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EDITOR'S LETTER

This first issue of 2016 includes three articles regarding architecture and engineering but also have an impact on education. Architects, engineers and teachers design and build the society, environments and products of the future. The research presented in these papers will contribute improving the approach to the exercise of their profession and the way to serve the whole of society.

The first article of present volume discusses the design of data collection tools to facilitate the inclusion of blind students in school building evaluations following the principles of Universal Design (UD). The goal of the study is to enable the incorporation of people with disability in field research in Architecture and Design through the application of appropriate investigation tools. The data collection instruments developed were a tactile map to support interviews with blind children and a 3D questionnaire as tactile models.

The aim of the second study is to investigate the attitudes of architecture students towards people with a disability, comparing those who received inter-professional universal design education with those who had not.

The motivation of the third article is the observation that many activities in both educational and work environments involve teamwork and searching on the web. The study aims to understand what barriers may exist to visually impaired searchers taking part in cross-modal collaborative information seeking. And also, what approaches are employed by participants to overcome these difficulties. This study gives us the opportunity to detect the challenges and opportunities that exist in supporting visually impaired (VI) users to take an effective part in collaborative web search tasks with sighted peers.

After presenting the content of the issue, it only remains to invite you to dive into the reading of the articles to discover in detail all new knowledge produced by the researchers.

Daniel Guasch Murillo

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Editorial

Articles

Journal of Accessibility and Design for All

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TOOLS TO INCLUDE BLIND STUDENTS IN SCHOOL BUILDING PERFORMANCE ASSESSMENTS

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Abstract: This article discusses the design of data collection instruments or tools that can facilitate the inclusion of blind students in school building evaluations. Principles of Universal Design (UD) are the basis of the development of these tools. The goal of this study is to enable the inclusion of disabled persons in field research in Architecture and Design through the application of appropriate investigation tools. The data collection instruments developed were a tactile map to support interviews with blind children and a 3D questionnaire as tactile models. The study involved students from the pre-school program of a school for the blind who had not yet mastered the Braille system. The ease of understanding the test questions and the use of tools of these students was evaluated. A multidisciplinary team consisting of architects, designers, educators, and psychologists lent support to the study. The results showed that the data collection instruments adapted to blind students were successful in testing the design of the tools and the understanding by the participants of the questions asked. Assessment of school environments as experienced by blind students was made possible through these tools. An analysis of the participatory phase showed that the limitations imposed by blindness determine the specificities in the adaptation and implementation process of tools for Post Occupancy Evaluations of school buildings. Practical recommendations for future studies are presented. The study presented here is in line with the global trends to include disabled persons in society and

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base design decisions on diverse users' experience, opinions, satisfaction rates, desires and needs.

Keywords: Universal Design (UD), Data Collection Instruments, Tactile Maps, Visual Impairment.

Introduction

In 2006, the General Assembly of the United Nations adopted the Convention on the Rights of Persons with Disabilities - CRPD (United Nations, 2006). According to article seven of this convention: all parties shall take all necessary measures to ensure the full enjoyment by children with disabilities of all human rights and fundamental freedoms on an equal basis with other children. The CRPD is regarded as having empowered the world's largest minority to claim their rights and to participate in international and national affairs on an equal basis with others who have achieved specific treaty recognition and protection (Kayess & French, 2008).

Many countries have taken initiatives to promote and regulate accessibility in schools and to ensure compliance with the relevant legislation, according to the principle of 'Design for All' or Universal Design (UD). UD is about design that facilitates the use of space or objects by most people, including the elderly, children, pregnant women and people with permanent or temporary impairments. Due to its importance as a mechanism for social inclusion, school buildings must fully incorporate the principles of UD (Kowaltowski, 2011).

The concept of UD includes accessibility, which is the possibility and condition to reach, perceive and understand the use of transport, space, equipment, furniture, objects, software, information, and communication, among other things, with safety and autonomy (ABNT, 2004). Disabled persons have the right to participate in education, employment and social life. Autonomy in mobility is fundamental for human beings because through movement individuals can interact directly with their physical space.

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People with visual impairments have specific and special difficulties and needs. Blindness denotes the inability of a person to visually capture the images projected from surrounding objects. To a visually impaired person tactile perception is very important because it allows contact, knowledge of objects and reading by means of the Braille system. For orientation and mobility, hearing is another important sense for the user with visual impairment, because it allows spatial relationships to be perceived. Smell may provide clues for orientation and the location of environments such as the kitchen and gardens, for instance. Kinaesthesia is the sensitivity to perceive muscle or joint movements. This capability alerts humans to the position and movement of the body when raising an arm, for example, or when going up or down a slope, thus it is perceived without sight as well.

In this context, Wayfinding Design, is an important concept. It involves elements in a system that helps spatial orientation of users. The design of environments with Wayfinding in mind must be based on clear circulation routes with well-marked entries, exits and vertical access points. Tactile maps, models, printed maps, indication signs, the location of the information desks, among others, are important elements for Wayfinding design. For persons with visual impairments, Wayfinding systems must include special attention to physical elements, such as: layout and wall configurations, baseboards and tactile warnings. The design of handrails, ramps and the correct placement of tactile ground surface indicators must be carefully considered in design for all. Wind and sun are natural elements that may help orientation and sensorial elements such as smell from flowers and sound from water can be explored as well (Arthur & Passini, 1992; Gibson, 2009; Golledge, 1999; Meuser & Pogade, 2010; Passini, 1984).

