with a visual indicator)♣
  2. Offer redundant modes of operation utilizing the next larger set of motor movements (finger to hand; hand to arm ; arm to foot)
  3. Establish consistent display/motion relationships left to right and forward/up to increase, backward/down to decrease)
  4. Provide definitive feedback cues (control positions (detents) should "snap" into position)
  5. Reduce the complexity of all operations (minimize the number of tasks)
  6. Place critical, and frequently used controls within easiest reach (cluster controls on basis of priority)
  7. Prevent accidental actuation of critical controls (relocate, recess, or provide a guard)
  8. Provide adjustable product/user interfaces (horizontal/incline, vertical/incline, raise/lower, push/pull)
  9. Design for use by a variety of populations (male/female, young/old, weak/strong, large/small)
  10. Design to facilitate physical and cognitive function (encourage user to practice and improve by making operations easy and enjoyable)
  11. Design beyond the basic physical/functional need (enhance the user's independence, self-respect, and quality of life)
  12. Compensate for a range of accommodation levels (provide for some exercise through user interaction/participation)

♣ This is the most important generic guideline when trying to accommodate a visually disabled individual.

## ACCESSIBLE PRODUCT GUIDELINES

There are four different approaches to making products more accessible to the disabled and listed as follows in order of desirability:

1. Direct Accessibility,
2. Accessibility via Standard Options or Accessories from the Manufacturer,
3. Compatibility with Third Party Assistive Devices, and
4. Facilitation of Custom Modifications.

### \* Direct Accessibility:

For most types or degrees of impairment, there are simple and low cost (or no cost) adaptations to product designs which can significantly increase their accessibility and usefulness to individuals with functional impairments. By incorporating these design modifications into the initial product design, the standard product can be more accessible directly out of the box.

Inclusion of these design features or approaches in the standard product can be of substantial benefit to society as a whole to the extent it enables individuals with disabilities to lead more independent and productive lives.

Bonus: it has often been found that designs which are accessible to people with disabilities may benefit other users without disabilities or impairments as well by reducing fatigue, increasing speed, decreasing the number of errors made and decreasing learning time.

Example: MacDonald's has embossed Braille characters on the tops of its soft drink cover along with the letters labeling the pushdown buttons on the lid that indicate whether the drink is diet, etc..

### \* Accessibility via Standard Options or Accessories:

Sometimes it is not possible to design the standard product to make it directly accessible for some disability populations. Alternatives to standard design may be identified, but offering all of them may not be practical due to some alternatives being mutually exclusive.

When this occurs, it may be more effective to make these adaptations or alternatives available as standard options or accessories from the manufacturer. These may be extra-cost, special order items, or items available free on request. These special features or accessories should be listed and described in the standard documentation that comes with the product. They could also be listed in advertising for the product.

Example: Microwave ovens are often made with smooth glass control panels. That is, there are no tactilely discernible buttons. This can present a problem for people with visual impairments. Ideally, the control panel should be designed with ridges around each button and some type of tactile identification of button function. If this is not possible, the manufacturer may make available either a raised or Braille overlay. These could be free upon request.

**\* Compatibility With Third Party Assistive Devices:**

Special Assistive Interfaces: Sometimes direct accessibility, or even the use of standard options, is impractical for the mass market producer to provide for all disability types and degrees. This is particularly true for individuals with severe or multiple impairments (e.g., a person with a severe physical disability must be unable to use a standard keyboard even with accessibility features built in). In these cases, special interfaces or accessories may be available from third party assistive device manufacturers.

Example: The mass market manufacturer can facilitate the efforts of third party manufacturers in a number of ways, including using standard approaches, providing appropriate connection points, providing advance access to new versions of products, and providing technical assistance in understanding and properly attaching accessories to the product. Consideration in the design of a keyboard for example could make it easier for third parties to develop keyguards and other keyboard accessories.

General Purpose Assistive Devices: In some cases, people with particular disabilities may already have general purpose assistive devices which they would like to be able to use in conjunction with a product (e.g., a blind person with a dynamic Braille display who would like to use it with home information systems). Unfortunately, it is often difficult or impossible to connect the assistive devices to standard products.

Cooperation between mass manufacturers and assistive device manufacturers could result in standard or built-in product connection points (connectors or infra-red links) which facilitate the connection of special devices as well as properly designed hardware to facilitate the use of assistive manipulation devices.

**Facilitation of Custom Modifications:**

There may be some cases where all the other approaches to Accessible Design prove to be impractical or uneconomical, most likely for people with combination or severe disabilities. In such case, custom modifications of the product, either by the product manufacturer or a third party, may be the best solution. Standard product manufacturers should facilitate this as much as they can. For example, leaving room for special attachments or labels, documenting hooks or places to patch into hardware or software, publishing information on safe or effective ways to modify products, or honoring warranties for products which have been modified for accessibility but where the modification did not result in the problem.

**Summary:**

The best approach of the four approaches to Accessible Design is the first type - Direct Accessibility. It allows the greatest access to products by persons with disabilities at the lowest cost. It also allows them to access products in public places where they could not otherwise modify the products to meet their particular needs. It also removes the stigma of "special" aids or modifications. This is especially important for older users who do not want to be labeled "disabled" even though their abilities are weakening.

It should also be noted that most of us become temporarily "disabled" in a number of ways throughout our lives. Sometimes it is by accident such as a broken arm or eye injury. Sometimes it is by circumstance, such as operating things in the dark where we can't see well, in loud environments where we can't hear well, with things in our arms where we can't reach well, when we're tired or on cold medication and can't think well, etc. Only those products which were designed to be more easily used directly "from the box" will be of use to us then. As mentioned above, more accessible designs are also usually easier to use by everyone all the time. But only if the ease of use is directly built in.

**Consumer Product Design Guidelines:  
Accessible Design of Consumer Products to Increase their Accessibility to People with Disabilities or Who are Aging.**

The following is a presentation of guidelines for the design of consumer products to increase their accessibility to people with disabilities or who are aging. Statements marked with a √ are pertinent to the design of equipment for the visually disabled and are amplified in Appendix B.

<p><b>Section 1</b> <b>Output/Displays:</b> Includes all means of presenting information to the user.</p>	<p><b>Maximize the number of people who can ...</b></p> <p>O/D 1 - ... hear auditory output clearly enough.  O/D 2 - ... receive important information if they can't hear.  O/D 3 - ... have line of sight to visual output and reach printed output.  √ O/D 4 - ... see visual output clearly enough.  √ O/D 5 - ... receive important information if they can't see.  O/D 6 - ... understand the output (visual, auditory, other).  O/D 7 - ... view the output display without triggering a seizure.</p>
<p><b>Section 2 Input/Controls:</b> Includes keyboards and all other means of communicating to the device.</p>	<p><b>Maximize the number of people who can ...</b></p> <p>I/C 1 - ... reach the controls.  √ I/C 2 - ... find the individual controls/keys if they can't see them.  √ I/C 3 - ... read the labels on the controls/keys.  √ I/C 4 - ... determine the status or setting of the controls if they can't see them.  I/C 5 - ... physically operate controls and other input mechanisms.  I/C 6 - ... understand how to operate controls and other input mechanisms.  √ I/C 7 - ... connect special alternative input devices.</p>
<p><b>Section 3 Manipulations:</b> Includes all actions that must be directly performed by a person in concert with the device or for routine maintenance (e.g., inserting disk, loading tape, changing ink cartridge)</p>	<p><b>Maximize the number of people who can ...</b></p> <p>√ M 1 - ... physically insert and remove objects as required to operate a device.  M 2 - ... physically handle and/or open the product.  M 3 - ... remove, replace, or repositions often used detachable parts.  M 4 - ... understand how to carry out the manipulations necessary to use the product.</p>
<p><b>Section 4 Documentation:</b> Primarily operating instructions.</p>	<p><b>Maximize the number of people who can ...</b></p> <p>√ D 1 - ... access the documentation.  D 2 - ... understand the documentation.</p>
<p><b>Section 5 Safety:</b> Includes alarms and protection from harm.</p>	<p><b>Maximize the number of people who can ...</b></p> <p>√ S 1 - ... perceive hazard warnings.  S 2 - ... use the device without injury due to unperceived hazards or user's lack of motor control.</p>

## COMPUTER SCREEN GUIDELINES

There are many nonvisual display techniques for output from graphics-based computers. We will examine eleven information types.

The visual channel has a tremendous capacity for information transfer. As a result, it is heavily relied upon in normal human-computer interface systems. Most of the information that is presented, however, is not inherently visual in nature, and could just as easily, though perhaps not as efficiently, be presented in an alternate verbal form (spoken, or written words), if access to the root information were provided. For example, a pull-down menu or an array of icons representing files could just as easily be presented in Braille or an auditory list of choices. Similarly, a pie chart could be represented as a series of values or displayed tactilely as a series of bars of varying height. Other information, however, is pictorial in nature, such as the layout of a room, an electronic circuit diagram, or a picture of a face. Although this information may be described verbally (voice, Braille, etc.), the results are either very lengthy or do not contain all the information presented in the picture or diagram. Multisensory or multiple-attribute systems will provide the best interface for both sighted and blind users.

In all the alternate display approaches listed below, it is assumed that the information being displayed can somehow be turned back into pure information. For example, it is assumed that the image of a menu, with choices displayed in different colors to represent accessibility, would be available as (or could be changed into) an ASCII listing of the words on the menu, with plus or minus signs indicating which choice was available at that time. Similarly, a display showing a thermometer with the mercury halfway up would be replaced by the value (50%) that the image is meant to present.

### Summary of Nonvisual Display Techniques by Information Type

Information Type	Description	Possible Solutions
<b>*Running Text</b>	This includes any information that is displayed in straight ASCII characters. No formatting, underlining, or spatial relationship between words is included, other than that each word follows the one preceding it.	<ul style="list-style-type: none"> <li>a. Braille (single character, 1-40 cell, or full page).</li> <li>b. Speech</li> <li>c. Tactile image (Optacon).</li> <li>d. Morse code (auditory or tactile).</li> </ul>
<b>*Text Attributes</b>	This includes any nonspatial attribute of the text, including boldface, superscript/subscript, underlining, italics, and shadow print.	<p><b>With Speech</b></p> <ul style="list-style-type: none"> <li>a. Announcement</li> <li>b. Background tone (presence, pitch, volume, apparent direction, short or continuous).</li> <li>c. Speech attribute (timbre, voice, volume, pitch).</li> <li>d. Environment (echo, tremolo).</li> </ul> <p><b>With Braille</b></p> <ul style="list-style-type: none"> <li>a. See items listed under "With Speech"</li> <li>b. Frequency of pin vibration.</li> <li>c. Slow pulse of pins.</li> <li>d. Extra pins at top or bottom of text.</li> <li>e. Separate tactile or electrocutaneous stimulator.</li> </ul>
<b>*Spatially Related (Text) Information</b>	This includes the information presented as the spatial relationship between two items of text, such as which words are placed specifically above, below, beside, in the same column, in the same row, etc., as other words.	<ul style="list-style-type: none"> <li>a. Apparent source of speech.</li> <li>b. Pitch.</li> <li>c. Haptic sense (with haptic tablet or joystick).</li> <li>d. Haptic with tone.</li> <li>e. Tactile tablet (full or virtual) (with tones, speech).</li> <li>f. Grids.</li> <li>g. Temporary ridges.</li> <li>h. Lockable tracking mechanism.</li> <li>i. Driven cursor, (puck, mouse, joystick).</li> </ul>
<b>*Pick From List</b>	This includes all instances in which the individual is presented with a series of choices from which he or she is to choose one or more items.	<ul style="list-style-type: none"> <li>a. Direct request (voice or keyboard).</li> <li>b. Best match.</li> <li>c. High/low-speed scan.</li> <li>d. Direct control scan (slider with indents or puck with ridges between choices).</li> <li>e. Search/read as block of text.</li> </ul>

<b>*Interruption or Alert</b>	This includes all instances in which information is abruptly presented to the individual at a time when he or she may not be expecting it (beeps, messages, etc.).	<ul style="list-style-type: none"> <li>a. Concurrent sound (beep, tone, or sound).</li> <li>b. Speech announcement.</li> <li>c. Tactile stimulator (vibrator or electrocutaneous stimulator).</li> <li>d. Olfactory.</li> </ul>
<b>*Directing</b>	This includes all information presented to the user in order to direct his or her attention or activity to a particular point or action (e.g., an arrow that appears on the screen pointing to an object or an object that starts flashing). This also includes cursors that flash and draw the user's attention to the text insertion point.	<ul style="list-style-type: none"> <li>a. Speech.</li> <li>b. Tone and echo location.</li> <li>c. Pitch and repetition rate of beep.</li> <li>d. Pitch and timbre.</li> <li>e. Virtual source.</li> <li>f. Braille.</li> <li>g. Tactile direction indication.</li> <li>h. Haptic table with auditory or tactile cross hair (absolute position).</li> <li>i. Driven mouse/puck (absolute position).</li> </ul>
<b>*Icon Image</b>	Small images that always appear exactly the same (size may vary, but not shape/graphic description).	<ul style="list-style-type: none"> <li>a. Recognized and announced (by number or name).</li> </ul>
<b>*Stereotypic Image</b>	Images that vary but follow a specific predefined format (e.g., particular histograms, pie charts, etc.).	<ul style="list-style-type: none"> <li>a. Image interpretation with verbal output (see above for text display approaches).</li> </ul>
<b>*Pictographic Image</b>	This includes all information that is basically pictorial in nature and cannot be easily or completely expressed verbally.	<ul style="list-style-type: none"> <li>a. High-resolution, full tactile tablet.</li> <li>b. Pressure-sensitive full tactile tablet (with tones, speech).</li> <li>c. Virtual tactile tablet (with tones, speech).</li> <li>d. Driven puck, graphics, or tactile tablet using guided or constrained movement.</li> <li>e. Object drop-out.</li> <li>f. Zoomed images.</li> <li>g. Image interpretation.</li> </ul>
<b>Animated Image</b>	This includes all information that is presented through a dynamic, moving display.	<ul style="list-style-type: none"> <li>a. Depends on information being presented.</li> </ul>
<b>Three-Dimensional Image</b>	This includes all displays of three-dimensional image information.	<ul style="list-style-type: none"> <li>a. Methods are unknown.</li> </ul>

## Appendix A

### Amplification of Leading Causes of Visual Impairment

#### **Glaucoma:**

Chronic elevated eye pressure in susceptible individuals may cause optic nerve atrophy and loss of peripheral vision. Early detection and close medical monitoring can help reduce complications. In advanced glaucoma, print may appear faded and words may be difficult to read.

#### **Macular Degeneration:**

The deterioration of the macula, the central area of the retina. A scotoma (blind spot in the field of vision) appears in the central field of vision. The peripheral or side vision remains unaffected so mobility need not be impaired. With macular degeneration, print appears distorted and segments of words may be missing.

#### **Cataract:**

An opacity of the lens results in diminished acuity but does not affect the field of vision. There is no scotoma (blind spot in the field of vision), but the persons' vision is hazy overall, particularly in glaring light. Print appears hazy or lacking in contrast.

#### **Retinitis Pigmentosa:**

Is a retinal pigmentary degeneration that primarily attacks males. In this disease the rods of the retina are slowly destroyed and the remainder of the retina atrophies. These changes usually begin in the mid-periphery, sparing the macula and extreme peripheral areas until later. Night blindness is the first symptom and usually occurs in early youth.

#### **Diabetic Retinopathy:**

The leaking of retinal blood vessels may occur in advanced or long-term diabetes and affect the macula or the entire retina and vitreous. Not all diabetics develop retinal changes, but the likelihood of retinopathy and cataracts increases with the length of time a person has diabetes. In diabetic retinopathy, reading vision is variable and print may be distorted or blurred. If cataracts are also present, print is hazy as well as blurred.

## **Appendix B**

### **Amplification of the Guidelines that Apply to the Visually Impaired for the Design of Consumer Products to Increase Accessibility**

Each guideline is phrased as an objective, followed by a statement of the problem(s) faced by people with disabilities. The problem statement is accompanied by more specific examples. Next, design options and ideas are presented to provide some suggestions as to how the objective could be achieved.

Note, for each guideline, only the problem statements that relate to visual disability will be expanded upon with additional information. The role of these guidelines then, is to raise awareness and understanding of designers. General recommendations or design ideas are provided to help designers identify areas where attention can increase accessibility.

## **Output/Displays**

### **O/D - 4 Maximize the number of people who can see visual output clearly enough.**

**Problem:** Visual output (e.g., information presented on screens, paper printouts, cueing and warning lights or dials) may not be effectively seen.

**Examples:**

1. Individuals who are visually impaired may not be able to see output that is too small.
- 2.\* Those who are visually impaired may have difficulty discerning complex typefaces or graphics.
- 3.\* Individuals who are color blind may not be able to differentiate between certain color pairs.
- 4.\* People with poor vision have more difficulty seeing letters/pictures against a background of similar hue or intensity (low contrast).
- 5.\* Individuals with visual impairments may be much more sensitive to glare.
6. Those who have visual impairments may not be able to see detail in low lighting.

**Options:**

1. Fonts:
  - a.\* Make letters and symbols on visual output as large as possible or practical.
  - b.\* Use upper and lowercase type to maximize readability.
  - c.\* Use Helvetica sans-serif as a font.
2. Color:
  - a. Use only black and white or use colors at varying intensity so that the color itself carries no information.
  - b. Provide adjustable color selection, i.e., hue and/or intensity.
  - c. Replace or supplement color coding with different shapes or relative position coding.
  - d. Avoid the use of the color blue to convey important information.
3. Image Size:
  - a.\* Provide adjustable display image size.
  - b. Provide a video jack for attaching larger image displays or utilizing special assistive equipment such as electronic magnifiers.
4. Contrast:
  - a.\* Provide contrast and/or image adjustment.
5. Lighting:
  - a. Minimize glare, and provide the best possible lighting for display areas containing instrumentation.

### **Output/Displays**

#### **O/D-5 Maximize the number of people who will not miss important information if they can't see.**

**Problem:** Visual output (e.g., information presented on screens, paper printouts, cueing and warning lights, and dials) may not be seen at all by some users.

**Examples:**

1. Individuals who are severely visually impaired or blind may not be able to see visual output, even when magnified and clarified.
- 2.\* Individuals who are deaf and blind may only be able to perceive tactile output.
- 3.\* Individuals who do not have any visual impairment may miss warnings, cues, or other information if it is presented only in visual form while their attention is diverted.

