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USING VIRTUAL REALITY TO TEACH DISABILITY AWARENESS*

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ABSTRACT

A desktop virtual reality (VR) program was designed and evaluated to teach children about the accessibility and attitudinal barriers encountered by their peers with mobility impairments. Within this software, children sitting in a virtual wheelchair experience obstacles such as stairs, narrow doors, objects too high to reach, and attitudinal barriers such as inappropriate comments. Using a collaborative research methodology, 15 youth with mobility impairments assisted in developing and beta-testing the software. The effectiveness of the program was then evaluated with 60 children in Grades 4-6 using a controlled pretest/posttest design. The results indicated that the program was effective for increasing children's knowledge of accessibility barriers. Attitudes, grade level, familiarity with individuals with a disability, and gender were also investigated.

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Inclusive education of children with disabilities in public education institutions is now common in developed countries. In Canada, this means that 373,824 children with special needs between the ages of 5-14 years, attend regular classes [1]. Inclusive education is considered by most as a positive experience for both children with and without disabilities, and an important social policy toward ensuring full participation and accessibility for individuals with disabilities [2]. Theoretically, inclusive education allows children with disabilities the opportunity for "free and appropriate public education" as determined by the Education of the Handicapped Act (EHA) in the United States in 1975.

However, in reality, children with disabilities often have to contend with structural, physical, and attitudinal barriers for the 30 hours per week they spend at school. Examples of structural barriers include steep ramps, uncut sidewalk curbs, heavy doors, and one-inch thresholds [3, 4]. Stairs, narrow bathrooms, revolving doors, and turnstiles have also been reported as impediments which limit access and inclusion for individuals who use wheelchairs [5]. In addition to structural barriers, children with disabilities have to manage the physical limitations inherent to their disability. For example, a child with spina bifida may have to contend with poor upper extremity function (limiting fine motor skills such as writing), poor hand-eye coordination, potential neurological deficits, and difficulties with organizational skills [6].

Perhaps the most difficult type of barrier encountered by children with disabilities is negative attitudes expressed by their peers [7]. Attitudinal barriers experienced in educational integration such as rejection and stereotyping [8, 9] or covert and overt bullying [10] can further isolate children with a disability, and impact on their feelings of social acceptance and self-esteem. Social isolation has been linked to difficulty with future peer relations [4] and lower academic and cognitive development [11].

In order to increase social awareness, understanding, and acceptance toward children with disabilities by their non-disabled peers, disability awareness programs have been developed. Current methods of disability awareness programs for school children include: 1) simulating a disability (e.g., sitting in a wheelchair or wearing a blindfold); 2) providing information about disabilities; 3) live and video presentations/testimonials by individuals with disabilities; 4) pairing disabled and non-disabled children together in a buddy system; 5) group discussions about disability; and, 6) a combination of the above methods [7]. Along with disability awareness, Roberts and Smith [12] recommend providing children without a disability with knowledge and practical skills that assist with social interactions with their disabled peers. Logic dictates that one of the most effective ways to impart knowledge about the realities for children with disabilities is to try to simulate the experience of the disability. In other words, to provide an opportunity where the child without a disability literally experiences different situations, viewpoints, perceptions, and interactions from the perspective of a child with a disability.

Simulation has been the cornerstone of virtual reality (VR), and in fact, the first uses of VR involved the simulation of military experiences as noted by Kozak, Hancock, Arthur, and Chrysler [13]. VR is defined as a three-dimensional, participatory, computer-based simulation which occurs in real time and is often multi-sensory [14]. In other words, VR responds to the user's actions, has real-time 3-D graphics and provides a sense of immersion. There are many advantages to using VR for simulation. For example, VR provides a safe environment for practicing a skill, such as learning to cross street intersections [15-17]. Simulations using VR may also be less costly than real-world simulations [18] and provide the user the opportunity for repetitive practice [19, 20]. Experiences which are not available in the real world can be simulated in a virtual environment, such as moving through a cellular structure or visiting historical sites that are presently non-existent or too far away to be accessible. Past experience has shown us that children using VR find it very interesting and stimulating, thus motivating the training experience [21]. Finally, desktop VR can provide a simulation which can be made widely accessible through dissemination via the Internet.