For schools buildings Wayfinding design must be based on the analysis of special needs of children, including those with visual impairments. A participatory design process is recommended so that proposals incorporate needs and desires of users. This type of design process should have an analytical, a decision-making and a creative or propositional phase. The analytical phase involves data collection, often as Post-Occupancy Evaluations – POE of existing buildings. The development of data collection

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instruments for studies that involve the participation of children is however a challenging task. This becomes even more challenging when these participants are blind.

This article discusses the design of data collection instruments or tools for building performance assessments – BPA that include the opinions of blind students, in accordance with the principles of UD. The goal of this study is to demonstrate the importance of adapting data collection instruments for the inclusion of disabled persons in field research in Architecture and Design. The limitations imposed by blindness on users determine the specificities in the adaptation and implementation process of the tools to evaluate school buildings. The development of such instruments to allow the full participation of blind children in school building assessments is described and these are tested.

School Building Performance Assessment

Preiser and Nasar (2014) in a recent review on assessing building performance - BPA, as Post-Occupancy Evaluation - POE is denominated today, have shown that these evaluations are important for a design process to be successful in providing users with buildings that respond to their needs and desires. These authors also showed that such assessments should employ participatory methods. A renewed interest in evaluation at the intersection of the physical and the social is therefore detected in the literature and this, represents a return to the origins of POE in environmental psychology. It also reinforces that building evaluation currently strongly favours 'bottom up' approaches to evaluation, which value the opinions of the user (Preiser & Nasar, 2008). Many studies have shown that in order to assess usability, one has to focus on the effect of the building on the user organization's fulfillment of goals, as well as the end users' satisfaction and experience (Blastad, 2010; Baker, 2011; Kowaltowski et al., 2013, 2014).

For better quality school buildings Dudek (2008) recommends a greater involvement of users in the design process. Attempting user involvement is not without its own difficulties. The participation of children in the design process is however strongly recommended by many in the field of school

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architecture including the schoolyard (Curtis, 2003; Addo-Atuah, 2012). In school building assessment one of the difficulties encountered is the fact that children of varying ages should participate in the design process. Children, before they have learned to read and write, should not be excluded. To overcome some of the hurdles of user participation in a school design process, and evaluate buildings against a “criteria of quality”, Cleveland and Fischer (2014) recommend a mixed-method approach to data collection. Walkthroughs, questionnaires, interviews and focus groups are employed.

Within learning environment research, the investigation of learners' perceptions tends to rely on verbal skills of participants, and this could prioritise certain aspects. With children these verbal methods can be enhanced with story telling, gaming, mental maps and drawings that give young users the opportunity to express their preferences and desires. However, such methods need to be accompanied by a multidisciplinary team that includes educators and psychologists, and such processes will always need parent consent (Kowaltowski, 2011).

Woolner (2009) explored the pros. and cons. of participatory processes in school design. She detected enthusiasm within both education and architecture for the inclusion of students and other users of the school building in the design process. Such processes are seen as a way for architects to achieve a better understanding of the business of education and therefore supporting the design of more appropriate buildings and outdoor spaces. However, such involvement is not without difficulties, according to Woolner (2009). Within the educational context, examining previous waves of school building reveals that in the past consultation has tended to leave out certain users. Woolner (2009) recommends that, if participatory processes in school design are to aim to be genuinely inclusive, avoiding past experiences of narrow understanding, they must involve as wide a cross-section of the school community as possible. This should include teachers, support staff, technicians, administrators, cleaners, lunchtime supervisors, students of varying ages, parents and the local community. Involving such a diverse range of people produces many practical

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considerations, especially in the choice of research methods to be adopted to ensure a high quality participatory process, a process that results in school premises that offer a good fit to the needs and aspirations of the school's users.

Woolner et al. (2010) further argue that for both educationalists and social researchers visual methods are particularly appropriate for the investigation of people's experiences of the school environment. The authors have applied a range of visual methods, based on photographs and maps, to investigate the views of a diverse sample of school users. Methods which make more use of visual and spatial material are therefore seen as being able to widen participation to include all users, and are particularly appropriate for examining the contribution learning of the physical setting (Lodge, 2007; Prosser, 2007). It is vital to grapple with the issue of choices about research tools, because inevitably they affect research results, as Dewey put it in 1938: ''a tool is also a mode of language, for it says something to those that understand it: about the operations of use and their consequences'' (Woolner et al., 2010)

In her study on participatory school design processes Woolner (2009) does not include pupils with varying disabilities. How to assure an inclusive process is therefore still a challenge. Special difficulties arise when users, and particularly children, are visually impaired or blind. A further problem arises with the inclusion of blind children in a participatory design process when they have not yet mastered the Braille system. Visual methods are no longer appropriate and verbalization or articulation of preferences cannot be ascertained through normal written questionnaires. For the inclusion of such children to be made possible special tools and methods are paramount.

Methodology

A case study is described. A special education school for visual impaired pupils was chosen for the development of the assessment tools described. This school is located in São Paulo, the largest city in Brazil. The school provides primary education for around one hundred students. 15 children are

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attended in the preschool program, which was used in this case study. Various ages were represented, from 5 to 15 years, because children are grouped according to their cognitive abilities. In the final test 10 pupils were included, because 5 students had additional intellectual disabilities and were unable to participate. All students were considered totally blind but verbally competent. Although various ages were represented all participants had academic competence only at the preschool level and did no master the Braille system.