**Options:**

- 1.\* Provide all important visual information (redundantly) in audio and/or tactile form.
2. Make information which is visually displayed (both text and graphics) also available electronically at an external connection point (standard or special port) to facilitate the use of special assistive devices (e.g., voice synthesizers, Braille printers). Preferably the information would be available in an industry or company standard format.
- 3.\* All visually displayed information could be provided via voice synthesizer. The cost for voice output is dropping rapidly. A small button could be used to turn the voice on or off. This can be useful to people who are blind, have low vision, or have difficulty reading the display.
- 4.\* An inexpensive and unobtrusive approach would be to provide a small infra-red LED which would transmit the displayed information as a pulse train of light. Information could be sent in ASCII which could be picked up by a device which would translate the information into voice or Braille.

### **Input/Controls**

#### **I/C-2 Maximize the number of people who can find the individual controls/keys if they can't see them.**

**Problem:** People with visual impairments may be unable to find controls.

**Example:**

- 1.\* Individuals who are severely visually impaired may be unable to locate controls tactilely because they are on a flat membrane or glass panel (e.g., calculators, microwave ovens) or because they are placed too close together on in a complicated arrangement.
- 2.\* Individuals who have diabetes may have both visual impairments and failing sensation in fingertips, making it hard to locate controls that have only subtle tactile clues.

**Options:**

1. Varying the size of controls (also texture or shape) with the most important being larger to facilitate their location and identification.
2. Providing controls whose shapes are associated with their functions.
3. Providing sufficient space between controls for easy tactile location and identification as well as easier labeling (large print or Braille).
4. Locating controls adjacent to what they control.
- 5.\* Making layout of controls logical and easy to understand, to facilitate tactile identification (e.g., stove burner controls in corresponding locations to actual burners).
- 6.\* Providing a raised lip or ridge around flat (membrane or glass) panel buttons.
7. Providing a (redundant) speech recognition input option.

### **Input/Controls**

#### **I/C-3 Maximize the number of people who can read the labels on the controls/keys.**

**Problem:** Labels on controls, keys, etc., are difficult or impossible to see due to their size, color or location.

**Example:**

- 1.\* Individuals with low vision may have difficulty identifying controls or keys on a keyboard because the label lettering is too small and/or because the contrast between letters/graphics and background is poor.
2. Individuals with color blindness may have difficulty distinguishing controls which are color-coded, or which use certain pairs of colors for labels and background.
3. Individuals who are blind may not be able to see printed labels at all.

**Options:**

- 1.\* Make lettering used for labels as large as possible/practical. Lettering which uses most of the key or button surface facilitates readability.
- 2.\* Use sans serif fonts for non-text lettering for labels, dials, etc.. Helvetica typeface is easier for those with low vision to read.
- 3.\* Use high contrast between letters/graphics and background
4. Supplement color coding with use of different button/key shape or letter/graphic labels.
- 5.\* Provide tactile labels, and use voice output to "speak" the names of keys or buttons as they are pressed. This capability would need to be turned on or off as needed.
- 6.\* Arrange controls in groupings which facilitate tactile identification (e.g., using small groups of keys that are separated from the other keys, or placing frequently used keys near tactile landmarks such as along the edges of a keyboard.
7. Provide a (redundant) speech recognition input option.

### **Input/Controls**

#### **I-4 Maximize the number of people who can determine the status or setting of the controls if they can't see them.**

**Problem:** Determination of control status or setting may depend solely on vision.

**Example:**

Individuals with visual impairments may be unable to see a control setting or on/off indicator (e.g., where a dial is set, whether a button is pushed in, whether a light is on, flashing or off, or what a numeric setting on a visual display reads).

**Options:**

- 1.\* Provide multi-sensory indication of the separate divisions, positions and levels of the controls (e.g., use of detents or clicks to indicate center position or increments, raised lines, etc.).
- 2.\* Use absolute reference controls (e.g., pointers) rather than relative controls (e.g., pushbuttons to increase/decrease, or round, unmarked knobs).
- 3.\* Use moving pointers with stationary scales.
4. Provide multi-sensory indications of control status (e.g., in addition to a status light indicating "on", or providing an intermittent audible tone and/or tactilely discernible vibration).
5. Use direct keypad input.
- 6.\* Provide speech output to read or confirm the setting.

### **Input/Controls**

#### **I-7 Maximize the number of people who can connect special alternative input devices.**

**Problem:** Standard controls (or other input mechanisms) cannot be made accessible for all of those with severe impairments.

**Examples:**

Blind individuals cannot use input devices which require constant eye-hand coordination and visual feedback (e.g., a computer mouse, trackball or touchscreen).

**Options:**

1. Consider input devices with voice synthesizers built into them.
2. It is recognized that some activities, such as free-hand sketching on a computer, cannot be easily done other than with an eye-hand coordination input device.
- 3.\* Devices that can be controlled remotely by standard programmable infra-red controllers.
4. A standard for low cost bi-directional infra-red data transmission doesn't currently exist. Creation of such a standard would make it easier for appliance manufacturers to make display information available electronically as well as to allow remote and special devices to be used to control the appliances

## Manipulations

### **M-1 Maximize the number of individuals who can physically insert and/or remove objects as required in the operation of a device.**

**Problem:** Insertion and/or removal of objects required to operate some devices (e.g., diskettes, compact discs, cassette tapes, credit cards, keys, coins, currency) may be physically impossible. In addition, damage to the object or device can occur from unsuccessful attempts.

**Example:**

Individuals who are blind may be unable to determine proper orientation or alignment for insertion (i.e., object may be held upside down, backward or at the wrong angle).

**Options:**

1. **Facilitating Orientation and insertion:**
  - a.\* Provide a simple funneling system or other self-guidance/orienting mechanism which will properly position the object for insertion. Orientation can be easily marked tactilely by having a clipped corner or unsymmetrical shape.
  - b. Where possible, allow the object to be inserted in several ways (e.g., a six side wrench can be positioned in a mating bolt six different ways; two sided keys can be inserted upside down).
  - c.\* Provide visual contrast between insertion point and the rest of the device (making the "target" more obvious).
  - d. Clearly mark the proper orientation both visually and tactilely.
2. **Facilitating Removal:**
  - a. Provide ample ejection distance to facilitate easy gripping and removal of objects.
3. **Facilitating Handling:**
  - a. Make object to be inserted rugged and able to take rough handling.

## **Documentation**

### **D-1 Maximize the number of people who can access the documentation.**

**Problem:** Printed documentation (e.g., operating or installation instructions) may not be readable.

**Examples:**

1. Individuals with low vision may not be able to read documentation due to small size or poor format.
2. Poor choice of colors may make diagrams ambiguous for people with color blindness.
3. People who are blind cannot use printed documentation, especially graphics.

**Options:**

- 1.\* Provide documentation in alternate formats: electronic, large-print, audio tape, and/or Braille.
2. Use large fonts. Large print and large print labels are very effective with older individuals who develop low vision, since they often do not have powerful reading tools.
3. Use sans-serif fonts such as Helvetica.
- 4.\* Any information which is presented via color-coding could be presented in some other way which doesn't rely on color (e.g., bar charts may use various black-and-white patterns under the colors or patterns in the colors).
- 5.\* Provide a text description of all graphics (this is especially important for use in electronic, taped and large print forms).
- 6.\* Make printed documentation "Scanner/OCR - friendly". Avoid: text/background colors which are not high contrast (black on white is recommended, highly stylized or broken fonts, pictures which are screened and placed behind the text, text which is not arranged in straight rectangular columns, and text which flows around graphics).

## **Safety**

### **S-1 Maximize the number of people who can perceive hazard warnings.**

**Problem:** Hazard warnings (alarms) are missed due to monosensory presentation or lack of understandability.

**Example:**

People with visual impairments may not see visual warnings.

**Options:**

1. Use redundant visual and auditory format for alarms (e.g., flashing lights plus alarm siren).
2. Reduce glare on any surfaces containing warning messages.
3. Use common color-coding conventions and/or symbols along with simple warning messages.

## **APPENDIX O**

### **MM Design Principles**

## Pro/Con Positions on Multimedia Guidelines (Reed, 1993)

Position	Comments
Supporting Arguments for User Interface Standards -----	> 1. Standards improve ease of learning and ease of use. 2. Standards increase comfort and well-being. 3. Standards assist in software procurement and product evaluation. 4. Standards facilitate re-use of user interface design and code.
Arguments opposing software user interface standards -----	> 1. We don't know enough about "usability" to standardize. 2. Standards inhibit innovation in user interface design. 3. Only testing can assure usability.

## Hypertext Structure Guidelines (Hewett, 1987)

1. The reader should be able to move around the hypertext easily and quit when finished.
2. Any hierarchy should be shallow and wide, not narrow and deep.
3. There should be multiple paths through the information.
4. It should be obvious where the links are on a screen.
5. It should be obvious what is each link's destination.

### **General System Guidelines for Multimedia** (Weber, 1992)

1. Graphical interactive screens are, overall, more effective than text screens.
2. Animation can aid considerably to make interactive information more effective.
3. Interactive video or multimedia sequences tend to hold the interest of users
4. Users of interactive systems and programs should have an expanded role in design and development.
5. The setting in which computer-based interactivity is carried out can greatly affect desired outcomes.
6. People can learn a lot using interactive communication technology systems and programs.
7. For instruction, interactive systems fit well as part of a course which also uses conventional methods.
8. Interactive systems are effective for enhancing conventional communication approaches.

### **Digital Audio in Multimedia** (Barron, 1991)

1. Balance the quality of audio sources.
2. Separate spoken phrases with a short silence (about 1/2 second)
3. Develop on baseline hardware
4. Use a professional narrator
5. Keep narration short
6. Include visual cues
7. Avoid synchronization
8. Include a "repeat audio" option
9. Include an "interrupt audio" option.

### **Redundant Audio Better Than Text** (Barron and Atkins, 1994)

1. An audio-based version with total textual redundancy -- the audio is word for word, the same as the instructional text on the screen.
2. An audio-based version in which the audio and graphics are the same as version #1, but the visual text of #1 is reduced to bulleted items, rather than full text.
3. An audio-based version in which the audio and graphics are the same as version #1 and #2, but there is no visual text.

### **Appropriate Use of Speech in CBI** (Sales and Johnston, 1993)

1. Whose voice is used in the delivery of feedback in CBI seems to be of little importance.
2. The image associated with the speaker is of little importance.
3. It is reasonable to assume that speech is going to effect a change in learning outcomes, then the amount and positioning of the speech within a lesson are of critical importance.
4. During the research teachers and school staff repeatedly commented on the effect headphones had on student behavior. Students intently focused their attention on the computer lesson when wearing headphones.
5. Another observation made during the studies was that students in the animated character treatments were more demonstrative.
6. Regardless of what our research finds, we may not have a choice but to use speech and agents in instructional software.
7. In multimedia environments identification of primary symbol systems and the "most essential characteristics" of each is no small task. Furthermore, these characteristics may have varying degrees of importance to different learners.

### **Location Coding** (Chapman, 1993)

1. A consistent screen location stimulus improves the performance time of a non-linear interactive visual presentation.
2. Color-coded stimulus improves the performance time of a non-linear interactive visual presentation.
3. A consistent screen location stimulus is more effective than color-coding in improving performance time of a non-linear interactive visual presentation.

## Learner Control Guidelines (Park and Reeves, 1991)

1. **Content Instruction:** In general, it is not advisable to allow learners to control access to "essential content" unless reliable, valid performance measures indicate that they have mastered that content. Content defined as enriching or repetitive should be under learner control.
2. **Sequence of Instruction:** Well-designed CBI will include a variety of instructional options including overviews, statements of prerequisites and objectives, pretests, tutorials, simulation exercises, and post tests. Although there is some evidence that learners are not always the best judges of what kinds of and how much instruction they need, a well-structured orientation to instructional options may provide them with a better basis for selection. Contextual and presentational options, (if included, should be subject to learner preferences).
3. **Instructional Pacing:** Student control of pacing within CBI is strongly advised. (Ironically, this strategy may prove difficult for local implementers as they attempt to manage students completing instructional units at widely varying times).
4. **Feedback Mechanisms:** The type of feedback options (right, or wrong, correct response, elaboration) should be based upon instructional requirements. If more elaborative feedback than knowledge of results is appropriate, allowing student control of access to the feedback is generally advised.
5. **Advisement:** Learner control with advisement is highly recommended over unaided learner control. The nature of the advisement will be dependent upon the sophistication of the performance measures incorporated into the CBI as well as knowledge of learner error patterns.
6. **Instructions:** The success of CBI can be maximized by providing students with instructions and feedback that would encourage them to make internal attributions about their ability and effort related to their success. This argues for some variant of learner control with advisement whereby students are given advice about their instructional progress and needs, but the actual selection of instructional strategies would be left up to them.
7. **Affirmation:** CBI should be designed to enhance the self-esteem of students through positive affirmations. However, repetitive innocuous affirmation such as "that's great" or "correct" will be ignored by students after a short time. Contextual individualized, creative affirmations are recommended.
8. **Navigation:** The navigation procedures and basic structure of CBI should be consistent, but moderate variations in style of presentation and content will stimulate beneficial curiosity.
9. **Hawthorne Effect:** Whenever a new technology such as CBI is introduced, a certain amount of "Hawthorne Effect" is inevitable. However, if the CBI is well-designed and effectively implemented, the perceived and real value of it will continue long after the novelty has worn off.
10. **Goal Selection:** If the content and context allow, CBI should be designed to enable students to set their own goals and develop at their own rate.
11. **Needs:** The lower level needs of students must be satisfied if they are expected to be motivated by higher order needs. The environment in which CBI is implemented must be comfortable, non-threatening, and supportive.
12. **Expect Success:** Implementers of CBI should have positive expectations with respect to their students. CBI should be designed to encourage students to expect success.
13. **Satisfaction:** CBI should be designed to take advantage of whatever is known about the student's internal motives so that their level of satisfaction is enhanced.
14. **Games:** Trainers may want to incorporate some of the features of computer-based games into CBI, but only if the nature of the content and context indicates that it is appropriate.
15. **Motivation:** CBI designers should include Keller's design activities (which relate to Keller's four major categories of motivation in instruction, ARCS; Attention, Relevance, Confidence, and Satisfaction, (Also Keller 1987a, 1987b) into their overall instructional development model to maximize the motivational aspects of their programs.

## Cognitive Apprenticeship Model Features (Wilson and Cole, 1991)

<b>Content:</b>	Teach tacit, heuristic knowledge as well as textbook knowledge: <ol style="list-style-type: none"><li>1. Domain knowledge is the conceptual, factual, and procedural knowledge typically found in textbooks and other instructional materials.</li><li>2. Heuristic strategies are "tricks of the trade" or "rules of thumb" that often help narrow solution paths.</li><li>3. Control strategies are required for students to monitor and regulate their problem-solving activity.</li><li>4. Learning strategies are strategies for learning; they may be domain, heuristic, or control strategies aimed at learning.</li></ol>
<b>Situated learning:</b>	Teach knowledge and skills in contexts that reflect the way the knowledge will be useful in real life. <ol style="list-style-type: none"><li>1. Learners learn to apply their knowledge under appropriate conditions.</li><li>2. Problems-solving situations foster invention creativity</li><li>3. Learners come to see the implications of new knowledge.</li><li>4. Knowledge is stored in ways that make it accessible when solving problems.</li></ol>
<b>Modeling and explaining:</b>	Show how a process unfolds and tell reasons why it happens.
<b>Coaching:</b>	Observe students as they try to complete tasks and provide hints and helps when needed. <ol style="list-style-type: none"><li>1. Coaches need to monitor learner's performance to prevent their getting too far off base, but leaving enough room to allow for a real sense of exploration and problem solving.</li><li>2. Coaches help learners reflect on their performance and compare it to others.</li><li>3. Coaches use problem-solving exercises to assess learners' knowledge states.</li><li>4. Coaches use problem-solving exercises to create the "teachable moment".</li></ol>
<b>Articulation:</b>	Have students think about their actions and give reasons for their decisions and strategies, thus making their tacit knowledge more explicit.

(continued on next page)

## Cognitive Apprenticeship Model Features

(Wilson and Cole, 1991)

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<b>Reflection:</b>	Have students look back over their efforts to complete a task and analyze their own performance. Reflection is like articulation, except it is pointed backwards to past tasks. Collins and Brown (1988) suggest four kinds or levels of reflection: imitation, replay, abstracted replay, and spatial reification.
<b>Exploration:</b>	Encourage students to try out different strategies and hypotheses and observe their effects.
<b>Sequence:</b>	Present instruction in an ordering from simple to complex, with increasing diversity, and global before local skills: <ol style="list-style-type: none"><li>1. Increasing complexity,</li><li>2. Increasing diversity,</li><li>3. Global before local skills.</li></ol>

## Interaction

(Schwier, 1992)

1. **Reactive interaction:** is a response to presented stimuli, such as an answer to a specific question (Lucas, 1992). In other words, a learner reacts to given stimuli. Such approaches emphasize coaching, tutorial, or Socratic designs wherein the learner and computer are engaged in a responsive, albeit preordained, discussion.
2. **Proactive interaction:** emphasizes learner construction and generative activity. The learner becomes the protagonists. The learner goes beyond selecting or responding to existing structures and begins to generate unique constructions and elaborations beyond designer-imposed limits.
3. **Mutual interaction:** the highest level of interaction, is characterized by artificial intelligence or virtual reality designs. In such programs, the learner and system are mutually adaptive, that is, capable of changing based on encounters with the other. Sometimes, this is referred to as recursive interaction. Recursion is based on the mathematical notion of indefinite repetition, and in multimedia, it suggests a conversation which can continue indefinitely. This is a useful distinction, but it will fall short of the capabilities of multimedia systems for the near future.

**Event at Each Functional Level of Interaction**  
(Schwier, 1992)

	<b>Confirmation</b>	<b>Pacing</b>	<b>Navigation</b>	<b>Inquiry</b>	<b>Elaboration</b>
<b>Reactive</b>	Learner matches answer given by system	Learner turns page when prompted	Learner selects choice from a menu	Learner uses "help" menu	Learner reviews a concept map
<b>Proactive</b>	Learner requests test when offered	Learner selects an abbreviated version of instruction	Learner defines paths through instruction	Learner searches text using keywords	Learner generates a concept map of the instruction
<b>Mutual</b>	System adapts to progress of learner and learner may challenge assessment	System adapts speed of presentation to the speed of the learner	System advises learner about patterns of choices being made during instruction	System suggests productive questions for the learner to ask, given previous choices	System constructs a metaphor based on learner input, and revises it as learner adds information.