The purpose of this project was to develop and evaluate a desktop VR program designed to teach children about the accessibility and attitudinal barriers faced by children with mobility impairments. Desktop VR utilizes a personal computer, where the virtual environment is displayed on a conventional computer monitor and movement within the environment is effected through either a mouse, keyboard, or joystick. Although less immersive than systems which use head mounted display units, desktop VR systems have the advantages of being less expensive, more portable, and easier to use. The developed program, entitled *Barriers: The Awareness Challenge,* used desktop VR to simulate the experiences of a child in a wheelchair, in an environment familiar to most children—an elementary school. The specific objectives of this project were to examine the effectiveness of using a disability simulation with virtual reality to: 1) increase children's knowledge of accessibility and attitudinal barriers that impact individuals with disabilities; and 2) promote more positive attitudes toward children with disabilities.

METHOD

There were four phases to The Barriers Project. The first was to utilize a collaborative research methodology, where youth with mobility impairments (our Disability Awareness Consultants) identified the barriers which would comprise the content of the software. The second phase was to develop the software, which involved organizing the barriers into a script or storyboard, building the virtual environment and then beta-testing it with our consultants. The third phase of the project involved evaluating the software to examine the impact of the program on youth without disabilities. The final phase involved disseminating information about the program and providing free access to the software via the Internet.

Collaborative Software Development

In order to ensure that the software reflected the current status of accessibility and inclusion within an elementary school setting, a collaborative research methodology was used. Fifteen Disability Awareness Consultants assisted in the content development and testing of the software. The consultants (aged 9-16 years) attended eight different schools on a full-time basis and had either cerebral palsy (n = 11) or spina bifida (n = 5). Their mobility impairments ranged from difficulty walking (on uneven surfaces and/or for long periods of time) to constant use of an electric wheelchair for independent mobility. The barriers to full inclusion in their schools and the proposed solutions to these barriers were identified by these consultants during three focus group meetings. The final list of barriers and proposed solutions were then prioritized by the focus group participants, where each person was given seven stickers and was asked to place one or more of the stickers on the barrier(s) they felt were necessary to include in the software. The barriers with the greatest number of stickers became the basis for the script or storyboard of the software program. Using this script, a virtual elementary school was developed which includes the exterior of a school, an outside playground, hallways, a classroom, a library, and two washrooms (one inaccessible). The children using the program are told that they are to travel in a "virtual wheelchair" and seek out all of the "building" and "bad attitude" barriers in the school. There are 24 barriers in the program, which include building barriers such as narrow hallways, crowded classrooms, a ramp that is too steep, a locker hook which is too high, and inaccessible bathroom fixtures. The attitudinal barriers include comments from virtual students such as: "Hey, look at the kid in the wheelchair" or "Ha! Ha! You can't play here."

The program presents a gaming style interface with a first person point of view during navigation through the world. The user moves within the virtual school using the cursor keys, and can activate events such as opening doors or using the elevator by pressing the left button of the mouse. Two message areas are used: a task message area and an information message area. The task messages instructs the child to complete specific tasks such as performing an action or going to a specific location. The information message center gives feedback to the child when barriers are identified. A "wheelchair damage" display is used to encourage children to be careful as they navigate through the world and is activated when they bump into walls, objects, or people. As each barrier is correctly identified, the score is updated. A number of icons (such as a coat, key, and book) are also displayed. The icons are added and removed as the student completes specific tasks. At the end of the program, a results section is displayed listing all of the barriers and each one is labeled as to whether it was found or not during the program.

The program was developed in VRML 2.0 (Virtual Reality Modeling Language) using CosmoWorlds. The CosmoPlayer 2.1 plug-in (for Netscape

Navigator and Microsoft Internet Explorer) was used as the 3D viewer. The virtual school that was developed used the scripting capabilities of VRML to control interactions with the virtual objects and people in the school. Fields, events, proximity nodes, and collision sensors are used extensively throughout the virtual world. Each barrier, whether it is structural or attitudinal, is activated by a proximity node. A number of fields are used to record the state of the world in relation to the location of the wheelchair and the interactions that have taken place. The child identifies a structural barrier by moving close to the barrier and clicking on the "Barrier" button that floats just in front of the virtual wheelchair. For example, when first entering the world, the user is placed in the parking lot facing the school (Figure 1).