In general, the development of data collection instruments for children is a challenging task because it requires the consideration of aspects relating to cognitive abilities, the researcher's experience in addressing the issues, and the available resources. Regarding data collection instruments such as interviews and questionnaires, even defining the questions and their order can raise ethical concerns as well, because specific formulations may induce answers, distorting the final analysis results.

In addition to meeting the research policy of the school involved, this study relied on the collaboration of a multidisciplinary team of architects, designers, educators and psychologists. Unstructured observations of the students and interviews with the aforementioned team were conducted, in addition to the pre-testing of the instruments.

Three types of tools were developed for this case study: a tactile map and tactile and audible models as 3D questionnaires. A visually impaired person uses the remaining senses to gain understanding of a tactile map and model, making use of the tactile, auditory (sound) and kinaesthetic senses. According to Bernardi and Kowaltowski (2006), it is important to differentiate the terms *map* and *model*. A map is a 2D representation of something described and/or portrayed with the clarity of a conventional geographic map, and a model refers to a 3D representation of a concept or object at a reduced scale.

The application procedures adopted, or protocols, in this case study were discussed in advance with the teachers of the institution in an interview. The actual application and testing of the tools took place in a spare classroom of

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the school, located near the normal classroom block. The test was performed by one of the researchers of this study with the support of two assistants, not employed by the school, who guided students movements (assistant 1) and with documentation of observations (photographs) and verbalization results (assistant 2). The tools were tested with children individually.

Interviews with a tactile map

Participatory design processes are mostly based on an analytical phase. Users and members of the design and execution team analyse or assess the present building situation or a building of the type planned. Sanoff (2012) adopts a multi-method process for this phase in the school context. This includes interviews; annotated walkthroughs; wish poems and evaluation of images representing design choices. Yates and Smith (1989) propose interviews as a method for obtaining data on phenomena that are only slightly susceptible to direct observation or with the aim of investigating a child's perceptions or conceptions. This technique has great potential and has been employed in qualitative studies to elucidate meanings that are subjective or too complex to be investigated by closed-ended and standardised instruments (Banister, et al., 1994). Thus, interviews allow the asking of questions and provide guidance and in-depth understanding on specific issues and topics.

Walkthroughs are a type of interview and are particularly important in building performance assessments, because being in a specific place will stimulate more accurate responses to questions. However, in a participatory design process, involving users with visual impairments, the application of this method yields few analytical briefing data. Thus "walking through" a building needs special support. In this case study a tactile map (Figure 1) was introduced representing the actual school building in 2D.

Tactile maps, representing a specific reality, can enhance spatial knowledge of blind individuals, giving critical information and increasing mobility. Maps allow the identification and location of places and spaces, show directions and enable the calculation of distances. Rich and varying information

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(physical and socioeconomic) can be gained and users may make inferences through comparisons with other tactile map experiences.

The tactile map (Figure 1) used in this case study was developed to support interviews with the 10 children of the test. The main reason for introducing a tactile map was to promote interaction between students and the interviewer (applicator), substituting a walkthrough POE method.

The interview was in the form of a play-interview. Special care when interviewing children must be taken. Interview methods need to match children's developing cognitive, linguistic, social and psychological competencies (Gibson, 2012). Children often have a limited attention span and for this reason lengthy interviews should be avoided. Story telling and playing or gaming technics should be employed to ensure a child’s response to the topics of the interview. The language the interviewer uses should be appropriate to the vocabulary of the group of children being studied.

Figure 1. Tactile map as support for the play-interview with blind students.

3D questionnaire using tactile models

For building performance assessments - BPA important topics of investigation with users are: functional aspects (the ability to perform desired activities adequately), aesthetic impacts (visual impact), environmental comfort (thermal, acoustic and lighting conditions), psychological aspects (densities,

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privacy, territoriality, personal space, safety and security) and technical or very specific factors. To investigate these variables most BPA studies compare technical measurements and observations with user responses to questionnaires, including indications of satisfaction rates. For the last twenty years BPA or POE studies have used questionnaires to assess functional and technical aspect of the built environment from the user's perspective (Baird et al., 1995). The number of questions should however be limited to avoid exhausting the individual and allow research to be completed in available time.

Generally, the use of closed-ended questions is more appropriate for questionnaire design. Classification of results is made easier and the induction influence of the researcher is reduced (Sommer & Sommer, 1997). In this study, the Likert scale was adopted, being most appropriate in questionnaires on attitudes, opinions, evaluations and satisfaction levels. The number of alternatives should take into account the respondent's discriminatory capacity (Cohen, Manion, & Morrison, 2000). In this case study with children, the usual five levels of this scale was reduced, and only three alternatives were used.

The role of models is to represent an object in a smaller than full-scale format but in its proper proportions to help in the understanding of a project or building by users or observers. Blind persons can manipulate different data and information in a concrete manner in 3D, and models may provide a perception and understanding of a place or object.

A 3D questionnaire was developed in this study. The main goal of this instrument was to assess issues relating to the environmental comfort levels (thermal and acoustic) of classrooms by blind users in the school of this case study. Thus, the opinions of blind students on the comfort conditions could be registered. Teachers participated in the development of these specific 3D questionnaires and prior to application the interview procedure was discussed.