**Interaction Taxonomy for Multimedia Instruction**  
(Schwier, 1992)

Levels	Functions	Transactions
Reactive Proactive Mutual	Confirmation Pacing Navigation Inquiry Elaboration	Space Bar/Return Touch Target Move Target Barcode Keyboard Voice Input Virtual Reality

**Transactions Available to Serve Different Functions and Levels of Interaction**  
(Schwier, 1992)

	<b>Reactive</b>	<b>Proactive</b>	<b>Mutual</b>
<b>Confirmation</b>	Touch Target Drag Target Barcode Keyboard Voice Virtual Reality	Keyboard Voice Virtual Reality	Keyboard Voice Virtual Reality
<b>Pacing</b>	Touch Target Space Bar/Return Barcode Keyboard Voice Virtual Reality	Keyboard Voice Virtual Reality	Keyboard Voice Virtual Reality
<b>Navigation</b>	Touch Target Barcode Keyboard Voice Virtual Reality	Keyboard Voice Virtual Reality	Keyboard Voice Virtual Reality
<b>Inquiry</b>	Touch Target Barcode Keyboard Voice Virtual Reality	Keyboard Voice Virtual Reality	Keyboard Voice Virtual Reality
<b>Elaboration</b>		Keyboard Voice Virtual Reality	Keyboard Voice Virtual Reality

**Links and Nodes**  
(various authors)

1. **Referential links:** simply connect two nodes (Jonassen, 1991)
2. **Organizational links:** communicate the type of relationship that exists between the nodes (Jonassen, 1991).
3. **Replacement links:** give a hierarchical structure to the document (Hardman, 1988).
4. **Reference links:** take the reader to another part of the same document, or to a different document (Hardman, 1988).
5. **Note links:** bring a temporary window on the screen to display a short aside (Hardman, 1988).
6. **Associative links:** tie the nodes together, allowing users to navigate among nodes (Jonassen, 1991).

### **Recommended Navigation Features** (adapted from Cole and Search, 1993)

<b>Feature</b>	<b>Purpose</b>
An Outline Facility	To display selected (usually high level) items, such as chapter and section headings, and ignore other items (Cole, 1990).
Pop-Up Displays	To allow the temporary display of additional information on demand. These can be used for the equivalent of footnotes, marginal notes, and glossary entries in paper documents (Cole, 1990).
Folding	To allow sections of a document to be hidden behind a "button" on the screen and revealed on request. Folding should be allowed to any level, so hidden sections can contain further buttons (Cole, 1990).
A linkage Facility	To enable users to follow links or cross-reference automatically (Cole, 1990).
Control Bar	When presenting program content along with user control and navigation options, the screen could become crowded. To avoid this a "" can be incorporated to provide control and navigation options (advocated by Iuppa and Anderson, 1988 in Kinzie, 1991). The control bar provides a number of options, including: Return (to program), Skip (to next segment), Submenu (go to last menu), Main Menu (quick jump to main menu), Help (information on program features), and Quit (Kinzie, 1991).
Reference Point	So that users would know where they were in the program. It is often observed that, without the visual references of beginning, end, chapter, and page that are commonly depended on when reading, users of interactive programs can feel lost (Kinzie, 1991).

## Elements and Approaches to Overcoming Multimedia Navigation Problems (Search, 1993)

Element	Approach
Acknowledge the limitations of the medium	The introduction of hypermedia computing has been accompanied by unrealistic expectations and numerous misconceptions about the power and capabilities of the medium. To begin, there is a tendency to view hypermedia programs as all-inclusive, authoritative databases of information that eliminate the need for external resources. However, most hypermedia projects do not include large, comprehensive databases that fulfill all the research and professional needs of the user.
Identify the multiple levels of authorship	Hypermedia programs contain several levels of authorship including the designers or editors of the program, the authors of the individual references in the data base, and the users themselves who create links between the references.
Define and visualize the semiotic model	A well-defined semiotic model for the hypermedia program is also an important criterion for successful navigation. The semantic structure of the program and the syntax of the interactive functions should be accurately mapped to a conceptual model of the user's tasks.
Provide spatiotemporal overviews	The hypermedia interface should provide overviews that indicate the content and scope of the database. The user can then evaluate the suitability of the database for a particular task and estimate the amount of time and effort needed to navigate through the information. These overviews should specify the organizational hierarchy of the information, the number of resources in the database, and the type of resources (e.g., full-text vs. bibliographic citations, color photographs vs. black and white illustrations, complete video productions vs. video excerpts).
Narrow objectives of navigation functions	Hypermedia programs can improve navigation by providing users with a record of the information that they have already seen (Simpson 1989, in Search 1993). Many hypermedia programs provide navigation functions that track the path of the user. However, these functions are usually multipurpose functions that attempt to accomplish the following objectives: <ul style="list-style-type: none"> <li>Allow the user to backtrack and retrieve information</li> <li>Locate the user's position in the database</li> <li>Identify what information has been accessed and what additional information is available</li> <li>Show the hierarchical and associative links in the database</li> </ul>

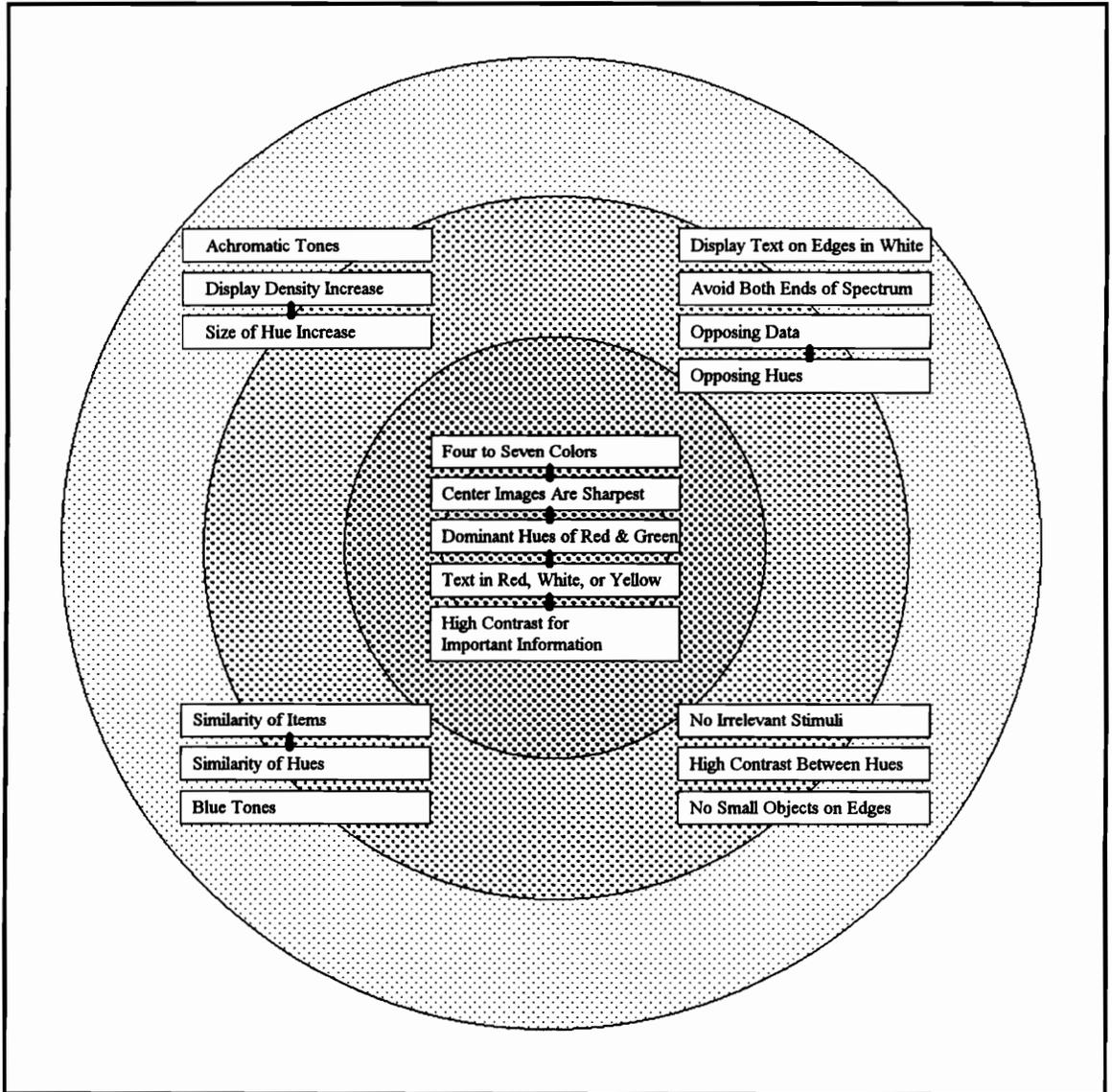
### **Color Coding Techniques and Enhancement Results (Chapman, 1993a)**

<b><u>Technique</u></b>	<b><u>Enhancement Value</u></b>
Greater Hue Separation	Increased
Greater Color Purity	Increased
Increased Brightness	Increased
Greater Object Size	Increased
Achromatic Background	Increased
Chromatic Background - Light	Increased
Center Location	Increased
Increased Number of Colors	Decreased
Chromatic Background - Dark	Decreased
Peripheral Location	Decreased

### **Advantages of Color Coding (Chapman, 1993b)**

1. Creates group associations.
2. Defines logical progressions.
3. Utilizes learned meanings.
4. Establishes links or pathways.
5. Defines intervals or scales.
6. Creates perceptual meaning.

## Pictorial Representation of Color Guidelines (Chapman, 1993a)



## Principles and Implications for the Design of Interactive Multimedia (Park and Hannafin, 1993)

Principles and Implications for the Design of Interactive Multimedia	
Principle	Implication
1. Related prior knowledge is the single most powerful influence in mediating subsequent learning.	Layer information to accommodate multiple levels of complexity and accommodate differences in related prior knowledge.
2. New knowledge becomes increasingly meaningful when integrated with existing knowledge.	Embed structural aids to facilitate selection, organization, and integration; embed activities that prompt learners to generate their own unique meaning.
3. Learning is influenced by the supplied organization of concepts to be learned.	Organize lesson segments into internally consistent idea units.
4. Knowledge to be learned needs to be organized in ways that reflect differences in learner familiarity with lesson content, the nature of the learning task, and assumptions about the structure of knowledge.	Linkages between and among nodes need to reflect the diverse ways in which the system will be used.
5. Knowledge utility improves as processing and understanding deepen.	Provide opportunities to reflect critically on learning and to elaborate knowledge; encourage learners to articulate strategies prior to, during, and subsequent to interacting with the environment.
6. Knowledge is best integrated when unfamiliar concepts can be related to familiar concepts.	Use familiar metaphors in conveying lesson content and designing the system interface.
7. Learning improves as the number of complementary stimuli used to represent learning content increases.	Present information using multiple, complementary symbols, formats, and perspectives.
8. Learning improves as the amount of invested mental effort increases.	Embed activities that increase the perceived demand characteristics of both the media and learning activities.
9. Learning improves as competition for similar cognitive resources decreases and declines as competition for the same resources increases.	Structure presentations and interactions to complement cognitive processes and reduce the complexity of the processing task.

<p>10. Transfer improves when knowledge is situated in authentic contexts.</p>	<p>Anchor knowledge in realistic contexts and settings.</p>
<p>11. Knowledge flexibility increases as the number of perspectives on a given topic increases and the conditional nature of knowledge is understood.</p>	<p>Provide methods that help learners acquire knowledge from multiple perspectives and cross-reference knowledge in multiple ways.</p>
<p>12. Knowledge of details improves as instructional activities are more explicit, while understanding improves as the activities are more integrative.</p>	<p>Differentiate orienting activities for forthcoming information based upon desired learning; provide organizing activities for information already reviewed.</p>
<p>13. Feedback increases the likelihood of learning response-relevant lesson content, and decreases the likelihood of learning response-irrelevant lesson content.</p>	<p>Provide opportunities to respond and receive response-differentiated feedback where critical information is involved, but avoid excessive response focusing when incidental learning is expected.</p>
<p>14. Shifts in attention improve the learning of related concepts.</p>	<p>Differentiate key terms, concepts, and principles through cosmetic amplification, repetition, and recasting.</p>
<p>15. Learners become confused and disoriented when procedures are complex, insufficient, or inconsistent.</p>	<p>Provide clearly defined procedures for navigating within the system and accessing on-line support.</p>
<p>16. Visual representations of lesson content and structure improve the learner's awareness of both the conceptual relationships and procedural requirements of a learning system.</p>	<p>Provide concept maps to indicate the interrelationships among concepts, and hypermaps to indicate the location of the learner relative to other lesson segments.</p>
<p>17. Individuals vary widely in their need for guidance.</p>	<p>Provide tactical, instructional, and procedural assistance.</p>
<p>18. Learning systems are most efficient when they adapt to relevant individual differences.</p>	<p>Interactive multimedia must adapt dynamically to both learner and content characteristics.</p>
<p>19. Metacognitive demands are greater for loosely structured learning environments than for highly structured ones.</p>	<p>Provide prompts and self-check activities to aid the learner in monitoring comprehension and adapting individual learning strategies.</p>
<p>20. Learning is facilitated when system features are functionally self-evident, logically organized, easily accessible, and readily deployed.</p>	<p>Employ screen design and procedural conventions that require minimal cognitive resources, are familiar or can be readily understood, and are consonant with learning requirements.</p>

### Color Use to Enhance Information Flow (Chapman, 1993)

Element	Comment
1. Critical information.	Must remain sharp and clear. Should be concentrated in the center of the display. Should be coded in dominant hues of red and green.
2. Saturation.	Highly saturated reds and yellows, as well as white, increase the speed of response. Blue is the least effective.
3. Important stimuli.	If important information must remain at the display edges it should be coded in white for maximum efficiency.
4. Placement.	The periphery of the display should lean toward achromatic or blue tones. Small objects or text at the outer borders should be avoided because this requires separate focusing and additional eye movement.
5. Backgrounds.	Should employ blue hues or achromatic tones to create a high contrast between foreground and background, thereby facilitating search and identification.
6. Contrast	Controlling visual contrast control can be achieved in two ways; (1) On chromatic versus achromatic displays, and (2) simultaneous and successive contrast. High contrast can draw attention to more important information while low contrast can indicate less important information.
7. Brightness.	Changes of brightness should be incorporated with color to further enhance differentiation. Without the ability to distinguish between display colors, a coded presentation will only confuse the student and possibly be detrimental.
8. Alphanumeric information.	Is best identified in the spectrum of red, white, and yellow.
9. Coding.	Code logically toward your objective. Must be related to the learning objective. Coding should not be related to irrelevant or inappropriate stimuli. Independent coding can identify links and define relationships. Redundant coding can perform those tasks as well as establish meaning, intervals, and perceptions.
10. Similarity between items.	Similarity between items should reflect contrasting hues.

<p>11. Content hierarchy.</p>	<p>Content hierarchy should be established.                  Important data displayed in high contrast.                  Normal information presented in equal contrast, thereby reflecting a group relationship.                  As a steering device in printed or linear visual information it can facilitate speed and accuracy of identification (however, consistency of color is not a guarantee in non-linear formats).                  Can enhance the short and long term cognitive effects.</p>
<p>12. Consistency.</p>	<p>Consistency of codes will allow for faster search and identification of coded data.</p>
<p>13. Alterations</p>	<p>Never alter the coding scheme during the presentation.                  Many applications can be enhanced by implementing a conventional association of content-specific colors.</p>
<p>14. Colors.</p>	<p>Should be consistent with conventional meaning.                  Learned color values must be addressed in color decisions as any learned meanings of color values will often supersede the desired response. Red is normally a signal to stop or to become aware of danger while yellow indicates a cautious approach (such learned stimuli should not be discounted).                  Color values must be separated sufficiently to avoid confusion, unless such proximity establishes a scale or progression.                  The number and type of colors on a display will directly affect the performance of the presentation (an increase in the number of non-targets containing the target color causes a substantial increase in the search time).                  Optimal coding efficiency generally occurs when color limit their range from four to seven</p>
<p>15. Aesthetics.</p>	<p>Colors need to be aesthetically pleasing.                  An irritating display may diminish the interest and involvement of the learner.</p>
<p>16. Design.</p>	<p>Design for the environment and task of the display.</p>
<p>17. Texture Coding</p>	<p>Avoid texture coding, not only can it be annoying but it does not appear to be an effective method to make out groups of similar objects stand out (Perlman and Swan, 1993).</p>

## **APPENDIX P**

### **Raw Data Tables for Times and Scores**

**Time To Complete: Instructions**  
(time in minutes)

<b>Gender</b>		<b>Presentation</b>			
		<b>Text (P1)</b>		<b>Multimedia (P2)</b>	
<b>Male (G1)</b>		11.00	9.70	13.80	9.20
		11.93	10.22	11.43	7.68
		13.43	12.03	12.92	9.52
		12.73	11.22	10.38	10.23
		9.42	10.57	10.50	11.03
		Mean:	<b>11.23</b>	Mean:	<b>10.67</b>
	Std-Dev:	<b>1.31</b>	Std-Dev:	<b>1.77</b>	
<b>Female (G2)</b>		11.08	7.32	10.18	10.47
		9.43	11.33	10.15	9.82
		11.82	10.53	10.47	10.07
		11.27	9.67	9.60	10.10
		10.92	9.62	9.78	11.22
		Mean:	<b>10.30</b>	Mean:	<b>10.19</b>
	Std-Dev:	<b>1.33</b>	Std-Dev:	<b>0.46</b>	

**Time To Complete: ABS Pretest**  
(time in minutes)

<b>Gender</b>		<b>Presentation</b>			
		<b>Text (P1)</b>		<b>Multimedia (P2)</b>	
<b>Male (G1)</b>		6.98	4.45	5.48	5.50
		7.25	2.72	3.85	2.42
		10.20	5.22	8.10	3.82
		9.72	3.38	4.35	10.02
		4.50	4.32	3.57	4.97
		Mean:	<b>5.87</b>	Mean:	<b>5.21</b>
	Std-Dev:	<b>2.57</b>	Std-Dev:	<b>2.28</b>	
<b>Female (G2)</b>		5.65	4.48	2.62	5.00
		4.98	4.15	4.87	4.22
		6.03	4.63	2.97	2.95
		4.18	5.05	2.87	4.42
		3.92	9.45	4.92	5.88
		Mean:	<b>5.25</b>	Mean:	<b>4.07</b>
	Std-Dev:	<b>1.62</b>	Std-Dev:	<b>1.14</b>	

