

Using Computer-Based Virtual Tours to Assist Persons With Disabilities

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Abstract

Results of a recent study concerning computer technology and people with disabilities indicate that virtual reality tours are effective in conveying information and, in some cases, reducing anxiety. One hundred and ten subjects with physical disabilities participated in the study, and seven quantitative and qualitative instruments were used to assess study variables. Three physical locations were recreated virtually and include interactivity, captioning, digital audio and video, mapping, and other features. The implications may be valuable in both physical and virtual educational settings as educators strive to serve a growing student population.

Keywords

Disabilities, Virtual reality tours

Statement of problem

According to the World Association of Persons with Disabilities (World, 2003) an estimated one in five people globally have a disability. To illustrate the magnitude of the issue, more than 166 international delegations and over 7,000 athletes with developmental disabilities will be participating at the upcoming Special Olympic World Games in Ireland.

According to 1997 census records in the U.S., 52.6 million people (19.7% of the population) had some level of disability and 33 million (12.3 percent of the population) had a severe disability. One in seven Americans, or 35 million individuals, have a disability severe enough to interfere with life's day-to-day activities (Scherer, 1996, p. 4). Access to physical facilities is also a challenge for students with disabilities. Universities and colleges throughout the world are working to assist students to access courses, classrooms, laboratories, and other campus programs and facilities.

Technology has long played a role in helping persons with disabilities live and work independently. The Community Access Through Technology (CATT) project, which is discussed in this paper, attempts to determine empirically if virtual computer tours of physical facilities can assist persons with disabilities in accessing important community resources.

Review of Literature

The promise of virtual reality (VR) technologies to provide powerful and unique educational and informational experiences is well known (Heim, 1998). Unfortunately, the public has often turned away from these technologies when expectations went unfulfilled due to hyperbole on the part of the media. Despite setbacks, however, use of VR is growing and will soon become commonplace, according to some researchers (Von Schweber, 1998). Specifically, in the CATT project, VR software was used to model various public buildings and other sites that individuals with disabilities want to visit. Therapeutic recreation specialists then use the

software with patients to allow them to virtually preview sites that they may later want to tour in person. This process of leisure education builds confidence in the clients and may lead to greater independence once they integrate into society. By enhancing this social self-efficacy, it is anticipated that carry-over will occur into education, employment, independent living, family support, and economic independence.

Virtual reality literature discusses many benefits for patients. Rothbaum, Hodges and Kooper (1997) reduced the fear of heights in patients after virtual reality exposure therapy. Wilson, Foreman and Stanton (1997) demonstrated that spatial information acquired by physically disabled children from exploration of a virtual environment will transfer to a real-world equivalent environment; Ring (1998) has suggested that patients with disabilities can be trained with virtual reality to judge architectural barriers and tackle environmental obstacles. The researcher advocates the use of virtual reality as a significant assistive technology in the future (Ring, 1998). This clear support of technology deserves the opportunity for development, not just to provide individuals with simulated experiences but to use the technology for the integration of people with disabilities into society.

Methodology

Subjects

Some 110 subjects with physical disabilities were recruited through advertisements in local newspapers, and through direct mailing to local hospitals, community housing facilities, non-profit agencies, and disability advocacy groups. All subjects were initially screened to ensure that they met minimum guidelines for participation in the study, which included being age 18 or older, no cognitive deficits, and having a physical disability that impaired mobility. Subjects were randomly assigned to groups for tours at the Denver Parks and Recreation 20th Street Recreation Center; National Sports Center for the Disabled at the Winter Park Ski and Recreation Area; and the Pepsi Center professional sports facility. Groups included a control group; VR only group which was provided an independent computer-based tour prior to a physical tour of the site; and a VR and leisure education group, which was provided the computer-based tour facilitated by a certified therapeutic recreation specialist. At the Pepsi Center site, an additional group was added that received only a traditional leisure education program. Thus, groupings for each site were as follows:

20th Street--#1 Control Group; #2 VR Only; #3 VR and Leisure Education

NSCD--#1 Control Group; #2 VR Only (Guided Tour); #3 VR and Leisure Education

Pepsi Center--#1 Control Group; #2 VR Only; #3 Leisure Education Only; #4 VR and Leisure Education