For this test case study two tactile models were developed. A tactile language was used. Special care was taken in the choice of materials and

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finishing of these models to make the tactile experience pleasant to the touch and avoid possible accidents from sharp edges. The dimensions adopted in the models took into account the anthropometric measurements of hands, the frontal reach and the distance between elbow to elbow when sitting of participants of the test (Panero & Zelnik, 1979). The type of model was inexpensive to produce and fairly easy to make, which should facilitate its replication. The application of the 3D questionnaire to the blind students occurred following the play interview with the tactile map of the school complex in the same place, individually, with the support of the same two assistants as outlined above.

The first tactile model (Figure 2) was designed to measure acoustic comfort levels. Blind students were asked about noise levels in their classrooms and indicated their answers through the specific tactile model, which emits sounds in three different noise levels as a Likert scale. The sounds were classroom noises recorded in the school itself, so that the test survey would represent the reality of the student’s daily experiences.

Figure 2. Tactile sound model designed for questionnaires in environmental comfort surveys with blind children.

This model had the following characteristics:

- Dimensions: Width: 18 cm / Length: 29 cm / Height: 0.5 cm

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- Configuration: Pressing one of the three buttons on the model emits three alternative sound levels, which were previously recorded by the research team in the classrooms of the school. At the bottom of the base a small 3D representation of a child's ear was attached. This was made from plaster to indicate that sound or acoustic conditions (hearing) are being evaluated.

- Materials: Styrofoam board coated with bond paper, three sound reproducers (called buttons), a model of a child's ear in plaster, hot glue, double-sided tape, contact paper, fine sandpaper were used.

- Construction: The Styrofoam base was covered with bond paper. The ear model was glued on the board with hot glue, and the recorders were attached with double-sided tape.

The second model, part of the 3D tactile questionnaire, measured thermal satisfaction levels (Figure 3). In this case blind students were asked about thermal conditions in their classrooms and indicated their answers through the specific tactile model, with three metal boxes that when touch gave three different temperatures sensations. Again the different thermal sensation levels represented the Likert scale satisfaction levels of typical questionnaires investigations on environmental comfort conditions.

This model had the following characteristics:

- Dimensions: Width: 18.5 cm / Length: 29.5 cm / Height: 8.5 cm

- Configuration: Touching one of the three boxes on the model three different temperatures can be felt by touch to indicate that thermal conditions are being investigated. One box is coated with insulating material, which was considered to correspond to a satisfactory or "nice" thermal room temperature condition. Another box is heated by a heating device and represents a "warm" sensation setting on a Likert scale. Finally the third box is made of stainless steel and touch would represent a "cold" temperature sensation. The three alternative thermal comfort levels are printed above the boxes for the researchers visualisation.

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Figure 3. Tactile thermal model designed for questionnaires in environmental comfort surveys with blind children.

- Materials: Cardboard box, bond paper, three stainless steel plates or boxes, insulation material, hot glue, double-sided tape, contact paper, fine sandpaper, portable infrared light device with a 110 V lamp.

- Construction: The positioning of the stainless steel boxes on the printed sheet at the top of the model and the distance between the boxes were measured to ensure that participants distinguish the three boxes. The insulating material was glued to one of the stainless steel boxes with hot glue. One of the boxes was perforated on one of the sides, because underneath an infrared light device was installed and lit when the model is in use and the box is heated to a warm temperature.

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Results

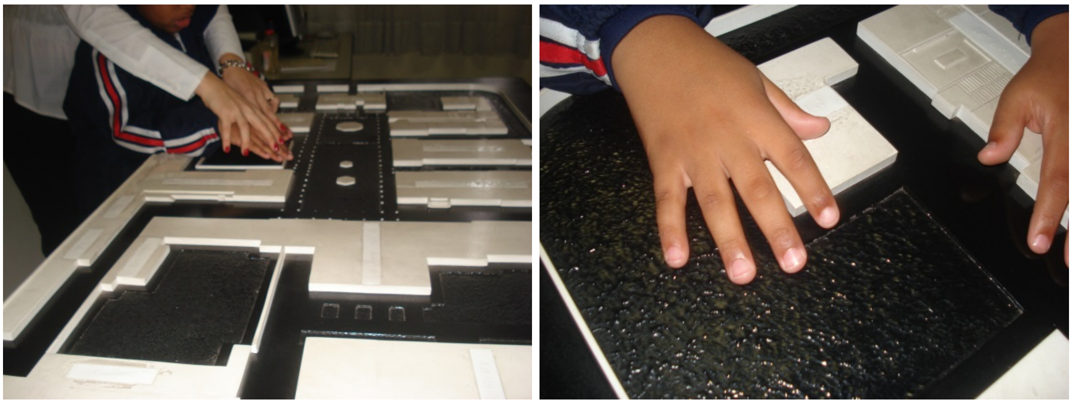
The location of the case study test, as a quiet room, favoured the play interview with the use of the tactile map and also the test of the 3D questionnaire on issues of environmental comfort aspects (acoustics and thermal). Students were able to concentrate on tasks and reflect on their responses. The two assistants were of vital important to guide students in their tactile tasks. These assistants also acted as observers, documenting the event.

Play interview with the tactile map

For this test each student was individually invited to the test room. Along the way, between the normal classroom and the test room, the assistant talked to the student, so that he or she would become familiar with the assistant's voice. The student was guided towards the front of the tactile map (Figure 4), representing the school building lay-out. An initial recognition of the map occurred so that each participant would understand the model and its purpose. While exploring, through touch, the tactile map the assistant would provide verbal descriptions of shapes that represent physical spaces of the school (Figure 4).