**Time To Complete: ATDP Form A - Pretest**  
(time in minutes)

<b>Gender</b>		<b>Presentation</b>			
		<b>Text (P1)</b>		<b>Multimedia (P2)</b>	
<b>Male (G1)</b>		6.70	4.27	6.50	5.58
		6.50	4.88	5.97	2.00
		9.12	5.02	6.75	3.67
		6.98	4.12	5.32	6.02
		5.18	5.97	4.05	5.03
		Mean: <b>5.87</b> Std-Dev: <b>1.52</b>		Mean: <b>5.09</b> Std-Dev: <b>1.47</b>	
<b>Female (G2)</b>		4.95	3.95	3.37	5.35
		3.70	5.63	5.87	5.52
		4.87	4.72	3.40	3.45
		3.67	3.75	3.87	4.57
		6.03	6.75	4.18	4.90
		Mean: <b>4.80</b> Std-Dev: <b>1.07</b>		Mean: <b>4.45</b> Std-Dev: <b>0.93</b>	

**Time To Complete: Pretest**  
(time in minutes)

<b>Gender</b>		<b>Presentation</b>			
		<b>Text (P1)</b>		<b>Multimedia (P2)</b>	
<b>Male (G1)</b>		55.45	57.55	61.53	55.32
		58.37	69.72	62.48	34.75
		69.15	46.78	93.80	37.03
		58.75	31.38	59.15	51.68
		81.33	61.52	35.08	30.07
		Mean: <b>59.00</b> Std-Dev: <b>13.54</b>		Mean: <b>52.09</b> Std-Dev: <b>19.15</b>	
<b>Female (G2)</b>		61.95	31.12	56.98	55.05
		34.20	62.12	59.30	46.98
		63.57	35.57	26.90	33.03
		66.92	23.05	34.18	57.02
		42.33	56.02	56.13	47.53
		Mean: <b>47.69</b> Std-Dev: <b>16.13</b>		Mean: <b>47.31</b> Std-Dev: <b>11.84</b>	

**Time To Complete: Study Material**  
(time in minutes)

<u>Gender</u>	<u>Presentation</u>			
	Text (P1)		Multimedia (P2)	
Male (G1)	41.58	48.90	79.38	67.52
	44.98	51.75	119.23	71.58
	52.35	29.70	106.88	59.70
	32.85	29.95	90.07	89.12
	33.33	41.67	120.40	110.42
	Mean: 40.71		Mean: 91.43	
Std-Dev: 8.80		Std-Dev: 21.95		
Female (G2)	43.88	39.63	95.33	100.73
	22.15	28.33	85.02	115.58
	34.97	15.07	77.08	94.80
	34.93	41.85	86.87	94.78
	25.43	53.18	103.63	119.77
	Mean: 33.94		Mean: 97.36	
Std-Dev: 11.38		Std-Dev: 13.23		

**Time To Complete: Posttest**  
(time in minutes)

<u>Gender</u>	<u>Presentation</u>			
	Text (P1)		Multimedia (P2)	
Male (G1)	43.47	52.40	26.05	56.83
	28.12	46.85	40.65	31.20
	67.88	43.97	48.43	33.53
	43.13	25.25	36.92	38.67
	52.97	42.93	34.72	24.13
	Mean: 44.70		Mean: 37.11	
Std-Dev: 12.16		Std-Dev: 9.87		
Female (G2)	50.00	48.73	37.63	50.18
	54.37	34.12	45.72	32.93
	57.22	53.87	36.85	27.37
	45.28	47.45	30.97	42.62
	47.57	55.24	38.45	49.62
	Mean: 49.39		Mean: 39.23	
Std-Dev: 6.65		Std-Dev: 7.38		

**Time To Complete: ATDP Form B - Posttest**  
(time in minutes)

<b>Gender</b>	<b>Presentation</b>			
	<b>Text (P1)</b>		<b>Multimedia (P2)</b>	
<b>Male (G1)</b>	5.10	4.27	2.92	4.98
	5.17	5.03	3.97	4.25
	8.02	5.38	5.02	3.07
	5.12	3.72	3.25	3.98
	3.92	5.40	3.42	4.28
	<b>Mean:</b>	<b>5.11</b>	<b>Mean:</b>	<b>3.91</b>
<b>Std-Dev:</b>	<b>1.19</b>	<b>Std-Dev:</b>	<b>0.75</b>	
<b>Female (G2)</b>	4.00	3.93	3.22	3.95
	3.27	3.90	4.07	3.72
	4.10	4.75	2.93	3.48
	3.52	3.80	3.05	3.70
	3.48	5.03	4.03	3.60
	<b>Mean:</b>	<b>3.98</b>	<b>Mean:</b>	<b>3.58</b>
<b>Std-Dev:</b>	<b>0.55</b>	<b>Std-Dev:</b>	<b>0.40</b>	

**Time To Complete: ABS Posttest**  
(time in minutes)

<b>Gender</b>	<b>Presentation</b>			
	<b>Text (P1)</b>		<b>Multimedia (P2)</b>	
<b>Male (G1)</b>	4.20	2.78	2.83	4.15
	3.40	4.12	2.45	4.05
	7.33	3.92	3.50	5.15
	4.98	2.65	2.23	3.65
	3.92	4.42	4.22	3.08
	<b>Mean:</b>	<b>4.17</b>	<b>Mean:</b>	<b>3.53</b>
<b>Std-Dev:</b>	<b>1.32</b>	<b>Std-Dev:</b>	<b>0.90</b>	
<b>Female (G2)</b>	2.72	2.72	1.72	3.05
	1.95	2.82	2.92	4.70
	3.20	2.92	3.08	2.33
	2.90	2.47	3.70	2.52
	2.23	3.35	4.38	3.10
	<b>Mean:</b>	<b>2.73</b>	<b>Mean:</b>	<b>3.15</b>
<b>Std-Dev:</b>	<b>0.42</b>	<b>Std-Dev:</b>	<b>0.91</b>	

**Time To Complete: Entire Experiment**  
(time in minutes)

<u>Gender</u>	<u>Presentation</u>			
	Text (P1)		Multimedia (P2)	
Male (G1)	184.48	184.32	198.50	209.08
	165.05	195.28	249.83	157.93
	237.48	150.68	285.40	155.48
	174.25	116.67	211.00	213.67
	194.10	176.12	215.95	193.02
	Mean: <b>177.84</b>		Mean: <b>208.99</b>	
Std-Dev: <b>31.39</b>		Std-Dev: <b>38.61</b>		
Female (G2)	184.23	101.88	210.05	233.78
	134.05	152.40	217.85	223.47
	185.10	132.05	163.02	177.48
	171.33	135.08	174.43	220.10
	145.92	198.80	225.52	244.95
	Mean: <b>154.08</b>		Mean: <b>209.07</b>	
Std-Dev: <b>30.20</b>		Std-Dev: <b>27.68</b>		

**Scores: ABS - Pretest**  
(range 30 - 120; lower score indicates favorable attitude)

<u>Gender</u>	<u>Presentation</u>			
	Text (P1)		Multimedia (P2)	
Male (G1)	50	68	56	49
	48	53	39	54
	32	74	46	61
	51	40	42	69
	49	38	57	46
	Mean: <b>50.30</b> Std-Dev: <b>12.83</b>	Mean: <b>51.90</b> Std-Dev: <b>9.22</b>		
Female (G2)	42	46	36	54
	38	36	38	41
	53	59	50	42
	43	48	44	38
	43	46	33	51
	Mean: <b>45.40</b> Std-Dev: <b>6.80</b>	Mean: <b>42.70</b> Std-Dev: <b>6.98</b>		

**Scores: ATDP Form A - Pretest**  
(range 0 - 180; higher score indicates favorable attitude)

<u>Gender</u>	<u>Presentation</u>			
	Text (P1)		Multimedia (P2)	
Male (G1)	126	72	112	135
	115	137	132	142
	172	100	118	96
	114	145	130	80
	103	133	123	156
	Mean: <b>121.70</b> Std-Dev: <b>27.58</b>	Mean: <b>122.40</b> Std-Dev: <b>22.22</b>		
Female (G2)	161	150	163	121
	147	150	152	155
	117	120	124	151
	138	155	141	141
	147	133	169	119
	Mean: <b>141.80</b> Std-Dev: <b>14.58</b>	Mean: <b>143.60</b> Std-Dev: <b>17.61</b>		

**Scores: Pretest**

(one fully correct answer per question will score 811 points)

		<u>Presentation</u>			
<u>Gender</u>		<u>Text (P1)</u>		<u>Multimedia (P2)</u>	
Male (G1)		145	25	161	213
		167	133	281	105
		210	63	127	227
		85	151	180	73
		123	131	88	96
		Mean: <b>123.30</b>		Mean: <b>155.10</b>	
	Std-Dev: <b>53.32</b>		Std-Dev: <b>69.17</b>		
Female (G2)		200	120	221	197
		177	173	215	145
		183	158	142	106
		153	77	162	90
		218	171	218	177
		Mean: <b>163.00</b>		Mean: <b>167.30</b>	
	Std-Dev: <b>40.17</b>		Std-Dev: <b>46.67</b>		

**Scores: Posttest**

(one fully correct answer per question will score 811 points)

		<u>Presentation</u>			
<u>Gender</u>		<u>Text (P1)</u>		<u>Multimedia (P2)</u>	
Male (G1)		471	305	326	360
		278	348	666	218
		451	241	340	414
		104	255	204	189
		244	341	524	245
		Mean: <b>303.80</b>		Mean: <b>348.60</b>	
	Std-Dev: <b>107.21</b>		Std-Dev: <b>152.99</b>		
Female (G2)		539	304	367	415
		331	252	465	255
		270	282	289	162
		195	559	393	337
		299	649	387	563
		Mean: <b>368.60</b>		Mean: <b>363.30</b>	
	Std-Dev: <b>154.67</b>		Std-Dev: <b>111.96</b>		

**Scores: ATDP Form B - Posttest**  
(range 0 - 180; higher score indicates favorable attitude)

<u>Gender</u>	<u>Presentation</u>			
	Text (P1)		Multimedia (P2)	
Male (G1)	102	91	106	138
	120	123	125	153
	174	113	136	80
	105	124	126	132
	98	117	118	146
	Mean: <b>116.70</b> Std-Dev: <b>23.01</b>		Mean: <b>126.00</b> Std-Dev: <b>21.06</b>	
Female (G2)	168	137	162	131
	156	156	147	154
	112	106	134	151
	141	159	152	161
	157	140	168	145
	Mean: <b>143.20</b> Std-Dev: <b>20.53</b>		Mean: <b>150.50</b> Std-Dev: <b>11.83</b>	

**Scores: ABS - Posttest**  
(range 30 - 120; lower score indicates favorable attitude)

<u>Gender</u>	<u>Presentation</u>			
	Text (P1)		Multimedia (P2)	
Male (G1)	58	72	50	37
	38	48	43	55
	30	57	46	59
	58	41	45	53
	61	49	58	38
	Mean: <b>51.20</b> Std-Dev: <b>12.46</b>		Mean: <b>48.40</b> Std-Dev: <b>7.86</b>	
Female (G2)	35	51	30	46
	35	36	38	42
	44	59	40	34
	41	52	43	32
	41	46	35	50
	Mean: <b>44.00</b> Std-Dev: <b>8.07</b>		Mean: <b>39.00</b> Std-Dev: <b>6.39</b>	

**Scores: ABS - Difference Between Pretest and Posttest**

		<u>Presentation</u>			
<u>Gender</u>		Text (P1)		Multimedia (P2)	
Male (G1)		8	4	-6	-12
		-10	-5	4	1
		-2	-17	0	-2
		7	1	3	-16
		12	11	1	-8
			Mean: <b>0.90</b>		Mean: <b>-3.50</b>
		Std-Dev: <b>9.46</b>		Std-Dev: <b>6.74</b>	
Female (G2)		-7	5	-6	-8
		-3	0	0	1
		-9	0	-10	-8
		-2	4	-1	-6
		-2	0	5	-1
			Mean: <b>-1.40</b>		Mean: <b>-3.40</b>
		Std-Dev: <b>4.33</b>		Std-Dev: <b>4.86</b>	

**Scores: ATDP - Difference Between Pretest and Posttest**

		<u>Presentation</u>			
<u>Gender</u>		Text (P1)		Multimedia (P2)	
Male (G1)		-24	19	-6	3
		5	-14	-7	11
		2	13	18	-16
		-9	-21	-4	52
		-5	-16	-5	-10
			Mean: <b>-5.00</b>		Mean: <b>3.60</b>
		Std-Dev: <b>14.47</b>		Std-Dev: <b>19.75</b>	
Female (G2)		7	-13	-1	10
		9	6	-5	-1
		-5	-14	10	0
		3	4	11	20
		10	7	-1	26
			Mean: <b>1.40</b>		Mean: <b>6.90</b>
		Std-Dev: <b>8.88</b>		Std-Dev: <b>10.27</b>	

### Scores: Pretest/Posttest Differences

		<u>Presentation</u>			
<u>Gender</u>		Text (P1)		Multimedia (P2)	
Male (G1)		326	280	165	147
		111	215	385	113
		241	178	213	187
		19	104	24	116
		121	210	436	149
		Mean: <b>180.50</b> Std-Dev: <b>92.56</b>			Mean: <b>193.50</b> Std-Dev: <b>125.64</b>
Female (G2)		339	184	146	218
		154	79	250	110
		87	124	147	56
		42	482	231	247
		81	478	169	386
		Mean: <b>205.00</b> Std-Dev: <b>166.85</b>			Mean: <b>196.00</b> Std-Dev: <b>91.86</b>

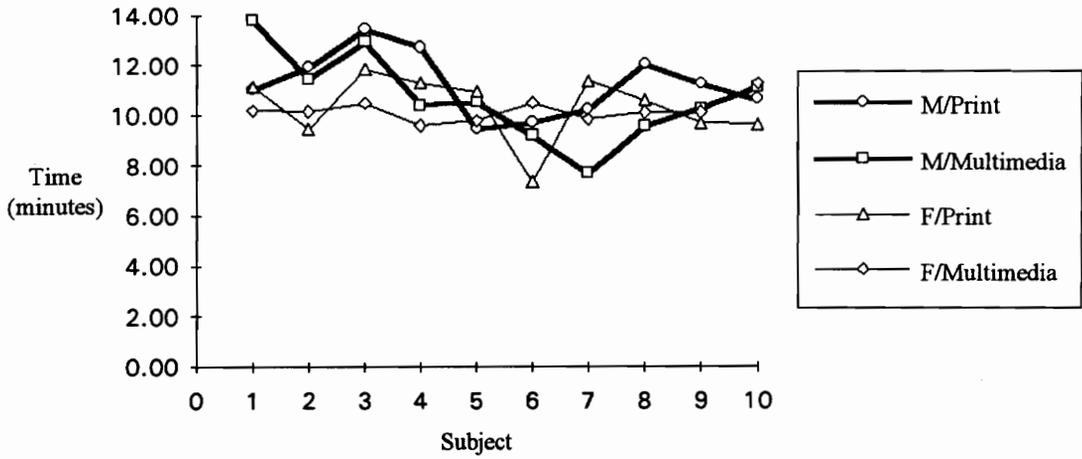
**Scores: Pretest/Posttest Comparison**  
 (one fully correct answer per question will score 811 points)

<u>Gender</u>		<u>Presentation</u>				
		Pretest		Posttest		
		Print	MM	Print	MM	
Male (G1)		145	161	471	326	
		167	281	278	666	
		210	127	451	340	
		85	180	104	204	
		123	88	244	524	
		25	213	305	360	
		133	105	348	218	
		63	227	241	414	
		151	73	255	189	
		131	96	341	245	
			<b>Mean: 139.20</b>		<b>Mean: 326.20</b>	
			<b>Std-Dev: 62.28</b>		<b>Std-Dev: 130.62</b>	
	Female (G2)		200	221	539	367
		177	215	331	465	
		183	142	270	289	
		153	162	195	393	
		218	218	299	387	
		120	197	304	415	
		173	145	252	255	
		158	106	282	162	
		77	90	559	337	
		171	177	649	563	
			<b>Mean: 165.15</b>		<b>Mean: 365.65</b>	
			<b>Std-Dev: 42.44</b>		<b>Std-Dev: 131.43</b>	