Instruments

➤ Self-Evaluation Questionnaire

The State-Trait Anxiety Inventory (STAI) (Spielberger, 1983) was one measure used to assess anxiety. The state anxiety scale (Form Y), used to measure a temporary condition of apprehension, tension, nervousness and worry, was completed by subjects. The scale is comprised of 20 statements with a range of 4 possible responses to each. The STAI has been used more extensively in psychological research than any other anxiety inventory (Buros, 1978). Data indicate that the state scale of the STAI has reliability coefficients above .90 for samples of working adults, students, and military recruits, with a median coefficient of .93. Additionally, it is reported that alpha reliability coefficients are typically higher for the state-anxiety scale when given under conditions of psychological stress (Spielberger, 1983, p. 14). Extensive research into the validity of the STAI has been conducted, and it is reported that the state-anxiety scale repeatedly has demonstrated sensitivity to environmental stress. Furthermore, the STAI has been shown to have excellent psychometric properties for the assessment of anxiety in elderly persons (Spielberger, 1983, p. 20).

➤ Visual Analog Scale (VAS)

Each subject was asked to perform a self-evaluation of anxiety at baseline and at the conclusion of their site tour. An 11-point Visual Analog Scale (VAS) (McCall, Fischer, Warden, Kopcha, Lloyd, Young and Schomaker, 1998; Vogelsang, 1988) was used. Lower scores (0-3) indicated greater comfort with the environment; middle scores (4-7) reflected moderate comfort, while higher scores (8-10) indicated severe discomfort.

➤ Heart Rate (HR) Measurement

In order to assess physiological changes as a result of anxiety, heart rate data were collected. Heart rate data were recorded every 5 seconds and stored using a Polar Accurex Plus Heart Rate Monitor from Polar Electro Oy, Kempele, Finland. All HR data were downloaded from the HR monitor's wrist receiver to a computer via a Polar Interface Plus (Polar, 1999). Each subject had his or her HR measured to establish a baseline and again while touring either the 20th Street Recreation Center, National Sports Center for the Disabled, or the Pepsi Center.

(A) Baseline

Heart rates were measured during an hour of "normal" daily activity while at home or in another "comfortable" environment chosen by the subject. An average HR was determined for this time period.

(B) 20th Street Recreation Center, NSCD, Pepsi Center

While touring the facility, the heart rate monitor was used to ascertain physiological changes due to environmental anxiety. Subjects completed assigned tasks while touring each facility. The subject pressed an event marker on the HR wrist receiver at set locations. This enabled the identification of a specific heart rate during a specific time interval.

➤ Cortisol Testing

Cortisol occurs naturally in human saliva and levels can be used to measure stress and anxiety. This test was used only at the Pepsi Center. Over fifty years ago, Hans Selye (1946) observed that a wide variety of stressful events led to predictable increases in the hormone, which is released from the adrenal cortex. This is a result of a series of physiological events in the body: 1) stress is sensed in the higher brain centers 2) neural signal is sent to hypothalamus 3) corticotrophic-releasing hormone (CRH) is secreted from hypothalamus 4) CRH stimulates anterior pituitary gland to secrete ACTH and 5) ACTH acts on adrenal gland to secrete cortisol. Cortisol is the most potent glucocorticoid produced by the human adrenal. It is synthesized from cholesterol and its production is stimulated by pituitary adrenocorticotropic hormone (ACTH) which is regulated by corticotropin releasing factor (CRF). High cortisol levels in a negative feedback loop inhibit ACTH and CRF secretions. Cortisol acts through specific intracellular receptors and affects numerous physiologic systems including immune function, glucose counter regulation, vascular tone, and bone metabolism. Cortisol is essential for glucose regulation (Nicolson, Storms, Ponds and Sulon, 1997; Chrousos and Gold, 1992).

➤ Recreation Information Questionnaire (RIQ)

A Recreation Information Questionnaire (RIQ) was developed for each of three sites to ascertain the subject's knowledge of recreation-related information, frequency of recreation center use, and community independence. Composite scores were calculated by adding correct responses for each statement.

➤ Technology Questionnaire (TQ)

A technology questionnaire assessed the subject's technology sophistication, such as their ability to utilize voice mail, e-mail, FAX machines, word processing, and search for information on the World Wide Web. This instrument was adapted from the Flashlight Project (Ehrmann and Zúñiga, 1997). Flashlight™ is comprised of various assessment tools useful in helping to answer questions about technology, and it has been subjected to content validity testing.