Figure 4. Application of the play interview with the tactile map designed for blind students (a-b).

(a) *(b)*



After this initial guided warm-up open-ended questions relating to the preferences of the school environment were asked. A pause was introduced

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after each question to permit reflection and answers as well as their recoding on the researchers questionnaire. The questions were:

- What is the place you like the most in the school?
- Why did you choose this place?
- What is the place you like the least in the school?
- Why did you choose this place?

All students answered the questions readily and without difficulty. The test lasted 15 minutes for each of the ten students. Although the 3D map was large all participants could reach the entire map with their hands. The second assistant acted as an observer and recorded the responses verbalised by the students, while the researcher asked the questions and the first assistant helped in guiding the tactile experience.

3D questionnaire tests

The 3D questionnaire application test took place in the same room shortly after the play interview. Each student was seated at a table where the tactile models were located.

First, the acoustic model was tested. The student was asked to feel the bottom of the model (Figure 5a) where the plaster model of a child's ear was located and the activity plan was explained. This was considered a warm-up phase to familiarize the participant with the model and its purpose.

The student's hands were then guided to the top of the model, where the three buttons with recorded sounds that emit different noise levels, are located (Figure 5b). The student haptically recognised the buttons and tested each one, as instructed by the assistant.

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Figure 5.3D questionnaire application using a tactile sound model designed for blind students (a-b)

(a) *(b)*

When pressed, each button reproduced the recorded sound of the students' classroom noise. After the warm-up phase the acoustic comfort question was asked:

- Which of these sounds represents the noise level in your classroom?

The student was asked to indicate, by touching one of the three buttons, the perception of the classroom noise level. The assistant recorded the response provided by the student. Most students indicated that the noise level is high in their classroom.

Next, the tactile thermal model was tested. An initial warm-up phase gave each student the opportunity to get familiar with the 3D questionnaire, in this case the three stainless steel boxes and the perception of different temperatures, through touch. During this phase the researcher explained that the exercise related to thermal comfort conditions in the normal classroom of the school. Students haptically explored the 3D questionnaire (Figure 6), first with one hand and then with both, to get a sense of comparison between the temperatures perceived. After this, a question relating to thermal comfort was asked verbally:

- How would you evaluate the temperature of your classroom?

The student then indicated one of three boxes or alternatives as his or her answer. All students, using both hands, were easily able to indicate their

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chosen alternative. The assistant recorded the response provided by the student. Most students considered their classrooms thermal conditions warm.

Figure 6. 3D questionnaire application using a tactile thermal model designed for blind students (a-b).

(a) *(b)*

Discussion and Recommendations

The tests of the data collection instruments were evaluated through observations of ease of application, length of familiarization phases, complexity of proposed tasks and the physical and mental efforts required by participant blind school children to use these. All participant students had good motor coordination and managed to perform all the tasks requested of them (answering the four questions of the simulated walk-through on the tactile map and indicating the perception of acoustic and thermal comfort conditions in their classrooms on the 3D Likert scale using tactile models). Thus the students understood the questions and were able to express their opinions adequately. The length of the exercise was considered adequate.

The tactile map was shown to be an important instrument to engage the participants in their physical environment when participating in a POE survey. The interview method was also considered adequate to promote interaction between student and interviewer (researcher).

The 3D questionnaires using the tactile models were found to be effective tools for expanding students' knowledge about an unfamiliar topic, environmental comfort conditions in the school environment. Participants

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were able to indicate their own perceptions on a three level 3D Likert scale for two important aspects of environmental comfort: acoustics and thermal sensations. Thus the aim of this study (the development of POE data collection instruments and the inclusion of visually impaired user participants) was fully achieved. Although questions on environmental comfort could be directly asked to participant pupils in a typical POE survey, the tools can allow participants to respond with autonomy in a ludic context. The tools also showed that students became interested in the experiment and asked questions on environmental comfort.

The challenge for the study was the design of instruments, which take into account the specific disability of participants and the extent to which POE data can be collected with blind children. Testing showed that the design of the instruments described is in accordance with UD principle.

Some lessons learned:

- Testing and research with children with disabilities can present stressful situations. The research team should be experienced and the support of teachers and caretakers of the school to be evaluated is important. Specific questions may arise when developing instruments and their method of application. To obtain productive answers the support of other professionals such as psychologists, speech therapist, physical therapists, and educators is imperative.

- The limitations and specificities of the disability have to be studied first. Interviews with the administration and teachers of a school should be conducted. Also researchers should conduct non-structured observations of the place and its users to familiarize themselves with the scope of a POE study. The main aspects to be investigated should be identified to focus the design of data collection instruments clearly on essential issues.

- The tests and or POE survey should be thoroughly prepared with the administration and teaching staff of a school. The scope of the study and all the instruments and their application methods must be presented. The stronger the bond of confidence between researchers

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and staff the easier the preparation and application of the instruments will be. Pre-testing is also extremely important to avoid problems during final evaluations. Pre-testing should occur in the same place as the final test.

- Preparation of tactile maps needs the support of documents belonging to the institution to be evaluated. Plans of the building are necessary, or measured drawings will have to be produced by the research team, which is a lengthy and laborious task. Time and resources must therefore be planned for far ahead.