A proximity node surrounds the front steps that lead up to the school. A number of fields indicate where the wheelchair is and which barriers have been found. For the front steps, the "atSidewalkSteps" field is initially "false" and the "SidewalkStepsIDed" field (which records whether the steps have been identified as a barrier or not) is set to "false." If the "Barrier" button is clicked when the wheelchair is not at any of the barriers, an audio clip is played that indicates an incorrect choice. When the child navigates closer to the steps, the virtual wheelchair collides with the proximity node that surrounds the steps. This collision triggers an event that sets the "atSidewalkSteps" field to "true." Now if the "Barrier" button is clicked, a number of events occur: 1) the number of correct barriers found is incremented; 2) an appropriate message is displayed in the

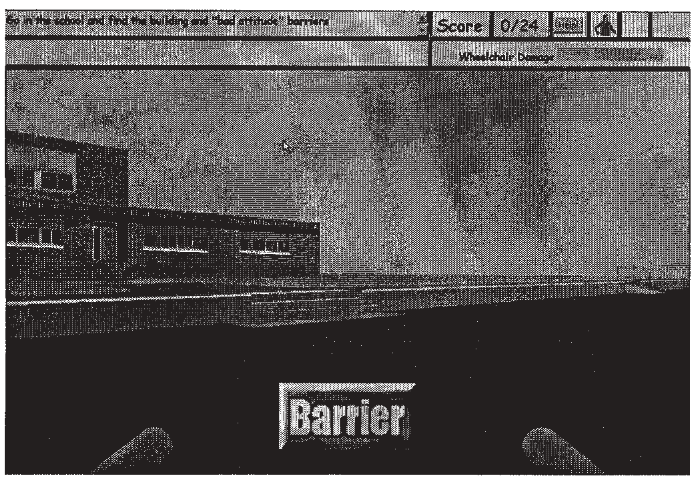

Figure 1. When first entering the world, the user is placed in the parking lot facing the school.

information message area (in this case, it informs the child that wheelchairs cannot go up stairs); 3) the "SidewalkStepsIDed" field is set to "true" which is used in the results section to indicate which barriers were found and which were not found; 4) the proximity sensor is permanently disabled; and 5) an HTML page that corresponds to the current running total of the number of barriers found is loaded in the score frame. If the child navigates out of the proximity node without identifying the barrier, the value of the "atSidewalkSteps" field is toggled back to "false."

Attitudinal barriers are identified by clicking on the "Barrier" button after hearing an audio "bad attitude" comment. The script works in a manner similar to the structural barriers, except that an audio node is triggered when a collision with the corresponding proximity node occurs. For example, when the child enters the classroom a collision with a proximity node that is located just inside the door is triggered. This event triggers a sound node to play an audio clip "It's the kid in the wheelchair" (said in a nasty, sarcastic tone indicating "a bad attitude"). While the wheelchair remains in the proximity node, the child can identify the attitudinal barrier (Figure 2). However, if the child moves further into the classroom, they will leave the proximity node and will be unable to identify the barrier unless they move back in (which will re-trigger the playing of the audio clip).

There are three distinct areas of the virtual world: outside the school, inside the school, and the results section. The transition between the areas is accomplished by using a touch sensor to trigger an event that uses a switch node to change to the

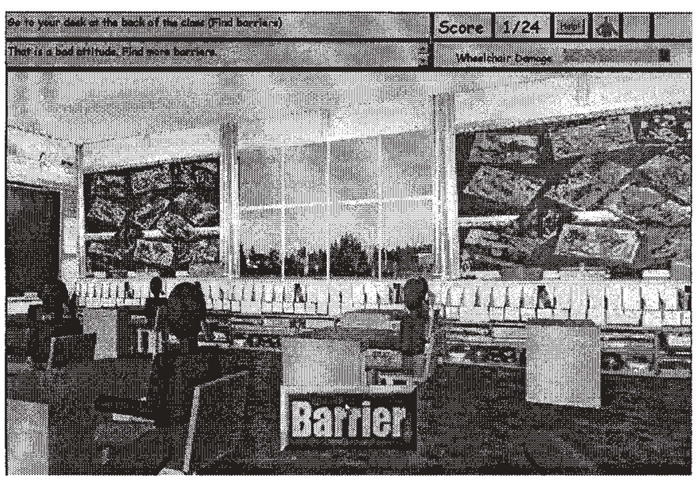

Figure 2. While the wheelchair remains in the proximity node, the child can identify the attitudinal barrier.