➤ Demographic Data

Each subject was requested to provide demographic information that included their age, sex, ethnicity, disability, current employment status, living arrangement, health status, use of assistive devices, and methods of transportation.

Experimental Design

Three sites were selected for developing and implementing the virtual reality tour software, for conducting virtual and real tours, and for collecting and analyzing data to see if the software was effective. The sites were the Denver Parks and Recreation 20th Street Recreation Center; National Sports Center for the Disabled at the Winter Park Ski and Recreation Area; and the Pepsi Center professional sports facility. One hundred and ten subjects participated in the study. However, one group from the Pepsi Center was omitted from the combined data analysis to be consistent.

Combined data (n=98)

Data were combined from all three sites:

- Groups one from all three sites were combined.
- Groups two from all three sites were combined.
- Groups three from the 20th street site and the Winter Park site were combined with group four from the Pepsi Center site.
- Group 3 from the Pepsi Center was omitted.
- The hrsite variable from the 20th street site was combined with the average of the hrsite and hrsitear variables from the Winter Park site and the average of the hrsite1, hrsite2, and hrsite3 variables from the Pepsi Center site.

20th Street Recreation Center

The 20th Street Recreation Center, a large multi-purpose facility operated by the City of Denver, Colorado, Department of Parks and Recreation, was created into a virtual environment that included photo-realistic panoramas of the facility, digital video of recreation equipment use, access annotations, and interactive maps of the facility. Potential subjects were initially screened to ensure meeting eligibility requirements and then were randomly assigned to either a control group (n=13), treatment group one that received virtual reality only (VR) (n=10) or treatment group two that received leisure education using the virtual reality scenario (LE-VR) (n=11). All subjects were pre-tested in their home or “comfortable” environment to determine baseline anxiety levels (i.e., Self-Evaluation Questionnaire, HR, and VAS), recreation knowledge (i.e., RIQ), technology sophistication (i.e., TQ), and demographic data.

Control group subjects independently toured the 20th Street Recreation Center, completing 11 assigned tasks such as signing up for a recreation center pass, locating specific exercise equipment, and viewing the swimming pool. During the tour, subject’s HR was recorded and tour data noted on voice-activated tape recorders. At the conclusion of the tour, subjects were met by project staff to complete their post-evaluation questionnaires and paperwork for receiving a stipend for participation.

Similarly, subjects in the VR only treatment group and LE-VR treatment group followed an identical protocol for their 20th Street Recreation Center visit. However, the subjects assigned to the VR treatment group had an opportunity to view and “navigate” through the Center virtually prior to their actual on-site tour. Each VR only subject, either coming to a computer lab of the CATT project or by having staff bring a laptop computer into the subject’s home, virtually toured the facility, navigating through the various rooms, examining equipment, and viewing the digital video clips. Staff had been instructed to assist subjects in using the computer only and not to provide explanation or information about the facilities.

Subjects in the leisure education-virtual reality (LE-VR) group also utilized the 20th Street Recreation Center virtual environment but had this computer tour facilitated by a certified therapeutic recreation specialist (CTRS). A leisure education program, created through a modified program planning process (Peterson & Stumbo, 2000), was used by the recreation therapist to assist LE-VR subjects in using the community facility. Content of the program included information about transportation, facility accessibility information, fees/costs for participation, equipment and adaptations available, and services provided through the Special Needs Program of Denver Parks and Recreation Department.

The National Sports Center for the Disabled

The National Sports Center for the Disabled at the Winter Park Ski Resort is nonprofit organization in its 32nd year of offering year-round outdoor recreation opportunities to more than 3,000 men, women and children with disabilities each year.

Potential subjects were initially screened to ensure meeting eligibility requirements and then were randomly assigned to either a control group (n=11); treatment group that viewed a virtual reality self-guided tour only (VR) (n=11); and a treatment group that received leisure education using an “explore on your own” virtual reality scenario (LE-VR) (n=11). As with the 20th Street Recreation study, all subjects were pre-tested in their home or “comfortable” environment to determine baseline anxiety levels (i.e., Self-Evaluation Questionnaire, HR, and VAS), recreation knowledge (i.e., RIQ), technology sophistication (i.e., TQ), and demographic data.

