

Community access through technology project: using virtual reality technologies for community integration

J Kaufman Broida, C Germann, S Houck and J M Broida

Metropolitan State College of Denver,
P.O. Box 173362, Campus Box 25, Denver, Colorado 80217, USA

ABSTRACT

The Community Access Through Technology project uses virtual reality and other advanced technologies to produce simulations of community resources. The virtual environment is created using Quick Time Virtual Reality, and access annotations, interactive maps, and digital video are added to enhance the experience of the user. To determine the efficacy of the virtual reality in reducing anxiety, the present study was conducted. Subjects were randomly assigned to one of three groups: control group, virtual reality treatment group, or leisure education-virtual reality treatment group. Results suggest that the virtual tour increased subjects recreation knowledge but had a negative effect on anxiety levels. However, subjects in the leisure education-virtual reality treatment group experienced significant recreation information gain and reduced anxiety. Further research examining more immersive virtual environments and use of additional physiological measures are recommended.

1. OVERVIEW TO THE PROJECT

The Community Access Through Technology (CATT) project uses virtual reality and other advanced technologies to produce simulations of community leisure resources so that persons with mobility impairments may become familiar with these resources prior to visiting them in person. CATT involves:

- developing three leisure facilities, including the 20th Street Recreation Center reported in this study, into virtual reality scenarios which incorporate multimedia components and access annotations,
- conducting usability testing of each scenario,
- researching the effectiveness of the virtual reality in minimizing anxiety, and
- disseminating information to assist in continuation and replication of project goals.

2. TECHNOLOGY USE AND DEVELOPMENTS

Several virtual reality technologies were considered for the project, including Virtual Reality Modeling Language (VRML) and panorama imaging software. Ultimately, QuickTime Virtual Reality, a panorama system, was chosen for the following reasons:

- use of photo-realistic scenes
- speed of production
- ease of learning by production staff
- ease of use by end users
- good integration with a Web-based environment

A Panoscan panorama camera system was used to quickly and easily capture the virtual reality environments. Digital video was also shot to better illustrate certain scenes that might prove particularly difficult or stressful to individuals with mobility impairments (e.g., entering the community recreation center's swimming pool using a hydraulic lift, adapting a rowing machine for use by a person in a wheelchair). The video was compressed using QuickTime and integrated into the VR scenario. Other multimedia techniques were used to provide text annotation of scenes, interactive maps of the facilities, voice-over and open-captioning of video, and other information pertinent to community-based access.

3. EFFICACY STUDY

3.1 Introduction

Research into the efficacy of virtual reality technology was conducted. This study is based on the premise that visiting new environments can be anxiety-producing, especially for individuals with disabilities that might not have knowledge about access-related issues. Therefore, the CATT project investigated if the use of a virtual tour prior to visitation of a new site would alleviate anxiety in subjects with mobility impairments. Further, it sought to determine if a facilitated virtual tour experience, one in which a therapist lead the subject through the virtual scenario, would be effective in reducing anxiety. Recreation information gain was also assessed.

3.2 Methods

3.2.1 Subjects. Thirty-six 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 prior participation at the 20th Street Recreation Center, no cognitive deficits, and having a physical disability that impaired mobility. Subjects were randomly assigned to one of three groups: control group, virtual reality treatment group (VR), or the leisure education-virtual reality treatment group (LE-VR). Thirty-four subjects, 21 males and 13 females, with a mean age of 47.5 years (range = 23 to 84 years) completed the study. Disabilities of the subjects were varied and included persons with spina bifida, paraplegia, quadriplegia, cerebral palsy, brain injury, and multiple sclerosis.

3.2.2 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 et al, 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 (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 Electro Oy, Kempele, Finland). Each subject had his or her HR measured to establish (A) a baseline and again while touring (B) the 20th Street Recreation 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

While touring the 20th Street Recreation Center, the heart rate monitor was used to ascertain physiological changes due to environmental anxiety. Subjects completed 11 assigned tasks while touring the Center. The subject pressed an event marker on the HR wrist receiver while also identifying the task by talking into a voice-activated cassette recorder. This enabled the identification of a specific heart rate during a specific time interval.

Recreation Information Questionnaire (RIQ): A 12-item Recreation Information Questionnaire (RIQ) was developed 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.

3.2.3 Experimental Design. 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.

3.3 Results

The premise that anxiety may be increased for individuals with disabilities who visit new environments was supported by the VAS and HR data. The STAI showed a difference in means, but it was not statistically significant. The instruments were administered to subjects in a control group before and after independently touring the 20th Street Recreation Center (Table 1).