next "level." The touch sensor for the transition from the outside to the inside is the automatic door opener and the one that triggers the loading of the results is on the computer in the library. Once you have left an area, you cannot go back. The switch node is used so that the entire program can be implemented in a single VRML file that interacts with the HTML frames in which the world is loaded. The single file was necessary so that the running score for the entire world could be maintained without the need for applications, CGIs, or servlets running on a server. This permits schools and other users with slow Internet connections to download the entire set of files once and then run them locally on their machine whenever they wish. Six of the Disability Awareness Consultants returned to the Rehabilitation Sciences Virtual Reality Lab at the University of Ottawa to beta-test the program for content validity and general usability. Modifications to the software were made based on their feedback.

Evaluation of the Software

Study Design

In order to evaluate the effectiveness of The Barriers software, a controlled pretest/posttest design was used. Using random assignment, half of the sample was given the VR intervention, and the other half received an alternate desktop VR program, similar in length and based in a school setting, but without disability awareness information, in order to control for computer practice effects. The control program entitled "Wheels," developed by R. J. Cooper & Associates, is an excellent desktop VR program designed to teach children how to use electric wheelchairs. Hence, the viewpoint of the control program is also from the first person perspective at wheelchair height. As well, the control program also simulates wheelchair usage such as orientating oneself properly to enter doorways. The main difference between the two virtual environments is the presence of barriers (physical and attitudinal) in the intervention program. The hypotheses were that children receiving the Barriers Program would, at posttest, have: 1) a greater knowledge of barriers than the control group; and 2) more positive attitudes toward peers with a disability compared to the control group.

Participants

Sixty youth (aged 9-11 years) participated in the study. All were from a local urban school and attended either Grade 4 ($n = 20$), Grade 5 ($n = 19$), or Grade 6 ($n = 21$). There were 24 males and 36 females in the sample. Half of the sample ($n = 30$) received the Barriers intervention, and the other half received the control program. Both programs took one-half hour to complete. Each child was tested individually and completed the program one time.

Measures

Two questionnaires were administered to the entire sample one week before and one week after the VR intervention. The Knowledge Questionnaire consisted of simply asking all of the children to write out as many "building" and "people" barriers that they could think of that might impact on children who use wheelchairs or crutches at school. Barriers were defined as "things which stop a person from doing what everybody else can do, or cause people to be treated differently because of a disability." The building barrier example that was given was "smooth elevator buttons for people who are blind," and the people barrier example given was "someone who has a 'bad attitude' toward those who are different." Although this questionnaire was not a standardized measure, it was a simple, effective method for determining the youth's current knowledge of accessibility and attitudes within a school setting. For each accurate statement, the youth received one point.

The attitude measure used was the Children's Social Distance from Handicapped Persons Scale, a scale developed specifically for school settings, which has shown to be a quick, reliable measure of affective attitudes toward peers with a disability (r = .78) [22]. Concern over the word "handicapped" was allayed through conversations with experts in attitude measurement who indicated that the word "handicapped" is better understood by children than the word "disabled" (Hazzard; Rosenbaum, personal communications, 1999). An example item of this measure is, "It would be okay if a handicapped kid sat next to me in class," to which the child could respond with "yes," "maybe yes," "maybe no," or "no." Scores on this scale range from 0-30, with higher scores indicating more positive affective attitudes. The children were also asked to indicate whether they knew someone who was handicapped, to indicate what that handicap was, whether the person was a friend, an acquaintance or a family member, and finally, how much they liked this person.