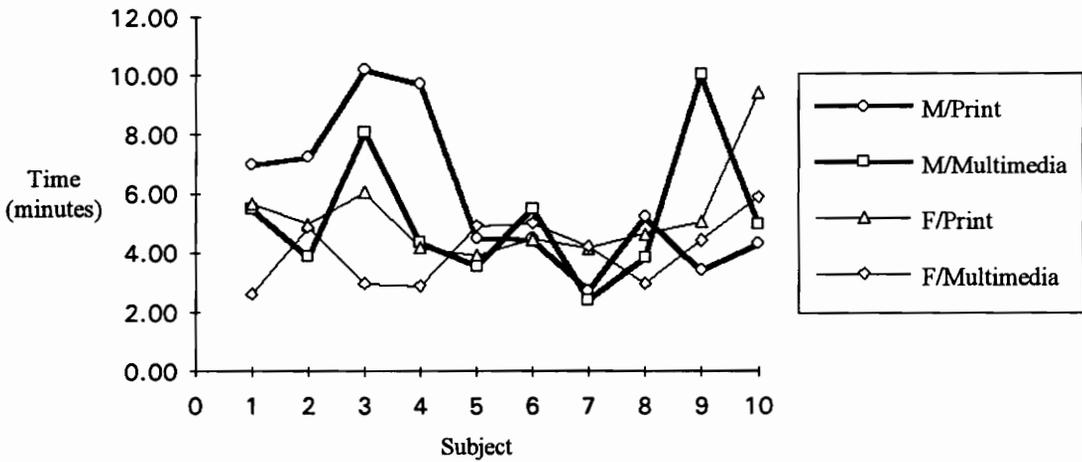
## **APPENDIX Q**

### **Graphs of Raw Data for Times and Scores**

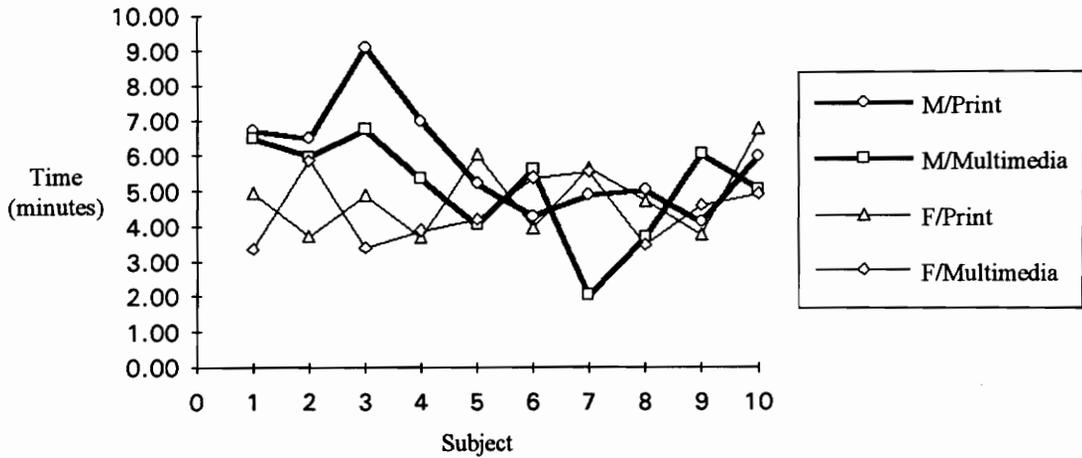
### Time - Instructions



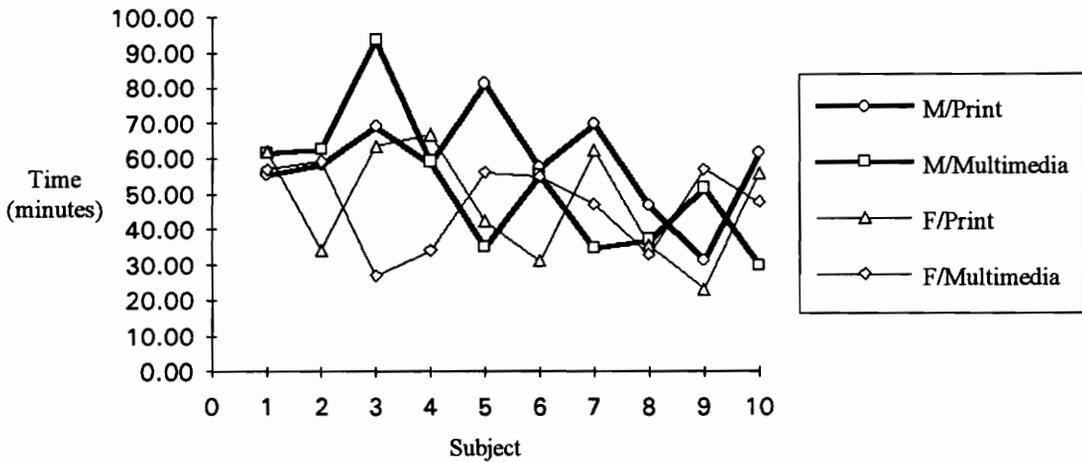
### Time - Pretest Attitude to Blindness Scale



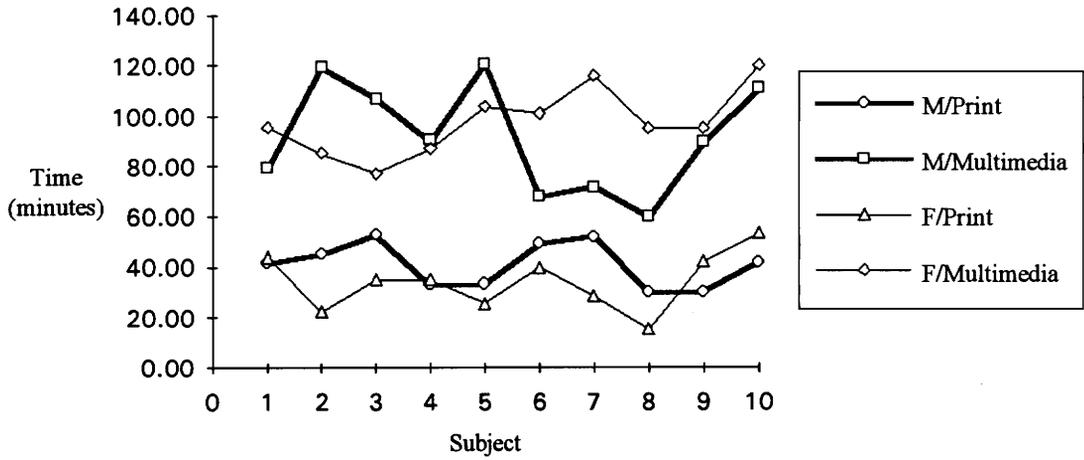
### Time - Pretest Attitude Toward Disabled People



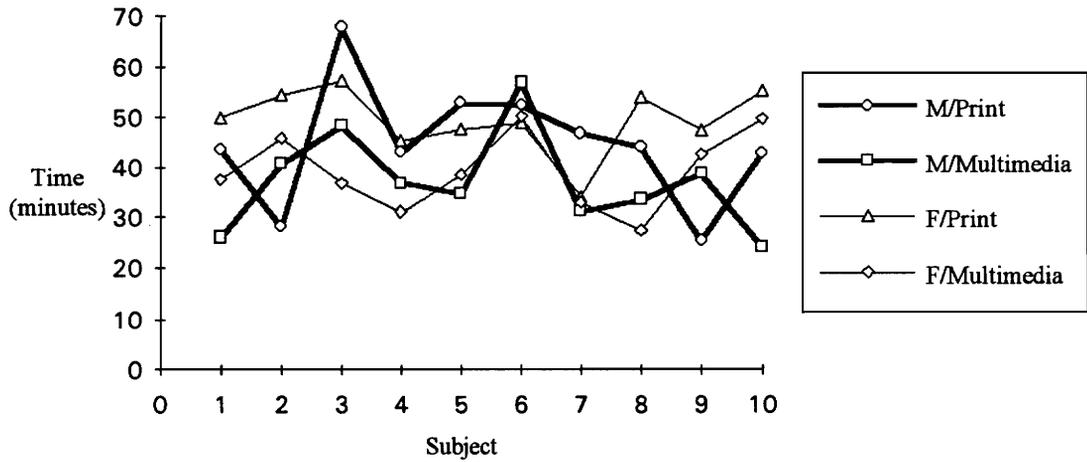
### Time - Knowledge Pretest



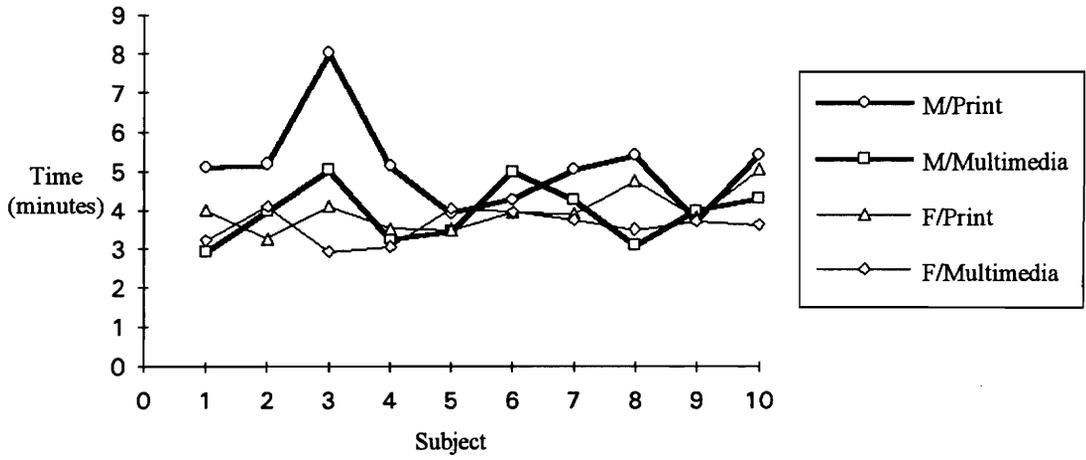
**Time - Study Material**



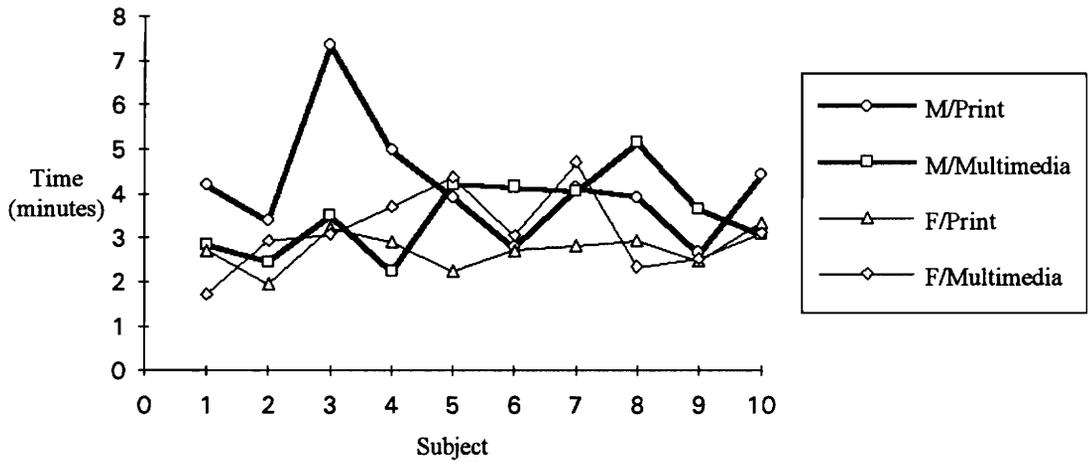
**Time - Knowledge Posttest**



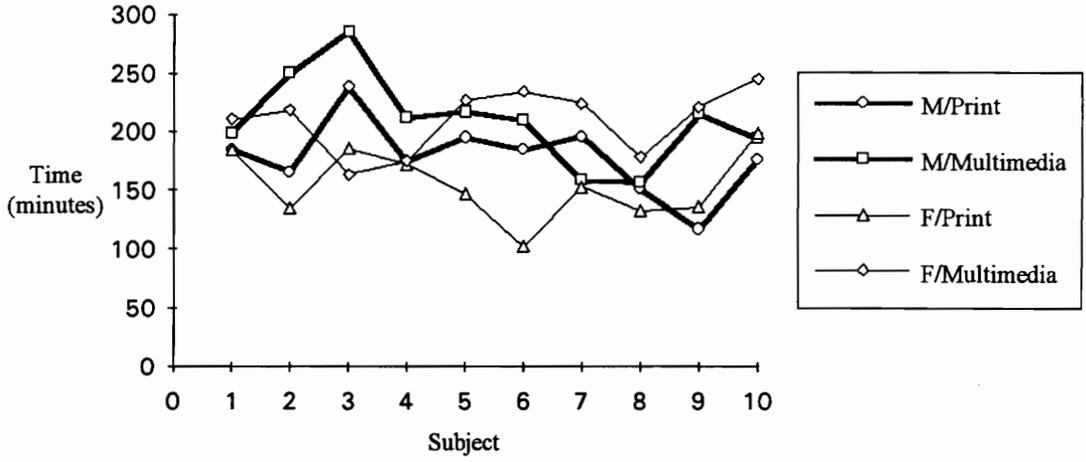
**Time - Posttest Attitude Toward Disabled People**



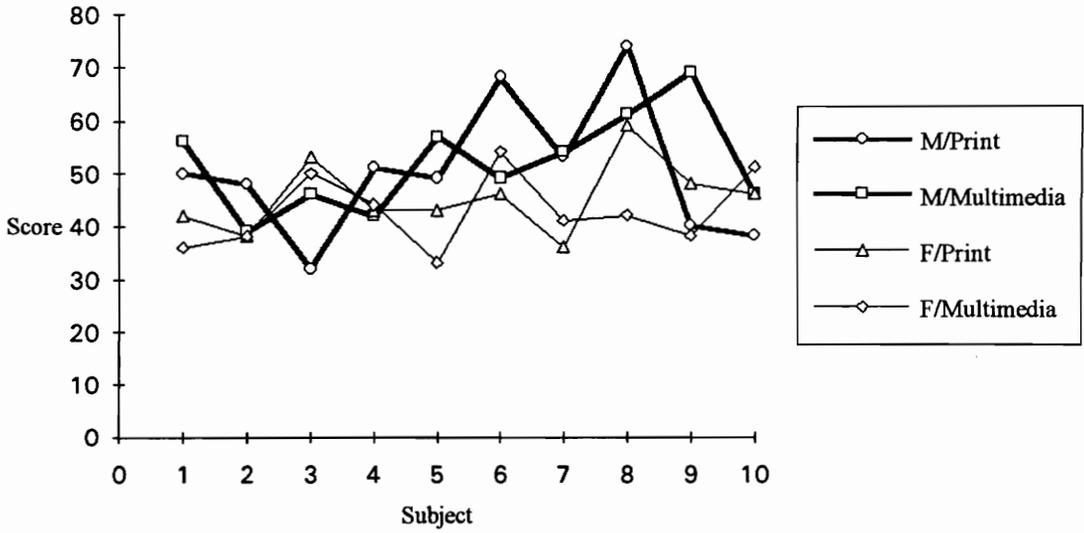
**Time - Posttest Attitude to Blindness Scale**



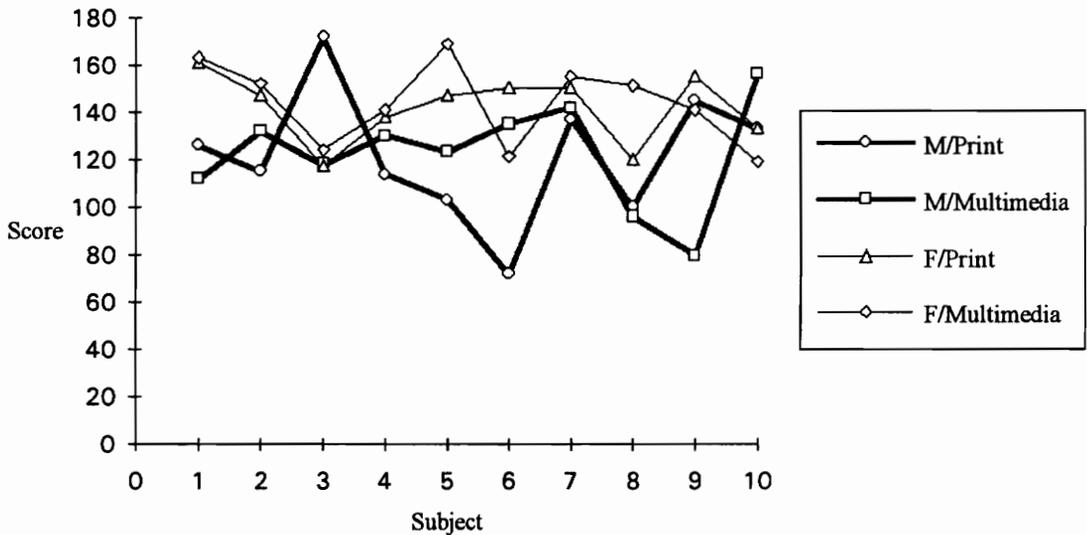
### Time - Complete Experiment



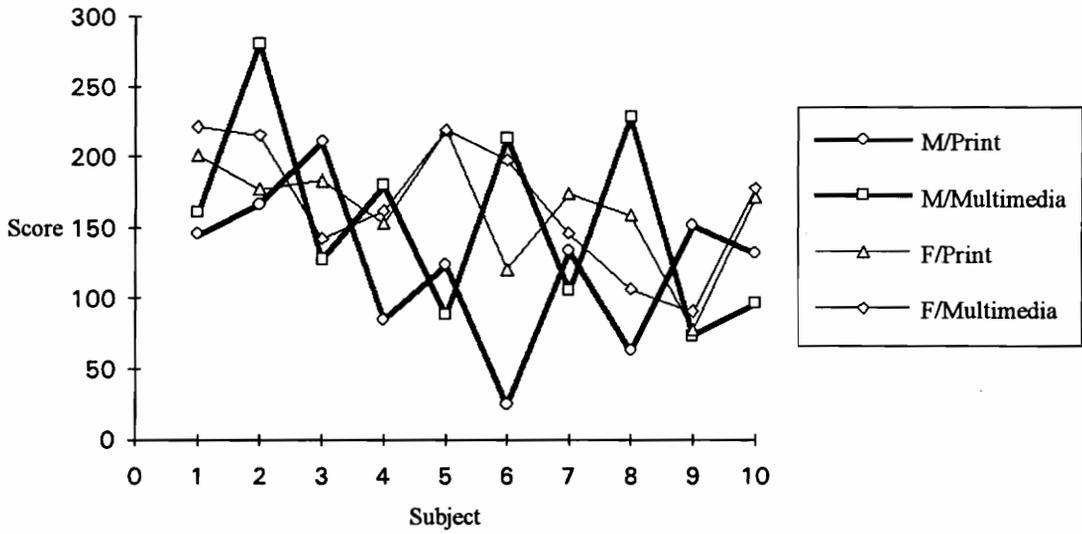
**Scores - Pretest Attitude to Blindness Scale**  
 (possible scoring range: 30 to 120)  
 (lower score indicates more favorable attitude)



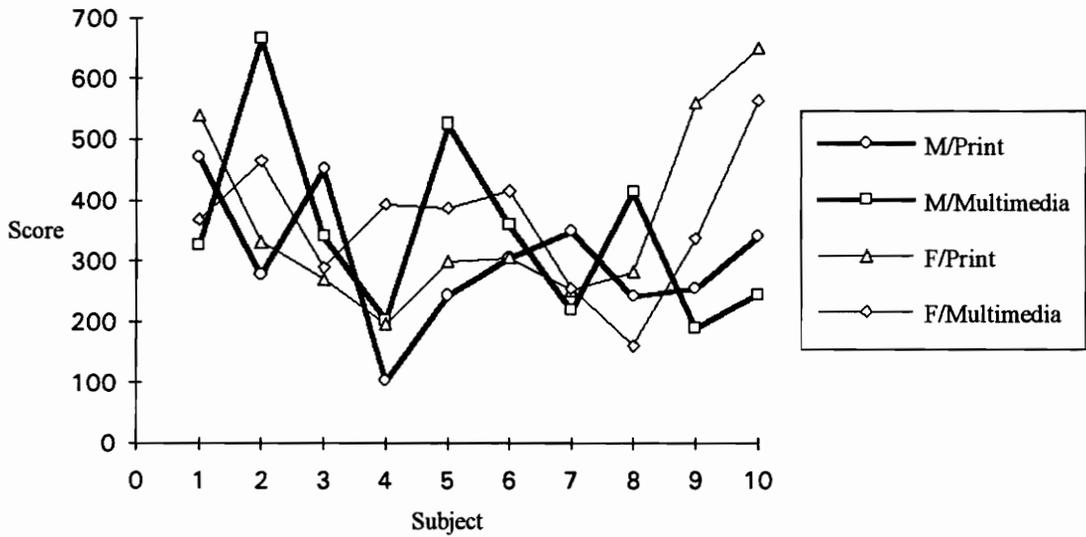
**Scores - Pretest Attitude Toward Disabled People**  
 (possible scoring range: 0 to 180)  
 (higher score indicates more favorable attitude)