Table 1. Means for Control Group (n=13)

	Pre-Site Visitation	Post-Site Visitation
VAS p<.05	2.25	3.66
HR p<.05	87.92	94.23
STAI	33.63	33.83

The second premise, that use of a virtual tour 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 (Table 2). 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.

Table 2. Means for VR Only Treatment Group (n=10)

	Pre-Site Visitation	Post-Site Visitation
VAS	2.5	5.1
HR	77.5	90.77
STAI	32.66	38.1

The third premise, that a facilitated virtual reality tour administered prior to visiting the 20th Street Recreation Center would reduce anxiety, was supported by data from the STAI (Table 3).

Table 3. Means for Leisure Education-Virtual Reality Treatment Group (n=11)

	Pre-Site Visitation	Post-Site Visitation
VAS	2.3	2.7
HR	86.18	91.77
STAI	38.09	32.36
p=<.10		

Additionally, the RIQ was administered to all subjects before and after site visitation. The RIQ was used to determine knowledge of recreation and related resources. Data indicate increased recreation knowledge by all groups. However, the greatest increase is evident in the LE-VR group, with the VR only treatment group also showing significant gains (Table 4).

Table 4. Means for Recreation Information for All Groups

	Control Grp	VR Only Grp	LE-VR Grp
Pre-Site Visitation	2.39	1.1	1.91
Post-Site Visitation	4.38	5.1	7.55
	p=<.05	p=<.05	p=<.05

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. Future data analysis will focus on relationships, if any, between the subjects' technical sophistication and anxiety on-site before and after VR treatment.

3.4 Discussion

Preliminary analyses of data suggest that (a) anxiety may increase in individuals with disabilities who visit new environments, (b) use of an unassisted virtual reality tour does not result in reduced anxiety, but does increase information gain, and (c) a facilitated virtual tour prior to site visitation does reduce anxiety and provide significant information gain. Additional data analyses will be performed to confirm these preliminary results, and qualitative research (e.g., interviews) will be undertaken to provide additional insight. Of particular interest, though, are the results from the Technology Questionnaire which suggest that technology sophistication played a role in the anxiety scores of the VR only subjects.

3.4.1 Problems and Limitations. The population measured may not be completely representative of the general population of persons with mobility impairments. Many subjects responded to newspaper advertisements, and thus may be more independent and exhibit more risk-taking behaviors than the larger population. This factor suggests that the study subjects may exhibit less anxiety than the larger population when visiting new and remote sites.

3.4.2 *Future Research.* 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, more analysis needs to be performed on the HR data since it is suspected that physical exertion at the site may result in increased heart rate in addition to anxiety. A second physiological measure, such as salivary cortisol, may be useful in measuring neuroendocrine responses to anxiety in a natural environment (Bandelow et al, 1997).

Finally, the production technology used for the virtual reality experience was only marginally immersive since it relied on Hypertext Markup Language (HTML) and Virtual Reality Modeling Language (VRML). 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.

Acknowledgements. Partial funding for this project has been provided through the U.S. Department of Education, Rehabilitation Services Administration, Award H128J990038-00

4. REFERENCES

- B Bandelow, D Wedekind, D Hüther, A Broocks, G Hajak, J Pilz and E Rüter (1997, June), Salivary cortisol in panic disorder [On-line]. Available: <http://www.gwdg.de/~bbandel/gjp-poster-bandelow-salivary.htm>.
- O K Buros (Ed.) (1978), *The eighth mental measurements yearbook*, Gryphon Press, Hyde Park, New Jersey.
- S C Erhmann and R E Zúñiga (1997), *The Flashlight™ evaluation handbook*, The American Association for Higher Education, Washington, D.C.
- J E McCall, C G Fischer, G Warden, R Kopcha, S Lloyd, J Young and B Schomaker (1999), Lorazepam given the night before surgery reduces preoperative anxiety in children undergoing reconstructive burn surgery, *Journal of Burn Care and Rehabilitation*, **March/April**, pp. 151-154.
- Polar Interface Plus User's Manual* (1999), Polar Electro Oy, Kempele, Finland.
- C D Spielberger (1983), *Manual for the State-Trait Anxiety Inventory*, Consulting Psychologists Press, Inc., Palo Alto, California.
- C A Peterson and N J Stumbo (2000), *Therapeutic recreation program design: Principles and procedures*, Allyn and Bacon, Boston, Massachusetts.
- J Vogelsang (1988), The visual analog scale: An accurate and sensitive method for self-reporting preoperative anxiety, *Journal of Post Anesthesia Nursing*, **3**, pp. 235-239.