RESULTS

Knowledge

The self-report Knowledge Scale was used to ascertain knowledge of both building or structural barriers and people or attitude barriers for both groups using ANOVA's (group membership × time). Overall knowledge of barriers were examined by adding both the structural and attitude barriers together. Table 1 describes the building and attitudinal barriers for both groups before and after the intervention.

These results indicate that prior to the VR intervention, both the control group and the intervention group reported similar levels of knowledge within their school setting, however, following the intervention, the youth in the Barriers group

Table 1. Mean (Std) Knowledge Scores Before and After VR Intervention

Group	Time: Before	Time: After
Barriers		
Building	2.9 (1.9)	6.4 (3.9)
Attitude	2.2 (1.8)	3.2 (2.6)
Total	5.2 (3.3)	9.6 (6.0)
Control		
Building	2.5 (1.7)	3.4 (2.6)
Attitude	2.5 (1.4)	2.9 (2.1)
Total	5.0 (2.7)	6.4 (4.2)

reported a significantly greater number of barriers than the control group, $F(1,57) = 5.35$, $p < .05$. When broken down by type (building or attitude barriers), there was a significant difference in post-reported barriers between the two groups for the building barriers, $F(1,56) = 11.27$, $p = .001$, with the Barriers group reporting more barriers.

There were no differences between groups for knowledge of attitudinal barriers, which was not unexpected since only four of the 24 barriers in the program were "bad attitude" barriers. Gender was also not a significant factor for knowledge of barriers. There was a significant difference for children receiving the Barriers intervention by grade level on the total barriers reported following the VR intervention, $F(2,57) = 3.26$, $p < .05$, with Grades 5 and 6 showing the greatest learning curve (see Figure 3).

Attitude and Previous Experience

No differences were found between the two groups or within groups for affective attitude measured with the Children's Social Distance from Handicapped Persons Scale [22]. However, there was a significant difference between males and females on the post attitude scale, $F(1,57) = 4.68$, $p < .05$, with males reporting higher affective attitudes than females. Previous experience of knowing someone with a disability has been shown to impact on attitude scores. In this study, neither knowledge nor attitude scores showed differences for children who: 1) knew someone with a disability; 2) the type of disability of that person; 3) whether that person was a friend, an acquaintance or a family member; or, 4) how much they liked that person. Interestingly, 54 of the 60 children reported they knew someone with a disability.

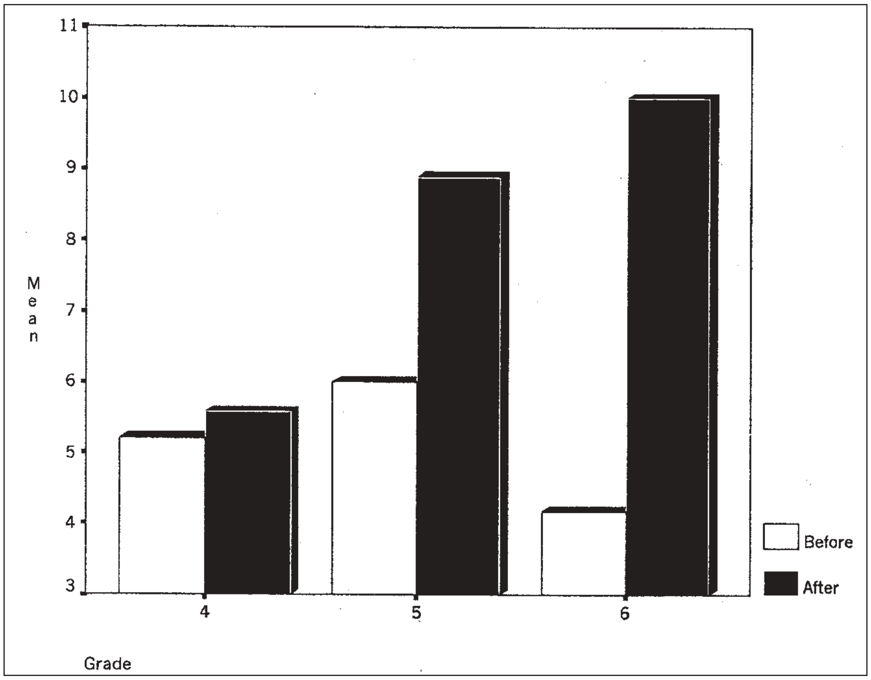

Figure 3. Pre- and post-knowledge of barriers by grade for intervention group.