- The scale of a tactile map is an important factor to be considered. The map cannot be too large that by touch a child will be unable to get an overview of the building and grounds. The scale cannot be too small either to prevent the user from understanding each space and important details that are part of the specific POE.

- The setup of a test and its instruments must consider the anthropometric data of the participants, in this case a large age span of children from five to fifteen ages. Children should be able to perform the haptic experience on their own, without having to be lifted to reach far corners of a tactile map. Generally, blind children feel very insecure when they are lifted. In the case of blind students who also use wheelchairs, the base supporting the instruments should allow frontal approximation of the wheelchair and be at the appropriate height of a wheelchair user's reach.

- Time is an important factor to be considered, especially with children. Their concentration span is mostly shorter and should be respected. Also, participants should not feel bored or over-taxed in taking them away from their main activities. Therefore, all details must be prepared prior to the tests to avoid time spent on installations and room and furniture layouts. Class-time should be used and not recreation or snack and lunchtime.

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- With children and especially with children with disabilities, individual tests are important to avoid distraction. A quiet environment is recommended for this reason as well.

- The support of assistants (non-school employees) as part of the research team is important. In this case two assistants were needed, one to guide each students in the right direction and place him or her in front of the instruments and one to record the observations and responses. The main researcher can then concentrate on the interview and questionnaires.

Conclusion

This study presented the development of data collection instruments to be applied with blind children in building environment assessments. Two types of tools were developed and tested. The specific results of these, such as the participants' opinions on spatial preferences and environmental comfort were only used to test the tools and their application protocols. The important result of the study is that specific tools are paramount when including the visually impaired and especially blind children in building assessment evaluations. The instruments developed in this study were specific to the evaluation of the preferences for certain spaces and for environmental comfort of those spaces. The results demonstrate that specific tools can be developed for the inclusion of blind children in POEs and the instruments can be expanded for wider UD related studies. Similar tools can also be developed for other POE variables such as: security for instance.

UD, the basis for an inclusive design, demands that the design of buildings respects and permits the participation of all potential users in the planning and design process as well as the use of the product of that process: the building, grounds and objects. For schools, children with disabilities should be part of this process. They play an important role in qualitative analytical research, enabling the introduction of improvements in proposals for the built environment and furniture and equipment design as well as stimulus for

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new ways of using space. A participatory process is also seen as an educational opportunity. In the case of school design, a specific group of users can reflect on traditional ways of doing things and propose innovations to improve the quality, not only of the built environment, but also of education in general (Kowaltowski, 2011).

The main aim of this study was to demonstrate that users with disabilities, in this case with visual impairment, can and should participate in building design processes. Also the research results showed that children from early ages of five years are able to participate in the analytical phase of a design process if appropriate tools are used with adequate methods of application. Building performance assessment is an important part of a quality architectural design process. Results from such evaluations are the basis of the briefing phase when needs are reflected upon and decisions are made on a detailed architectural programme. The inclusion of user opinions, perceptions and satisfaction rates enriches these two design process phases. For public buildings the inclusion of all types of users should be ensured. School building design is of prime importance to support teaching and learning activities and ensure a comfortable, secure and inspiring environment for pupils, teachers, staff, parents and the neighbourhood community. The school building design process therefore should also be participatory and inclusive. The extra challenge of a participatory process with children demands specific tools and protocols, as discussed here.

Although the study above showed positive results in relation to the inclusion of blind school children in BPA studies, the research also demonstrated that to introduce change in school building design with UD in mind is not an easy task and will not happen spontaneously. Efforts must be made on various fronts: attitudes, methods and protocols, instruments and tools, political and social will as well as technical developments. The contribution of this study is related to instruments and protocols of their application and serves as a stimulus to further efforts to impact positive change in school building design.

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DOES UNIVERSAL DESIGN EDUCATION IMPACT ON THE ATTITUDES OF ARCHITECTURE STUDENTS TOWARDS PEOPLE WITH DISABILITY?

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***Abstract*:** The impact of the built environment on the participation and engagement of all people in the community is now widely recognized. The principles of universal design originated from the field of industrial design and architecture, as a design foundation for more usable products and environments. The aim of this study was to investigate the attitudes of architecture students towards people with a disability, comparing those who received inter-professional universal design education with those who had not. A sample of 147 Australian undergraduate architecture students (response rate 39.7%) completed the Interaction with Disabled Persons Scale (IDP). Quantitative descriptive analysis of their scores was undertaken, along with inductive analysis (Mann-Whitney U tests and ANCOVA). Architecture students who had previously participated in inter-professional universal design education had significantly less negative attitudes on two items of the IDP – 'I wonder how I would feel if I had this disability' and 'I am grateful that I do not have such a burden. They also expressed significantly less fear towards people with a disability, as measured by that factor on the IDP. This study suggests education around universal design may promote more positive attitudes towards people with a disability for architecture students, but further research is required to gain a comprehensive understanding of this topic. This study is the first to explore the general attitudes towards disability of architecture students, and suggests that educational interventions may have a positive influence.

Keywords: universal design, attitudes, architecture, professional education.

Introduction

Disability is a universal human experience, currently experienced in some form by over one billion people or 15% of the world's population (WHO, 2013; WHO, 2014). It is widely recognised that the built environment can act as both a barrier and a facilitator to the participation of all people. (Larkin, Hitch, Watchorn & Ang, 2015). In response, architects have to consider diverse user needs when designing physical spaces within their communities.