### Scores - Knowledge Pretest (possible scoring range: 0 to 811)

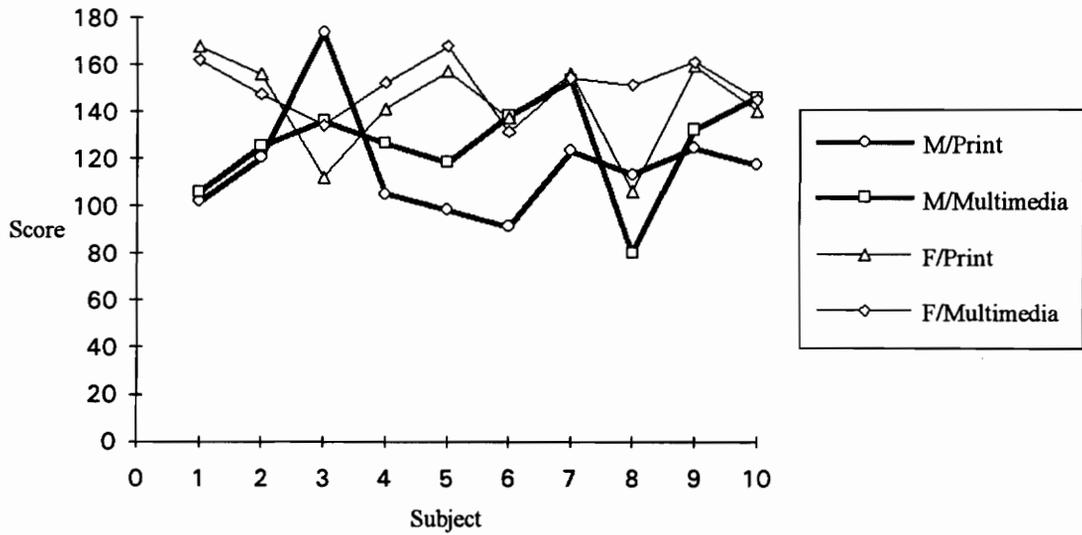


### Scores - Knowledge Posttest (possible scoring range: 0 to 811)



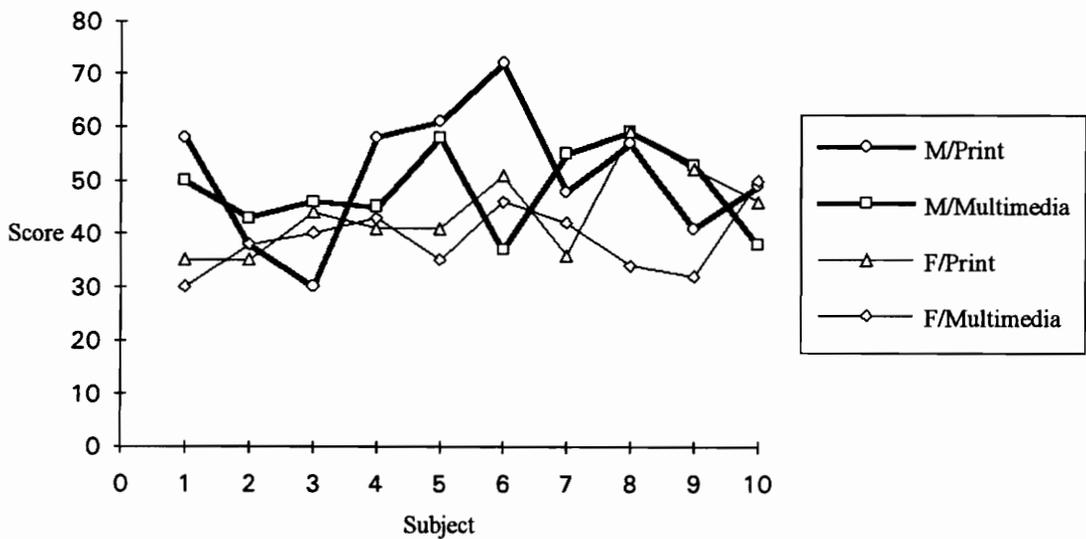
### Scores - Posttest Attitude Toward Disabled People

(possible scoring range: 0 to 180)  
 (higher score indicates more favorable attitude)



### Scores - Posttest Attitude to Blindness Scale

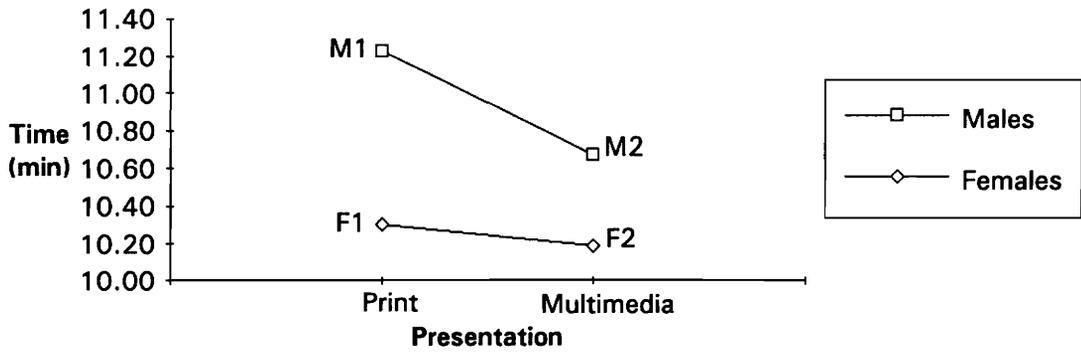
(possible scoring range: 30 to 120)  
 (lower score indicates more favorable attitude)