0DISCUSSION

Based on the results of this study, *Barriers: The Awareness Challenge* software was effective for increasing the knowledge of barriers within a familiar setting for children in Grades 4, 5, and 6. Building barriers were remembered most often, with Grades 5 and 6 showing the greatest change. It is unclear whether the older children remembered more of the program at the posttest or whether their greater change scores reflected previous findings that older children are more knowledgeable about disabilities [22] and are more accepting of their peers with a disability [23]. Regardless, sensitizing individuals to the difficulties associated with accessibility in public buildings remains an important component to disability awareness promotion. Rowley-Kelly provides an excellent checklist of potential accessibility barriers that school administrators can use to evaluate their structural resources for all different types of disabilities [24]. Examples include the need for wider aisles for access by people who use wheelchairs, tactile markings for individuals with visual impairments, flashing lights for fire alarms for individuals who are hearing impaired, and pictorial signage for those who have difficulty reading.

Although it has been 25 years since the precedent setting Education of Handicapped Act, our children's schools are still riddled with accessibility barriers that serve to further isolate them from full participation and inclusion. More resources need to be allocated to improve accessibility in schools and attention paid to making adjustments to existing provisions [25, 26]. Another recommendation for school resource allocation that arose from the focus groups with our Disability Awareness Consultants was the necessity for ensuring that teachers and support staff have disability awareness training. This suggestion has been reinforced in the literature, and specifically recommends that teachers be provided with training, sufficient materials and on-site assistance [27, 28].

The lack of differences in attitude scores between the control and experimental groups was in all likelihood a function of the very high attitude scores of all the students participating in the study. On both the pretest and posttest scores, both groups had attitude scores just under 90 percent, thus, either the measure was not sensitive enough and/or a ceiling effect occurred. Other factors which have been shown to impact on the effectiveness of disability awareness programs include gender, where females report more positive attitudes, and familiarity, where knowing someone with a disability positively influences knowledge of and attitudes toward persons with disabilities [29]. In our study, gender did not differentiate the two groups on knowledge of barriers or attitude before the VR intervention, however, males did report a significantly higher posttest attitude score. This result is inconsistent with the literature [30, 31]. One possible explanation is that males were more familiar with the interactive gaming aspect of the VR program, as indicated by their higher game scores during the program ($M = 16.5$, $S.D. = 4.56$) vs. females ($M = 14.39$, $S.D. = 3.57$). This gaming familiarity may have allowed the males to focus on the educational material being presented vs. manoeuverability and orientation.

Regarding familiarity with disability issues, the high attitude scores were most likely influenced by the great number of children in the study who knew someone with a disability [29], in this case, 90 percent of the total sample. As such, knowledge and attitude scores showed no differences for children who knew someone with a disability, the type of disability of that person, whether that person was a friend, acquaintance or family member, or how much they liked them. However, in evaluating the effectiveness of the software, even though most of the study sample knew someone with a disability, and, as a group had very positive attitudes, they were still able to learn about accessibility barriers. This is important since increased knowledge about disabilities is believed to be necessary for creating a lasting influence on positive attitudes [32].

The authors realize that no simulation program will ever be able to truly describe the experiences and perceptions associated with having a disability. The concern expressed by French is that simulation programs trivialize the cumulative social and psychological effects of a disability, and that they do not address the environmental and social barriers associated with a disability [33]. On the other hand, a lack of knowledge and understanding about issues related to disability has been shown to lead to discrimination and isolation in schools [8, 24]. The Barriers Project was designed with these concerns and issues in mind. The collaboration of youth with disabilities in the design of the program provided assurances of content validity, as well as support for the concept of using VR to impart knowledge to their peers. As well, the focus of the program is not based on simulating a sense of the physical limitations associated with a disability, but rather on the environmental and social barriers encountered by persons with a disability. Utilizing the social-political model of disability, the Barriers Project revolved around the impact of the environment (both physical and social) on the experiences of a person using a wheelchair [2]. Every effort was made to accurately design a program that simulates maneuverability in a wheelchair in order to highlight structural barriers such as narrow aisles, doorways, washroom stalls, and crowded classrooms. Although this provided a sense of frustration for the children tested on the program, it served to provide a sense of environmental constraints as well as to highlight the capabilities of their peers who use a wheelchair.