The principles of universal design originated in the field of architecture when Ronald Mace challenged conventional design approaches and provided a design foundation for products and environments that were more usable and accessible (Burgstahler, 2012). Seven principles of universal design were established for application to product development, education, architecture and built environments (Connell et al., 1997). These were: equitable use; flexibility in use; simple and intuitive use; perceptible information; tolerance for error; low physical effort; and, sufficient size and space for approach and use. Mace's intent was not to develop a design concept exclusive to people with disability or impairment; universal design is about taking a much broader perspective that includes but is not limited to, parents with prams, older citizens and others with diverse physical, sensory, cognitive and other needs. (The Center for Universal Design, 2008).

In recent years, there has been increased uptake and application of the principles of universal design around the world. However, there remain numerous contextual constraints to its application (Larkin, Hitch, Watchorn & Ang, 2015) and public spaces and buildings continue to be created that lack inclusivity and deny people opportunities to participate in society and daily life. With an increasing demand for sensitivity to the needs of users, architects need to develop new abilities and attitudes towards design

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(Bernardi & Kowaltowski, 2010). One way of encouraging and increasing the uptake of universal design strategies, is the provision of education and training during the important and influential years of professional education (Chang, Tremblay & Dunbar, 2000; Evcil, 2012; Helvacioglu & Karamanoglu, 2012). There has been some uptake of this into architecture and design higher education curriculum in recent years (Olgunturk & Demirkan, 2009; Paulsson, 2005). However, there are only two published evaluative studies around educational interventions in architecture that focused on inclusive or universal design for people with disabilities.

A cohort of architecture students in the Middle East took part in a specially designed course in inclusive design in interior architecture (Olgunturk & Demirkan, 2009). The course provided the opportunity for information transfer through lectures and the building of skills via a series of practical assessments. Students identified weekly assignments and in-class discussion as the most useful aspect of the curriculum, and their self-rated confidence around universal design also rose significantly through the course. However, the authors report the judgement the design project found there was limited application of the universal design techniques taught in the course, so there seems to have been a gap between learning and application. A further description of innovative practice came from a university in Brazil, where the principles of universal design were introduced in an architectural course (Bernardi & Kowaltowski, 2010). The faculty chose to focus on vision impairment as so much in design is communicated visually, with educational opportunities including role play, simulation and a design project with users. The design project with users was found to be more valuable, and challenged the assumptions of both the students and their teachers about vision impairment and design. The authors therefore advocated a combination of methods in initiatives with architectural education.

A further initiative in this area was the Design 4 Diversity program at Deakin University in Australia, which focused on inter-professional education around universal design practice for architecture and occupational therapy students (Larkin et al., 2010). This initiative incorporated a range of teaching and learning activities and resources including online interactive multi-media

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resources, virtual environments, lectures, practical workshops and inter-professional seminars. All of these occurred over a single trimester and were delivered to third year occupational therapy and first year architecture students. Staff from both disciplines provided teaching and support across both groups, and outcomes from the educational and other aspects of this initiative have been reported previously (Hitch, Larkin, Watchorn & Ang, 2012; Larkin, Hitch, Watchorn, Ang & Stagnitti, 2013).

The study described in this paper formed part of the evaluation of the educational intervention aligned to Design 4 Diversity. The aim of this study was to investigate the attitudes of third, fourth and fifth year architecture students towards people with a disability. In particular, the study sought to compare and contrast the attitudes of two groups of architecture students (those who received inter-professional universal design education through Design 4 Diversity and those who did not) towards disability. The null hypothesis was that there was no statistically significant difference in attitudes to disability between these two groups.

Universal Design in the Architecture Profession

There remains limited research discussing architects' application of universal design during the design process. Identified issues relating to the application of universal design by architects include a lack of knowledge of the principles and a lack of efficient and transparent dissemination of current research and knowledge (Heylighen, 2008), lack of an assessment or evaluation tool (Preiser, 2008), lack of systematic procedures and priority recommendations (Afacan & Demirkan, 2010; Preiser, 2008) and few consumer requests (Karol, 2008).

Many authors have discussed potential solutions for the lack of knowledge and application of universal design, including promotion in the architectural press (Heylighen, Herssens & Froyen, 2009), use of universal design patterns (Froyen et al., 2009) and specialized computer software (Marshall et al., 2010). However, architects currently working in the field are unlikely to have received education regarding universal design or human capacities and

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abilities as part of their training (Heylighen, 2008). Some authors have suggested a need for its compulsory implementation into architecture and design curriculum to ensure the appropriate education and training of new graduates (Evcil, 2012; Helvacioglu & Karamanoglu, 2012). A number of others have argued for the importance of universal design implementation in design curriculum (Bernardi & Kowaltowski, 2010; Olgunturk & Demirkan, 2009; Paulsson, 2005; Watchorn, Larkin, Ang & Hitch, 2013).

Bernardi and Kowaltowski (2010) further supported this view, stating that curricula must adapt its focus in order to maintain architecture education that is relevant to current public and political debates. Olgunturk and Demirkan (2009) recommended universal design implementation as both a separate course and within design studios. Paulsson (2005) elaborated on this, suggesting a number of important aspects for inclusion in curriculum including teacher education, course and project innovation and cooperation projects with users, experts, partners and other schools and organisations. Paulsson also discussed the need for devoted and competent teachers, further substantial research and the positioning of universal design as a distinct subject within the curriculum.