Control group subjects participated in a day ski program at the NSCD facility at the Winter Park Ski Resort. During the day, each subject’s HR was recorded. At the conclusion of the day, subjects completed their post-evaluation questionnaires and paperwork before receiving a stipend for participation.

Similarly, subjects in the VR only treatment group and LE-VR treatment group followed an identical protocol for their NSCD visit. However, the subjects assigned to the VR treatment group had an opportunity to view and “navigate” through the Center virtually prior to their actual on-site tour. Each VR only subject, either coming to a computer lab of the CATT project or by having staff bring a laptop computer into the subject’s home, virtually toured the facility, navigating through the various rooms, examining equipment, and viewing the digital video clips. Staff had been instructed to assist subjects in using the computer only and not to provide explanation or information about the facilities.

Subjects in the leisure education-virtual reality (LE-VR) group also used a “tour on your own” virtual environment but had this computer tour facilitated by a certified therapeutic recreation specialist (CTRS). A leisure education program, created through a modified program planning process (Peterson & Stumbo, 2000), was used by the recreation therapist to assist LE-VR subjects in using the community facility. Technology used to simulate the environment consisted of Hypertext Markup Language (HTML); Apple QuickTime VR panorama, modeling, and movies; and Macromedia Flash. Content included information about transportation, facility accessibility information, fees/costs for participation, equipment and adaptations available, and services provided through the National Sports Center for the Disabled.

Pepsi Center

The Pepsi Center professional sports facility is situated at the edge of downtown Denver and anchors Denver's thriving downtown entertainment district. It is the home facility for the Colorado Avalanche professional hockey team and the Denver Nuggets professional basketball team. Potential subjects were initially screened to ensure meeting eligibility requirements and then were randomly assigned to either a control group (n=11); treatment group that received virtual reality only (VR) (n=12); treatment group that received leisure education only (n=11); and the treatment group that received leisure education and VR (n=11). Subjects in a clinical rehabilitation program participated and baseline testing was completed by recreation therapists in the rehabilitation hospital. Baseline anxiety levels were determined by the Self-Evaluation Questionnaire, HR, and VAS; recreation knowledge was gained by the RIQ; technology sophistication by the TQ; and demographic data by a questionnaire. Questionnaires, HR measurement, and saliva samples were gathered at baseline at the hospital and during a community outing to the Pepsi Center.

Results

Results were calculated for data from all three sites combined as well as for individual sites.

Combined data

The following significant results were found:

The Recpost variable was found to have significant differences between the three groups: $F=11.691$ (df 2, 97), $p=.000$.

Post-Hoc tests showed the difference to be between:
Groups one and two,
Groups one and three.

The differences between pre-and post-test scores (and heart rate, base and heart rate, on site) were computed. Significant differences were found between the three groups in the recreation differences (recpre-recpost): $F=8.380$ (df 2, 97), $p=.000$.

Post-Hoc tests showed the difference to be both between:
Groups one and two,
Groups one and three.

No other significant differences were found, either at the .01, .05, or .1 levels, using the ANOVA test.

20th Street Recreation Center

The premise that a facilitated virtual reality tour administered prior to visiting the 20th Street Recreation Center would reduce anxiety, was supported by a difference in means from the STAI ($p=.104$).

The premise that a virtual tour prior to visitation to a new site would provide detailed, necessary information about that facility also was supported by the data. Analysis of data from the RIQ showed significant differences between both the VR-Only and the LE-VR treatment groups and the control group ($p=.003$).

The premise that use of a virtual tour alone prior to visitation of a new site would alleviate anxiety in subjects with mobility impairments, was not supported by the data. Subjects in the VR only group were administered three instruments, then provided the treatment of the virtual reality experience, and then measured again at the 20th Street Recreation Center location. Data indicates an increased level of discomfort, anxiety, and heart rate. While mean HR site data was lower for this group of subjects than for similar subjects in the control group, the range was much greater.

The Technology Questionnaire was administered to all subjects prior to site visitation. It assessed the technology sophistication of the subjects, including their ability to use voice mail, e-mail, FAX machines, word processing, and the World Wide Web. In order to determine whether an individual's knowledge of technology was a factor in levels of anxiety, a technology score was formed by adding together individual responses to technology questions. A significant negative correlation was found between technology composite scores and pretest anxiety scores. This would indicate that those who score higher in technology knowledge tended to score lower on self-reported anxiety in the pretest.