The program also attempted to provide facilitated learning by using a problem-solving approach. In designing an environment which required active exploration for solutions, we anticipated that the children would remember more barriers; a recommendation suggested by previous researchers [34-36]. However, during the beta-testing phase, when the entire VR school was open to exploration, we found that the children missed many areas important to the learning objective. It appeared that in providing a totally unstructured environment, the children focused on exploration vs. barrier identification. Thus, the program was modified to be semi-structured (i.e., where the children were directed to different areas, such as the library, where they could search and identify the barriers specific to that location). Overall, this was found to be an effective strategy based on the results and the anecdotal comments reported by the students testing the program. The anecdotal comments included that: 1) it gave them a better understanding of the accessibility barriers that are all around them which they had not previously noticed; 2) "bad attitudes" are just as difficult, if not more difficult than building barriers; 3) the VR program was good at simulating maneuverability in a wheelchair and could be extremely frustrating at times; 4) they had a new appreciation of the capabilities of people who use wheelchairs, and 5) the program was very motivating and that they were interested in trying it again.

Limitations and Recommendations

The most obvious limitation of this study is the lack of effect of attitudinal change. This was probably due to positive attitudes of the students toward peers with a disability before the intervention as well as the relatively few attitudinal barriers in the program. The school that agreed to be in the study is one of eight schools out of 128 that is identified as "accessible" in the school board. From a structural point of view however, the school had all of the accessibility barriers that were identified in the program. As part of the "accessible distinction," it is likely that there is a greater incidence of children with disabilities in this school (however, there were no children in the three classes tested who used wheelchairs or crutches) and thus, greater disability awareness. For future studies, we would recommend controlling for place effects by testing the program in settings with and without previous awareness and sensitivity training.

Another likely influence that impacted on attitudinal scores was the small percentage of attitudinal barriers presented in the program (four of twenty-four). Poor attitudes were depicted as nasty or sarcastic comments by virtual students. The use of these students or avatars in the program use up a considerable amount of memory which in turn slows down the program. For ease of use, we decided to include as few avatars as possible. However, as both the hardware and software capabilities improve in the future, more avatars can be used to depict attitudinal barriers. The content of the attitudinal barriers also posed difficulties. Many of the statements that our Disability Awareness Consultants proposed (such as the word "crip") were not included for fear of promoting or teaching negative attitudes. For that reason, this program could serve as a jump start for discussing negative attitudes toward people who are different.

VR was chosen as a teaching medium for a number of reasons: 1) it provided first person simulation effects; 2) allowed us to control the environment (e.g., define and place barriers where we chose); 3) is accessible to many individuals if distributed over the Internet; and 4) has shown to be an enjoyable experience for children. However, since this is the first VR program which provides disability awareness, we would recommend future studies compare it to traditional forms of disability awareness training such as real world wheelchair simulation, presentations, testimonials, and videos.

As well, since this project is the first of its kind to use VR to promote disability awareness, in this case for mobility impairments, it would be interesting to develop and test the effectiveness of VR for simulating other types of disabilities. It would also be interesting to give the user the opportunity to make modifications within the virtual environment that would erase barriers. For example, the user could widen aisles or lower drinking fountains in order to make them more accessible.

Even in a school whose students had very positive attitudes about peers with disabilities, they were still able to learn about structural barriers in their environment which negatively impacts on the lives of individuals with disabilities. Hence, *Barriers: The Awareness Challenge* was considered successful in teaching about the environmental conditions faced by individuals with mobility limitations and thus was made available free of charge via the Internet at http:/www.health.uottawa.ca/vrlab. We hope that along with children utilizing the program, teachers, staff, and parents also try the software. Along with raising awareness about structural and attitudinal barriers, we hope this program will serve to initiate further discussions about disabilities, highlight how environmental constraints and attitudes impact society's views toward their members with a disability, and provide a forum that emphasizes the capabilities of individuals who have disabilities.

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