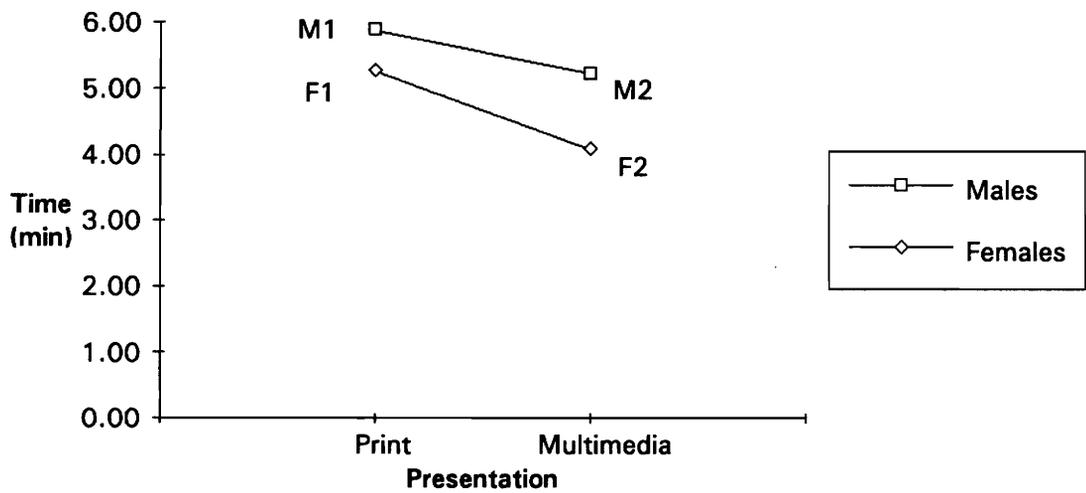
## **APPENDIX R**

### **Graphs of Means for Times and Scores**

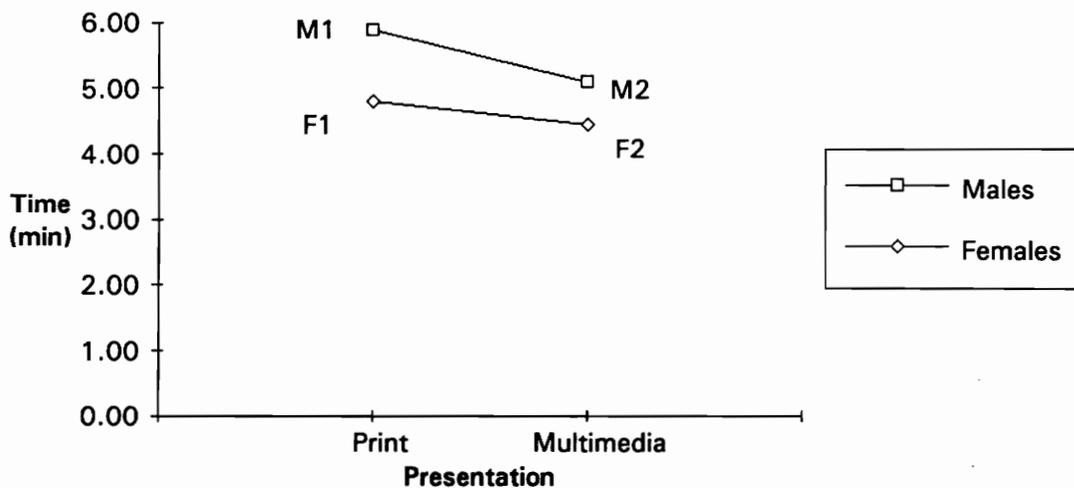
### Means for Instruction Time



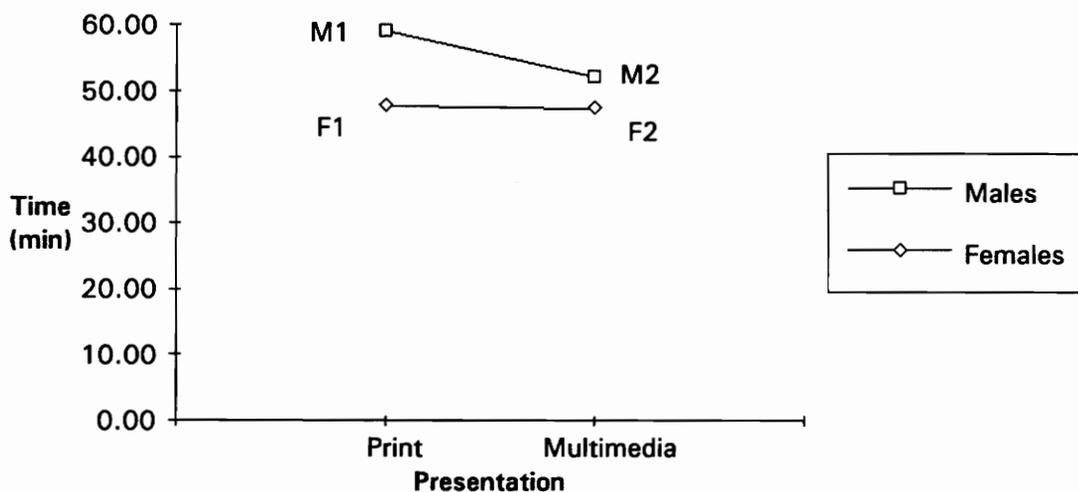
### Means for ABS Pretest Time



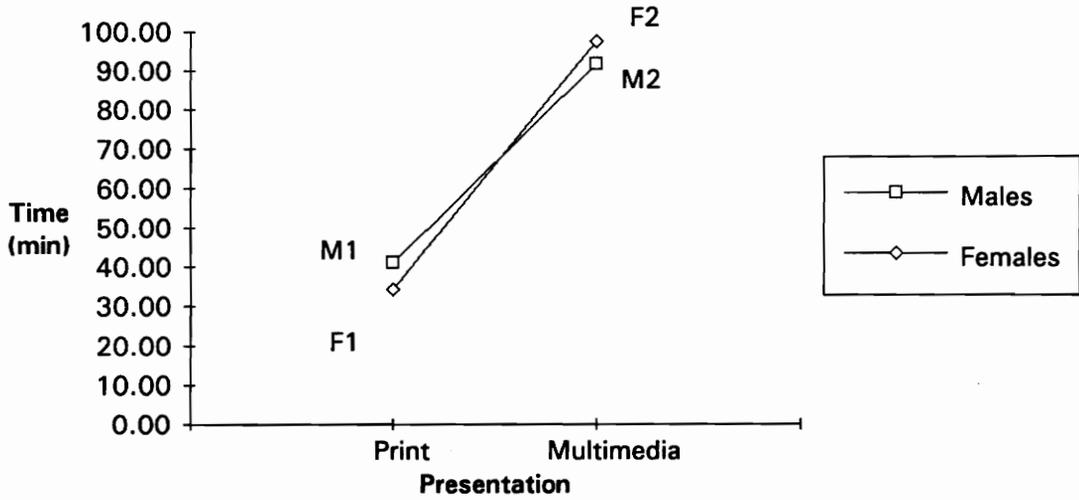
**Means for ATDP Form A Pretest Time**



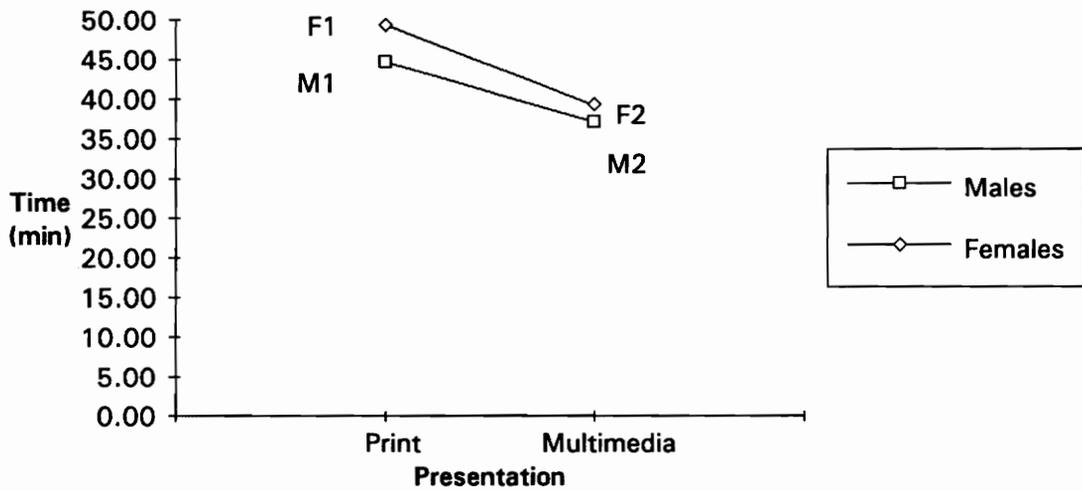
**Means for Pretest Time**



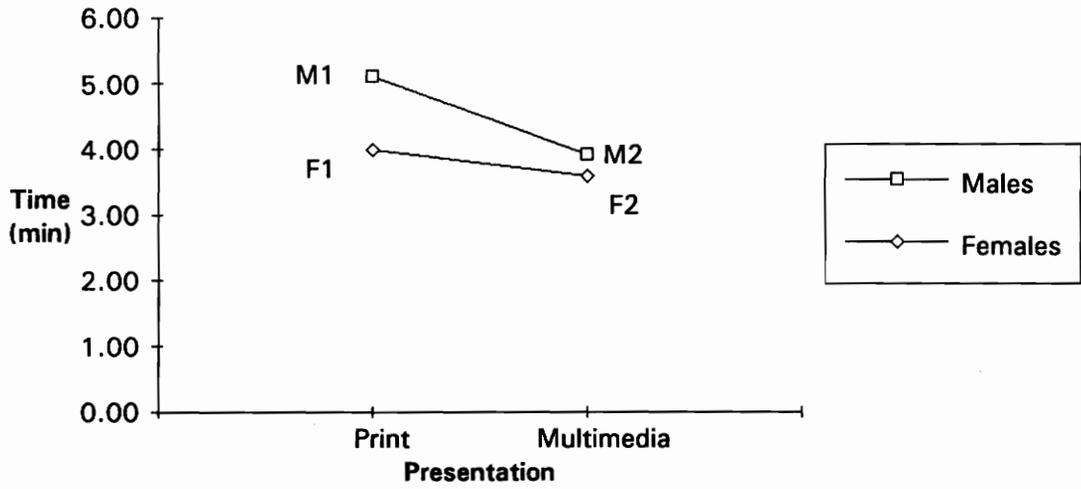
**Means for Material Study Time**



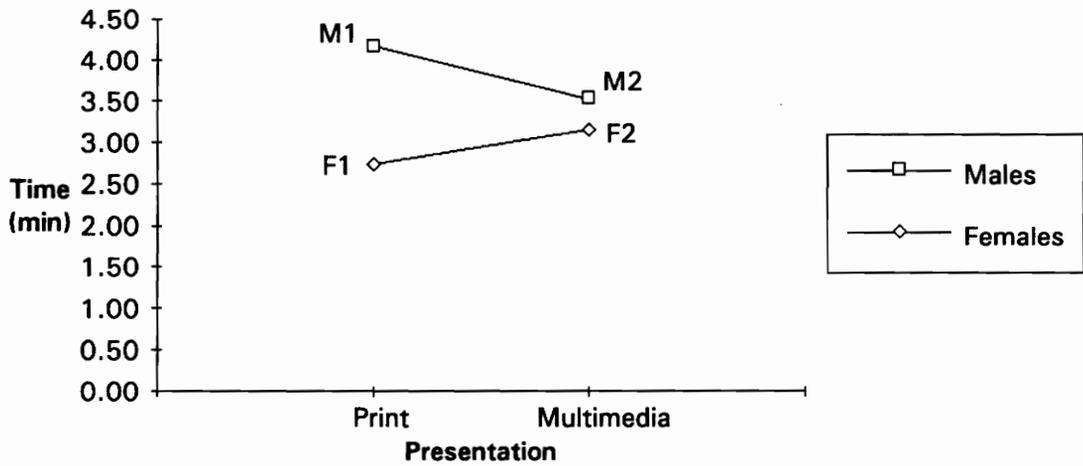
**Means for Posttest Time**

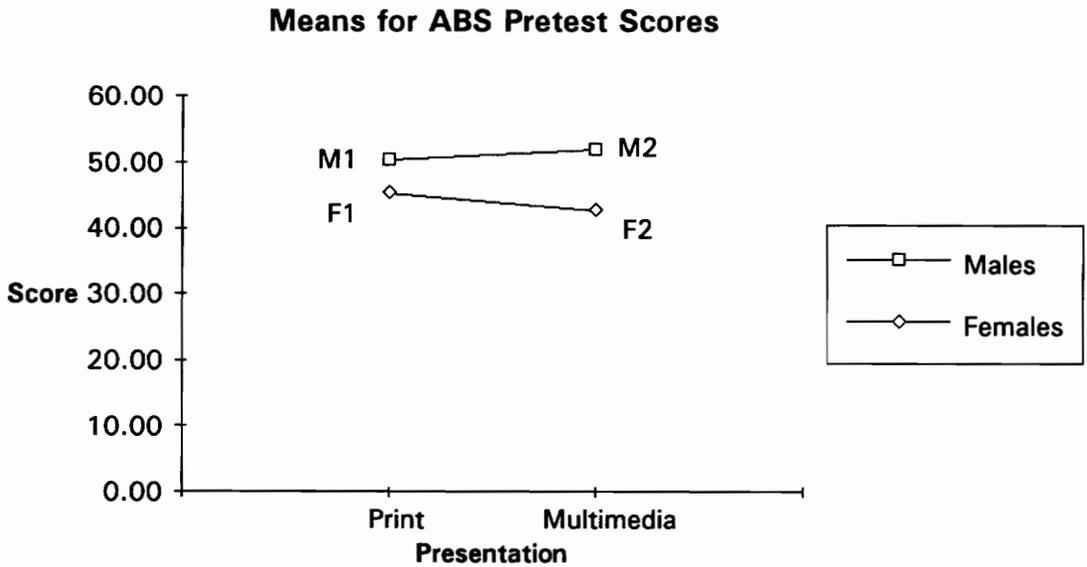
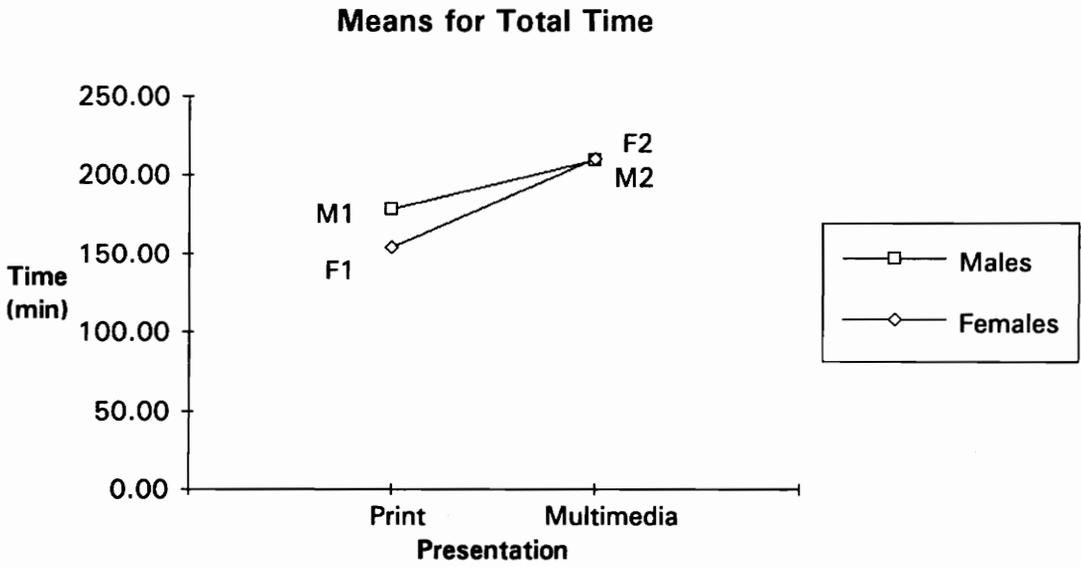


Means for ATDP Form B Posttest Time

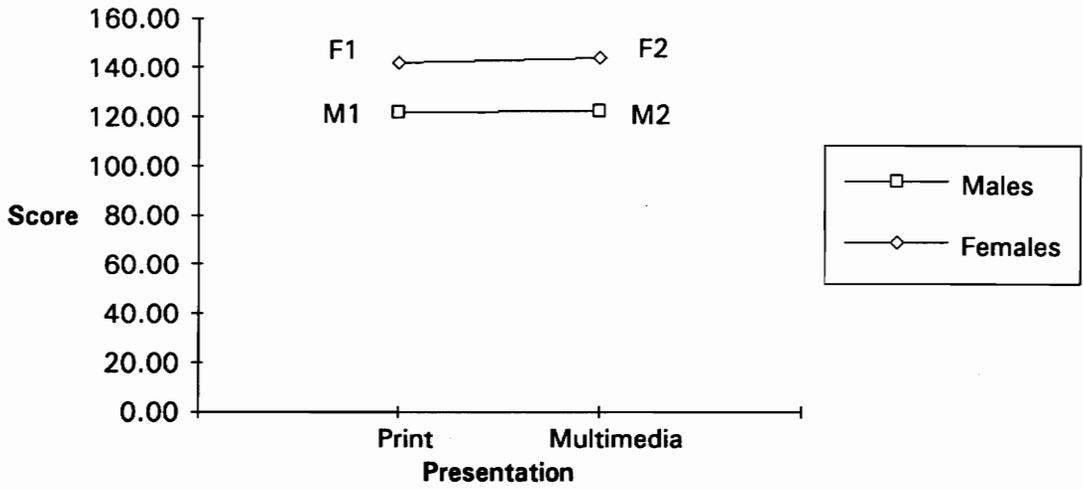


Means for ABS Posttest Time

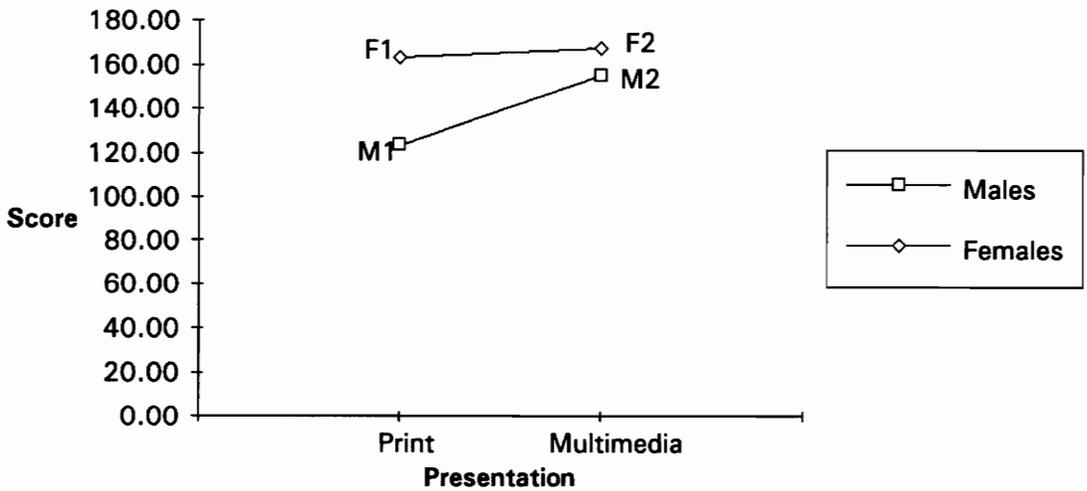




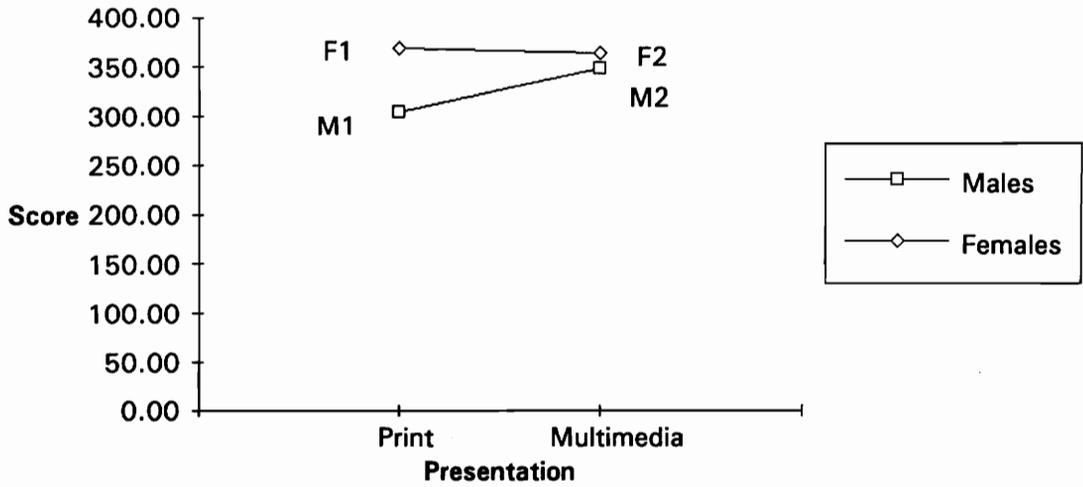
### Means for ATDP Form A Pretest Scores



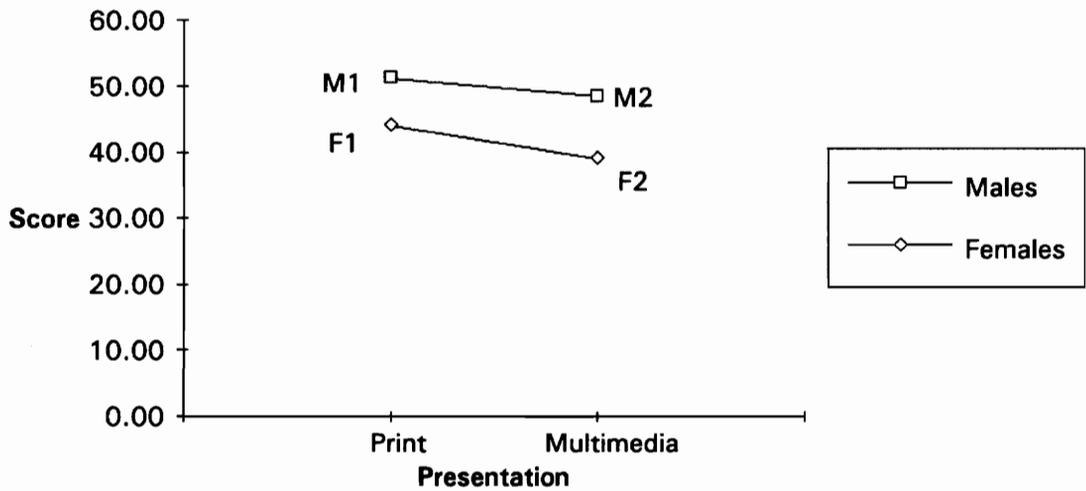
### Means for Pretest Scores



### Means for Posttest Scores



### Means for ABS Posttest Scores



## **APPENDIX S**

### **ANOVA Summary Tables for Times and Scores**

**ANOVA Summary Table**  
**Time to Complete: Instructions**  
 (\* = significance at  $p = 0.05$ )

Source	df	SS	MS	F	p
Gender (G)	1	4.963	4.963	2.91	0.097
Presentation (P)	1	1.119	1.119	0.66	0.423
G x P	1	0.491	0.491	0.29	0.595
S/GP	36	61.391	1.705		
Totals	39	67.964			

**ANOVA Summary Table**  
**Time to Complete: ABS - Pretest**  
 (\* = significance at  $p = 0.05$ )

Source	df	SS	MS	F	p
Gender (G)	1	7.726	7.726	1.97	0.170
Presentation (P)	1	8.519	8.519	2.17	0.150
G x P	1	0.660	0.660	0.17	0.684
S/GP	36	141.524	3.931		
Totals	39	158.430			

**ANOVA Summary Table**  
**Time to Complete: ATDP Form A - Pretest**  
 (\* = significance at  $p = 0.05$ )

Source	df	SS	MS	F	p
Gender (G)	1	7.336	7.336	4.54	0.040*
Presentation (P)	1	3.243	3.243	2.01	0.165
G x P	1	0.464	0.464	0.29	0.595
S/GP	36	58.233	1.618		
Totals	39	69.277			

**ANOVA Summary Table**  
**Time to Complete: Pretest**  
 (\* = significance at p = 0.05)

Source	df	SS	MS	F	p
Gender (G)	1	647.5	647.5	2.73	0.107
Presentation (P)	1	132.7	132.7	0.56	0.460
G x P	1	106.8	106.8	0.45	0.507
S/GP	36	8553.7	237.6		
Totals	39	9440.8			

**ANOVA Summary Table**  
**Time to Complete: Study Material**  
 (\* = significance at p = 0.05)

Source	df	SS	MS	F	p
Gender (G)	1	2	2	0.01	0.929
Presentation (P)	1	32570	32570	150.82	0.000*
G x P	1	403	403	1.87	0.181
S/GP	36	7775	216		
Totals	39	40750			

**ANOVA Summary Table**  
**Time to Complete: Posttest**  
 (\* = significance at p = 0.05)

Source	df	SS	MS	F	p
Gender (G)	1	115.91	115.91	1.33	0.257
Presentation (P)	1	786.33	786.33	9.00	0.005*
G x P	1	16.47	16.47	0.19	0.667
S/GP	36	3143.97	87.33		
Totals	39	4062.68			

**ANOVA Summary Table**  
**Time to Complete: ATDP Form B - Posttest**  
 (\* = significance at  $p = 0.05$ )

Source	df	SS	MS	F	p
Gender (G)	1	5.4317	5.4317	8.94	0.005*
Presentation (P)	1	6.4160	6.4160	10.57	0.003*
G x P	1	1.5840	1.5840	2.61	0.115
S/GP	36	21.8621	0.6073		
Totals	39	35.2938			

**ANOVA Summary Table**  
**Time to Complete: ABS - Posttest**  
 (\* = significance at  $p = 0.05$ )

Source	df	SS	MS	F	p
Gender (G)	1	8.3266	8.3266	9.37	0.004*
Presentation (P)	1	0.1199	0.1199	0.13	0.716
G x P	1	2.8249	2.8249	3.18	0.083
S/GP	36	31.9944	0.8887		
Totals	39	43.2658			

**ANOVA Summary Table**  
**Time to Complete: Entire Experiment**  
 (\* = significance at  $p = 0.05$ )

Source	df	SS	MS	F	p
Gender (G)	1	1402	1402	1.35	0.253
Presentation (P)	1	18543	18543	17.85	0.000*
G x P	1	1421	1421	1.37	0.250
S/GP	36	37391	1039		
Totals	39	58757			

**ANOVA Summary Table**  
**Scores: Pretest**  
 (\* = significance at  $p = 0.05$ )

<b>Source</b>	<b>df</b>	<b>SS</b>	<b>MS</b>	<b>F</b>	<b>p</b>
Gender (G)	1	6734	6734	2.36	0.133
Presentation (P)	1	3258	3258	1.14	0.293
G x P	1	1891	1891	0.66	0.421
S/GP	36	102775	2855		
<b>Totals</b>	<b>39</b>	<b>114658</b>			

**ANOVA Summary Table**  
**Scores: Posttest**  
 (\* = significance at  $p = 0.05$ )

<b>Source</b>	<b>df</b>	<b>SS</b>	<b>MS</b>	<b>F</b>	<b>p</b>
Gender (G)	1	15563	15563	0.87	0.357
Presentation (P)	1	4020	4020	0.23	0.638
G x P	1	6126	6126	0.34	0.562
S/GP	36	642230	17840		
<b>Totals</b>	<b>39</b>	<b>667939</b>			

**ANOVA Summary Table**  
**Scores: Pretest/Posttest Difference**  
 (\* = significance at  $p = 0.05$ )

<b>Source</b>	<b>df</b>	<b>SS</b>	<b>MS</b>	<b>F</b>	<b>p</b>
Gender (G)	1	1823	1823	0.12	0.731
Presentation (P)	1	40	40	0.00	0.959
G x P	1	1210	1210	0.08	0.779
S/GP	36	545689	15158		
<b>Totals</b>	<b>39</b>	<b>548761</b>			

**ANOVA Summary Table**  
**Scores: Pretest/Posttest Comparison**  
 (\* = significance at  $p = 0.05$ )

<b>Source</b>	<b>df</b>	<b>SS</b>	<b>MS</b>	<b>F</b>	<b>p</b>
Gender (G)	1	21386	21386	2.14	0.148
Presentation (P)	1	750781	750781	75.05	0.000*
G x P	1	911	911	0.09	0.764
S/GP	76	760299	10004		
<b>Totals</b>	<b>79</b>	<b>1533378</b>			

## **APPENDIX T**

### **Tables of Kruskal-Wallis Pretest/Posttest Attitude Scores**

For the Attitude to Blindness Scale (ABS), the range of possible scores is 30 to 120. A more favorable attitude is indicated by a lower score. Therefore, when looking at the scores by ranking, a higher average rank is better. That is, a 12.4 ranking is better than a 24.5 ranking.

However, for the Attitude Toward Disabled People (ATDP) Scale, the range of possible scores is 0 to 180. And the opposite is true, a more favorable attitude is indicated by a higher score. Therefore, when examining the scores by ranking, a lower average rank is better. That is, a 28.8 ranking is better than a 11.2 ranking.

**Note:** Although some of the Kruskal-Wallis tests showed a significant result the pair wise comparison(s) that were significant could not be determined. Thus, a Kolmogorov-Smirnov two-sample test was also conducted and no significant pairs could be found. This is unusual. However, the following quote may explain: "We also occasionally find that the overall F statistic in the analysis of variance is significant, but the LSD method fails to find any significant pairwise differences. This situation occurs because the F test is simultaneously considering all possible comparisons between the treatment means, not just pairwise comparisons" (Montgomery, 1991). Also, we don't know if the distribution is normal. The Kruskal-Wallis test is a nonparametric alternative to the usual analysis of variance (Montgomery, 1991). Therefore, although ANOVA is very robust, nonparametric analysis is not necessarily so.