The National Sports Center for the Disabled

An opportunity for individuals with disabilities to alpine ski is provided through the National Sports Center for the Disabled (NSCD) located at the Winter Park Resort in Colorado. The NSCD virtual environment encompassed all of the design features previously used but also included two methods of virtual tours: a tour on your own and a guided, linear tour. Similar data collection tools and procedures were used for subjects participating in the NSCD experience. However, therapeutic recreation specialists from community recreation departments assisted in subject recruitment, administration of study protocols, and data collection. Individuals with a mobility impairment residing in the community were randomly assigned to one of three groups of subjects, control group, VR only using a guided tour, and LE-VR facilitated experience.

Again, preliminary results suggest that all groups had recreation information gain. However, the guided tour group had the greatest gains, followed by the individuals in the LE-VR group, and then as expected, the control group. All groups had lower post-experience anxiety scores. Interestingly, the VR only group (guided tour) had the least anxiety, followed by the control group and the LE-VR group as indicated on the STAI. An initial explanation for this might be based on severity of disability. It appears that group 3, the LE-VR group, included individuals with more severe mobility impairment than the other groups.

The Pepsi Center

Since this project is interested in learning how leisure education and virtual reality can help facilitate someone's access into the community, it was determined that a population undergoing active rehabilitation would be used as subjects during the Pepsi Center evaluation. Volunteer patients from a local, specialized rehabilitation hospital were randomly assigned to one of four groups of subjects: control group, VR only treatment, leisure education-virtual reality, and traditional leisure education. Questionnaires, HR measurement, and saliva samples were gathered at baseline while in the hospital and during a community outing to the Pepsi Center. Similar to the 20th Street Recreation Center protocol, the control group received no virtual reality or leisure education, the VR only group received an unfacilitated virtual tour of the Pepsi Center, the leisure education-virtual reality subjects had a virtual tour facilitated by a certified therapeutic recreation specialist, and the fourth group of subjects was provided with a "traditional" leisure education program provided by the CTRS.

Preliminary results suggest that while all four groups gained recreation information, the LE-VR group (facilitated experience virtual reality experience) had the greatest information gain. It should be noted that the VR only group had slightly higher gains than the group with a traditional leisure education experience. Interesting, results from the STAI, while not statistically significant, indicate that the control group and the traditional leisure education group had lower post-anxiety scores while the subjects with virtual reality had higher post-anxiety scores.

Salivary Cortisol

A comparison of cortisol changes among the four groups, 1.Control, 2.VR Only, 3.Leisure Ed Only, and 4.VR plus Leisure, reveals a physiologically significant difference between baseline and site values in only two of the groups. There were decreases of 0.079 ug/dl in the Control group and 0.021 ug/dl in the VR Only group. This would indicate a decrease in anxiety in the VR Only. This was verified by an examination of the corresponding heart rates, which, in this group showed a decrease of 4 beats/min from baseline values. All other group's heart rates increased (Control increased 8 bts/min, Leisure Ed Only increased 5 bts/min, and VR plus Leisure Ed increased 9 bts/min)

Discussion

Future research may attempt to recruit subjects with mobility impairments from rehabilitation hospitals that are involved in active rehabilitation. This population may include persons with more recent disabilities, and these persons may exhibit greater anxiety when utilizing community-based facilities. Additionally, this population may be in greater need for the education due to the "newness" or severity of their injuries.

More analysis needs to be performed on the HR data since it is suspected that physical exertion at the site may have resulted in increased heart rate. A second physiological measure, such as salivary cortisol testing used at the Pepsi Center site, may be useful in measuring neuroendocrine responses to anxiety in a natural environment.

Finally, the production technology used for the virtual reality experience was only partially immersive since it relied on Hypertext Markup Language (HTML), Apple QuickTime VR panorama, modeling, and movies, and Macromedia Flash and Shockwave. Newer, more immersive and interactive technologies may be more effective in reducing anxiety. The use of these technologies needs to be explored in field-based settings. In addition, the virtual reality experiences need to be more "user friendly" and easier to use for persons without extensive technological experience.

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