**Kruskal-Wallis Test: ABS Scores - Pretest**

Level	Number of Observations	Median	Average Rank	Z Value
1 M/Print	10	49.50	22.8	0.72
2 M/Multimedia	10	51.50	26.3	1.81
3 F/Print	10	44.50	18.2	-0.72
4 F/Multimedia	10	41.50	14.7	-1.81
Overall	40		20.5	
<hr/>				
H = 5.70	d.f. = 3	p = 0.128		
H = 5.71	d.f. = 3	p = 0.127	(adjusted for ties)	

**Kruskal-Wallis Test: ABS Scores - Posttest**

Level	Number of Observations	Median	Average Rank	Z Value
5 M/Print	10	53.00	26.0	1.73
6 M/Multimedia	10	48.00	24.5	1.27
7 F/Print	10	42.50	19.0	-.048
8 F/Multimedia	10	39.50	12.4	-2.51
Overall	40		20.5	
<hr/>				
H = 8.37	d.f. = 3	p = 0.039		
H = 8.39	d.f. = 3	p = 0.039	(adjusted for ties)	

Post-Hoc Comparison (\* = significance):

Scores Compared	$\bar{R}_U$	$\bar{R}_V$	$n_U$	$n_V$	LHS	> RHS	T or F
ABS 5 - ABS 6	26.0	24.5	10	10	1.5	13.79	F
ABS 5 - ABS 7	26.0	19.0	10	10	7.0	13.79	F
ABS 5 - ABS 8	26.0	12.4	10	10	13.6	13.79	F
ABS 6 - ABS 7	24.5	19.0	10	10	5.5	13.79	F
ABS 6 - ABS 8	24.5	12.4	10	10	12.1	13.79	F
ABS 7 - ABS 8	19.0	12.4	10	10	6.6	13.79	F

Key:

Pretest: 1 M/Print  
 2 M/Multimedia  
 3 F/Print  
 4 F/Multimedia

Posttest: 5 M/Print  
 6 M/Multimedia  
 7 F/Print  
 8 F/Multimedia

**Kruskal-Wallis Test: ABS Scores - Pretest/Posttest Difference**

Level	Number of Observations	Median	Average Rank	Z Value
1 M/Print	10	2.50	25.3	1.48
2 M/Multimedia	10	-1.00	18.7	-0.55
3 F/Print	10	-1.00	20.6	0.05
4 F/Multimedia	10	-3.50	17.4	-0.98
Overall	40			
<hr/>				
H = 2.60	d.f. = 3	p = 0.457		
H = 2.62	d.f. = 3	p = 0.455	(adjusted for ties)	

**Kruskal-Wallis Test: ABS Scores - Pretest/Posttest Comparison**

Level	Number of Observations	Median	Average Rank	Z Value
Pretest	1 M/Print	10	49.50	0.92
	2 M/Multimedia	10	51.50	1.89
	3 F/Print	10	44.50	-0.23
	4 F/Multimedia	10	41.50	-1.30
Posttest	5 M/Print	10	53.00	1.43
	6 M/Multimedia	10	48.00	0.89
	7 F/Print	10	42.50	-0.87
	8 F/Multimedia	10	39.00	-2.73
Overall	80		40.5	
<hr/>				
H = 15.07	d.f. = 7	p = 0.036		
H = 15.11	d.f. = 7	p = 0.036	(adjusted for ties)	

Post-Hoc Comparison (\*= significance):

Scores Compared	$\bar{R}_U$	$\bar{R}_V$	$n_U$	$n_V$	LHS	> RHS	T or F
ABS 1 - ABS 2	46.8	53.5	10	10	6.7	32.47	F
ABS 1 - ABS 3	46.8	39.0	10	10	7.8	32.47	F
ABS 1 - ABS 4	46.8	31.5	10	10	15.3	32.47	F
ABS 1 - ABS 5	46.8	50.3	10	10	3.5	32.47	F
ABS 1 - ABS 6	46.8	46.6	10	10	0.2	32.47	F
ABS 1 - ABS 7	46.8	34.5	10	10	12.3	32.47	F
ABS 1 - ABS 8	46.8	21.7	10	10	25.1	32.47	F
ABS 2 - ABS 3	53.5	39.0	10	10	14.5	32.47	F
ABS 2 - ABS 4	53.5	31.5	10	10	22.0	32.47	F
ABS 2 - ABS 5	53.5	50.3	10	10	3.2	32.47	F
ABS 2 - ABS 6	53.5	46.6	10	10	6.9	32.47	F
ABS 2 - ABS 7	53.5	34.5	10	10	19.0	32.47	F
ABS 2 - ABS 8	53.5	21.7	10	10	31.8	32.47	F
ABS 3 - ABS 4	39.0	31.5	10	10	7.5	32.47	F
ABS 3 - ABS 5	39.0	50.3	10	10	11.3	32.47	F
ABS 3 - ABS 6	39.0	46.6	10	10	7.6	32.47	F
ABS 3 - ABS 7	39.0	34.5	10	10	4.5	32.47	F
ABS 3 - ABS 8	39.0	21.7	10	10	17.3	32.47	F
ABS 4 - ABS 5	31.5	50.3	10	10	18.8	32.47	F
ABS 4 - ABS 6	31.5	46.6	10	10	15.1	32.47	F
ABS 4 - ABS 7	31.5	34.5	10	10	3.0	32.47	F
ABS 4 - ABS 8	31.5	21.7	10	10	9.8	32.47	F
ABS 5 - ABS 6	50.3	46.6	10	10	3.7	32.47	F
ABS 5 - ABS 7	50.3	34.5	10	10	15.8	32.47	F
ABS 5 - ABS 8	50.3	21.7	10	10	28.6	32.47	F
ABS 6 - ABS 7	46.6	34.5	10	10	12.1	32.47	F
ABS 6 - ABS 8	46.6	21.7	10	10	24.9	32.47	F
ABS 7 - ABS 8	34.5	21.7	10	10	12.8	32.47	F

Key:

Pretest:	1 M/Print	Posttest:	5 M/Print
	2 M/Multimedia		6 M/Multimedia
	3 F/Print		7 F/Print
	4 F/Multimedia		8 F/Multimedia

### Kruskal-Wallis Test: ATDP Form A Scores - Pretest

Level	Number of Observations	Median	Average Rank	Z Value
1 M/Print	10	120.5	14.9	-1.73
2 M/Multimedia	10	126.5	15.3	-1.62
3 F/Print	10	147.0	25.3	1.50
4 F/Multimedia	10	146.0	26.5	1.86
Overall	40		20.5	
<hr/>				
H = 8.51	d.f. = 3	p = 0.037		
H = 8.51	d.f. = 3	p = 0.037 (adjusted for ties)		

Post-Hoc Comparison (\*= significance):

Scores Compared	$\bar{R}_U$	$\bar{R}_V$	$n_U$	$n_V$	LHS	> RHS	T or F
ATDP 1 - ATDP 2	14.9	15.3	10	10	0.4	13.79	F
ATDP 1 - ATDP 3	14.9	25.3	10	10	10.4	13.79	F
ATDP 1 - ATDP 4	14.9	26.5	10	10	11.6	13.79	F
ATDP 2 - ATDP 3	15.3	25.3	10	10	10.0	13.79	F
ATDP 2 - ATDP 4	15.3	26.5	10	10	11.2	13.79	F
ATDP 3 - ATDP 4	25.3	26.5	10	10	1.2	13.79	F

Key:

Pretest:	1 M/Print	Posttest:	5 M/Print
	2 M/Multimedia		6 M/Multimedia
	3 F/Print		7 F/Print
	4 F/Multimedia		8 F/Multimedia

**Kruskal-Wallis Test: ATDP Form B Scores- Posttest**

Level	Number of Observations	Median	Average Rank	Z Value
5 M/Print	10	115.0	11.2	-2.90
6 M/Multimedia	10	129.0	16.5	-1.23
7 F/Print	10	148.5	25.5	1.56
8 F/Multimedia	10	151.5	28.8	2.58
Overall	40		20.5	
<hr/>				
H = 14.28	d.f. = 3	p = 0.003		
H = 14.28	d.f. = 3	p = 0.003	(adjusted for ties)	

Post-Hoc Comparison (\*= significance):

Scores Compared	$\bar{R}_U$	$\bar{R}_V$	$n_U$	$n_V$	LHS	> RHS	T or F
ATDP 5 - ATDP 6	11.2	16.5	10	10	5.3	13.79	F
ATDP 5 - ATDP 7	11.2	25.5	10	10	14.3	13.79	T*
ATDP 5 - ATDP 8	11.2	28.8	10	10	17.6	13.79	T*
ATDP 6 - ATDP 7	16.5	25.5	10	10	9.0	13.79	F
ATDP 6 - ATDP 8	16.5	28.8	10	10	12.3	13.79	F
ATDP 7 - ATDP 8	25.5	28.8	10	10	3.3	13.79	F

Key:

Pretest: 1 M/Print  
 2 M/Multimedia  
 3 F/Print  
 4 F/Multimedia

Posttest: 5 M/Print  
 6 M/Multimedia  
 7 F/Print  
 8 F/Multimedia

**Kruskal-Wallis Test: ATDP Scores - Pretest/Posttest Differences**

Level	Number of Observations	Median	Average Rank	Z Value
1 M/Print	10	-7.00	15.3	-1.64
2 M/Multimedia	10	-4.50	19.4	-0.34
3 F/Print	10	5.00	21.4	0.27
4 F/Multimedia	10	5.00	26.0	1.72
Overall	40		20.5	
<hr/>				
H = 4.37	d.f. = 3	p = 0.225		
H = 4.37	d.f. = 3	p = 0.224	(adjusted for ties)	

**Kruskal-Wallis Test: ATDP Scores - Pretest/Posttest Comparison**

Level	Number of Observations	Median	Average Rank	Z Value
Pretest	1 M/Print	10	29.20	-1.64
	2 M/Multimedia	10	29.50	-1.61
	3 F/Print	10	48.70	1.19
	4 F/Multimedia	10	51.10	1.54
Posttest	5 M/Print	10	22.00	-2.69
	6 M/Multimedia	10	33.30	-1.05
	7 F/Print	10	51.50	1.60
	8 F/Multimedia	10	58.70	2.65
Overall	80		40.50	
<hr/>				
H = 23.66	d.f. = 7	p = 0.001		
H = 23.67	d.f. = 7	p = 0.001	(adjusted for ties)	

Post-Hoc Comparison (\*= significance):

Scores Compared	$\bar{R}_U$	$\bar{R}_V$	n <sub>U</sub>	n <sub>V</sub>	LHS	> RHS	T or F
ATDP 1 - ATDP 2	29.2	29.5	10	10	0.3	32.47	F
ATDP 1 - ATDP 3	29.2	48.7	10	10	19.5	32.47	F
ATDP 1 - ATDP 4	29.2	51.1	10	10	21.9	32.47	F
ATDP 1 - ATDP 5	29.2	22.0	10	10	7.2	32.47	F
ATDP 1 - ATDP 6	29.2	33.3	10	10	4.1	32.47	F
ATDP 1 - ATDP 7	29.2	51.5	10	10	22.3	32.47	F
ATDP 1 - ATDP 8	29.2	58.7	10	10	29.5	32.47	F
ATDP 2 - ATDP 3	29.5	48.7	10	10	19.2	32.47	F
ATDP 2 - ATDP 4	29.5	51.1	10	10	21.6	32.47	F
ATDP 2 - ATDP 5	29.5	22.0	10	10	7.5	32.47	F
ATDP 2 - ATDP 6	29.5	33.3	10	10	3.8	32.47	F
ATDP 2 - ATDP 7	29.5	51.5	10	10	22.0	32.47	F
ATDP 2 - ATDP 8	29.5	58.7	10	10	29.2	32.47	F
ATDP 3 - ATDP 4	48.7	51.1	10	10	2.4	32.47	F
ATDP 3 - ATDP 5	48.7	22.0	10	10	26.7	32.47	F
ATDP 3 - ATDP 6	48.7	33.3	10	10	15.4	32.47	F
ATDP 3 - ATDP 7	48.7	51.5	10	10	2.8	32.47	F
ATDP 3 - ATDP 8	48.7	58.7	10	10	10.0	32.47	F
ATDP 4 - ATDP 5	51.1	22.0	10	10	29.1	32.47	F
ATDP 4 - ATDP 6	51.1	33.3	10	10	17.8	32.47	F
ATDP 4 - ATDP 7	51.1	51.5	10	10	0.4	32.47	F
ATDP 4 - ATDP 8	51.1	58.7	10	10	7.6	32.47	F
ATDP 5 - ATDP 6	22.0	33.3	10	10	11.3	32.47	F
ATDP 5 - ATDP 7	22.0	51.5	10	10	29.5	32.47	F
ATDP 5 - ATDP 8	22.0	58.7	10	10	36.7	32.47	T*
ATDP 6 - ATDP 7	33.3	51.5	10	10	18.2	32.47	F
ATDP 6 - ATDP 8	33.3	58.7	10	10	25.4	32.47	F
ATDP 7 - ATDP 8	51.5	58.7	10	10	7.2	32.47	F

Key:

<p>Pretest:</p> <p>1 M/Print</p> <p>2 M/Multimedia</p> <p>3 F/Print</p> <p>4 F/Multimedia</p>	<p>Posttest:</p> <p>5 M/Print</p> <p>6 M/Multimedia</p> <p>7 F/Print</p> <p>8 F/Multimedia</p>
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## **APPENDIX U**

### **User Evaluation Form Raw Data Table and Friedman Two-Way Analysis of Variance by Ranks**

### Raw Data Summary Table

Question>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Subject 12	10	10	9	9	5	5	9	6	8	9	3	N/A	N/A	N/A	10	8	5	9	9	7	5	8	3	N/A
Subject 14	8	8	9	10	10	10	7	8	5	8	3	N/A	N/A	N/A	8	7	6		9	7	6	5	6	N/A
Subject 17	8	9	9	8	10	10	8	10	9	8	6	N/A	N/A	N/A	10	9	7	8	9	9	8	6	10	10
Subject 18	8	6	8	8	4	7	7	8	4	7	3	N/A	3	4	7	3	5	4	7	6	6	7	8	3
Subject 26	10	8	8	8	7	9	8	6	8	5	4	7	8	8	10	6	3	6	7	7	7	5	9	7
Subject 30	8	8	9	8	8	8	8	9	9	9	1	9	9	9	10	1	5	5	10	5	5	4	10	10
Subject 32	6	6	7	7	8	8	7	6	6	7	5	N/A	N/A	7	7	8	4	7	6	6	6	7	6	6
Subject 36	6	6	8	7	6	8	8	8	9	9	3	9	6	N/A	9	N/A	1	N/A	7	6	3	3	8	8
Subject 38	10	10	10	10	10	10	10	10	10	10	5	N/A	N/A	N/A	10	4	N/A	N/A	N/A	10	10	10	5	N/A
Subject 39	9	10	9	9	10	9	9	9	10	10	4	7	8	N/A	10	9	6	8	7	6	7	6	7	N/A
Subject 40	10	10	10	10	10	10	10	10	10	10	3	10	10	10	10	6	5	10	10	10	10	10	10	10
Subject 44	7	8	8	7	8	8	8	8	8	8	1	6	8	7	9	10	10	7	7	7	6	1	7	7
Subject 47	8	7	8	9	10	10	10	8	6	8	6	N/A	N/A	N/A	10	10	5	N/A	2	3	5	1	7	9
Subject 48	10	7	7	7	7	7	7	7	7	7	8	N/A	N/A	N/A	8	8	4	8	7	7	7	7	7	7
Subject 50	10	10	10	10	5	10	10	10	10	5	3	N/A	N/A	N/A	10	N/A	3	10	5	8	7	8	8	N/A
	8.53	8.20	8.60	8.47	7.87	8.60	8.40	8.20	7.93	8.00	3.87	8.00	7.43	7.50	9.20	6.85	4.93	7.45	7.29	6.93	6.53	5.87	7.40	7.70
	1.46	1.57	0.99	1.19	2.13	1.50	1.18	1.47	1.94	1.60	1.88	1.55	2.30	2.07	1.11	2.76	2.09	1.92	2.13	1.83	1.85	2.77	1.96	2.21

For purposes of conducting the Friedman two-way analysis of variance by ranks all blocks must contain an equal number of observations. Therefore, questions 12, 13, 14, 16, 17, 18, 19, and 24 will be dropped from the analysis. This is far from ideal but necessary for an analysis of any kind. Regardless, the information was collected solely from subjects volunteering to complete the form. And the information was intended only for general interest.

**Friedman Two-Way  
Analysis of Variance by Ranks**  
(\* = significance  $p = 0.05$ )

Question	Block	Median	Ranks
1	15	8.250	147.5
2	15	8.063	137.0
3	15	8.188	160.0
4	15	8.000	146.0
5	15	7.875	138.0
6	15	8.250	161.5
7	15	8.000	144.0
8	15	8.000	143.5
9	15	7.938	133.0
10	15	7.938	140.0
11	15	3.250	35.0 *
15	15	8.875	195.0
20	15	6.750	89.5 *
21	15	6.313	75.0 *
22	15	5.875	76.0 *
23	15	7.438	119.0

The observed statistic  $F_r$  is obtained from the following equation:

$$F_r = \left[ \frac{12}{Nk(k+1)} \sum_{j=1}^k R_j^2 \right] - 3N(k+1)$$

$F_r = 70.31$

When the number of rows and/or columns is large, it can be shown that the statistic  $F_r$  is distributed approximately as  $\chi^2$  with  $df = k - 1$ .

Therefore,  $F_{\text{tabled}} = \chi^2(15)$ .

$F_{\text{tabled}}(\alpha = 0.05) = 25.00$

Therefore, we may reject the null hypothesis that the four samples were drawn from a population with the same medians at the 0.05 level of significance since the observed value of  $F_r$  exceeds the critical value.

The critical difference for post-hoc comparisons is 92.03. The questions that are significantly different from at least one other question are marked with an asterisk. However, most are significantly different when compared to question 15 which dealt with the ease of learning the program. Only question 11 was significantly different from more than one other question.

## VITA

TIMOTHY JUDE AL-MOLKY (Determining Effectiveness of Visual Disability Guidelines Presented on a Multimedia Workbench) was born 03 October 1963, in Soest, West Germany. He received a Diploma of Engineering from St. Mary's University, Halifax, Nova Scotia, Canada in May of 1984. He then graduated from the Technical University of Nova Scotia, Halifax, Nova Scotia, Canada in May of 1987 with a Bachelor of Engineering (Mechanical).

From August 1990, to August 1993, he was employed as an aircraft and maintenance engineering officer at Canadian Forces Base Edmonton. He held the positions of Mechanical Support Officer, Avionics Support Officer, Base Photo Officer, and Chief of Explosive Ordnance Disposal Centre 21. He became a licensed professional engineer with the Association of Professional Engineers, Geologists, and Geophysicists of Alberta (APEGGA) in January 1993.

He currently holds the rank of Captain at Canadian Forces Base Rockcliffe, Ottawa, Canada where he works in the Directorate of Aerospace Engineering.

A handwritten signature in black ink, reading "Tim J. Al-Molky". The signature is written in a cursive style with a large, sweeping initial 'T' and 'A'.