Overall, the literature supports the implementation of universal design into architecture and design curriculum (Bernardi & Kowaltowski, 2010; Helvacioglu & Karamanoglu, 2012; Paulsson, 2005; Watchorn et al., 2013) although there is limited uptake of this approach. While universal design is so much more than being about the needs of people with disability, the key drivers of this approach in the past are in fact people with disability and their advocates. In a sense this has both promoted and limited the recognition of the need for universal design principles in the built environment (Watchorn et al., 2014). However, while people with disability do remain a key driver of this approach, it is important to investigate the attitudes of architects and architecture students towards this population as a potential influence to the application and implementation of universal design.

Attitudes Towards People with Disability

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Antonak and Livneh (1988) defined an attitude as “an idea charged with emotion which predisposes a class of actions in a particular class of social situations” (p.109). It is thought that attitudes mirror one's thoughts and opinions and have the ability to motivate behaviours (Shannon, Schoen & Tansey, 2009), although this can’t be assumed. Extensive research has been completed investigating the attitudes of undergraduate health students towards individuals with disability (Chenoweth, Pryor, Jeon & Hall-Pullin, 2004; Sahin & Akyol, 2010; ten Klooster, Dannenberg, Taal, Burger & Rasker, 2009; Tervo, Palmer & Redinius, 2004). However, there are few identified studies that have gone beyond the health sector and investigated attitudes within the profession of architecture.

An Israeli study (Vilchinsky & Findler, 2004) included architects (n=51) in a sample of various professions who are required to employ people with disabilities. The study explored attitudes towards new equal rights legislation, and utilised the Disability Rights Attitude Scale – Israel in a descriptive, cross sectional design. The attitudes of architects towards this legislation was found to be less favourable than all but one of the other professions, and the authors concluded that these findings may be the consequence of architects valuing aesthetics over functionality. More recently, a study into attitudes around the sexuality of people with intellectual disability (Franco, Cardosa & Neto, 2012), included undergraduate architecture students (n=78) as a control group in relation to medical and psychology students. In comparison to the health students, the architecture students had significantly less favourable responses, although their overall attitude was generally positive.

While previous research has had a specific focus, this study is the first to explore general attitudes towards disability of architecture students. Its significance lies in the increased contact and interaction architects are having with people with disabilities, as university continues to grow in influence, community attitudes change and new legislation is introduced. It is therefore important to understand the attitudes of this professional group, as they may have implications for the implementation of universal design and involvement of end users in the design process. The previously identified

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less favourable attitudes held by architects towards people with a disability deserves further exploration, as the current evidence base is fairly limited.

Methodology

This study used a quantitative, quasi-experimental design, comparing two naturally occurring groups (Punch, 2005). Using this method to obtain data provided the researcher with descriptive statistics about the sample, and a numerical representation of the attitudes of architecture students.

Sample

The sample for the study was collected via purposive sampling (Portney & Watkins, 2009) from two separate population groups; third and fourth year architecture students who had participated in the Design 4 Diversity program (Group One) and fifth year architecture students who had not participated in the Design 4 Diversity program (Group Two). Inclusion criteria for the study included students who were 1) undertaking a Bachelor of Design (Architecture) in their third year of study in 2013; 2) undertaking a Master of Architecture and in their fourth or fifth year of study in 2013; 3) who began a Bachelor of Design (Architecture) at the studied university and had continued through the degree without a break and without studying at any other educational institute; 4) who were aged 18 and over; and 5) who were able to speak English to a level that supports study at university.

A total of 370 architecture students were enrolled at the time of the study in the targeted classes at Deakin University, Waterfront Campus, Geelong. Of these students, 147 (39.7%) questionnaires were returned. Thirteen were then excluded as the participants did not meet the inclusion criteria or their questionnaires were returned incomplete. This left a total of 134 completed questionnaires with a response rate of 36.2%. Of these, 82 (64.9%) were completed by students in their third and fourth years of study (Group One) with a response rate of 32.8%. Fifty-two (38.8%) were completed by students in their fifth year of study (Group Two) with a response rate of 43.3%.

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Instrument

There are a number of measures that have been developed over the years and used within the literature to measure attitudes towards disability. These include the Attitudes Towards Disabled People (ATDP) (Yuker, Block & Younng, 1970); Scale of Attitudes towards Disabled People (SADP) (Antonak & Livneh, 1988); Multidimensional Attitudes Scale Towards Persons with Disabilities (MAS) (Findler, Vilchinsky & Werner, 2007); and, Interaction with Disabled Persons Scale (IDP) (Gething, 1991). It is important to recognize that most of the measures were developed almost 30 years ago with little attempt to update them to reflect the current and contemporary views of impairment and disability and relevance to current societal norms and values. However, this study chose to use the Interaction with Disabled Persons Scale (IDP) (Gething, 1991) based on its use in previous studies, availability, and ease of, and time required for administration.

The IDP scale was developed by Lindsay Gething in 1991 to measure negative or non-accepting attitudes towards people with disability (Gething & Wheeler, 1992). The scale measures 20 items to establish a person's discomfort in social interactions with people with disability (Gething & Wheeler, 1992), which has been identified as a central factor underlying negative attitudes (Gething & Wheeler, 1992). The IDP is concise and causes minimal inconvenience to participants (Forlin, Fogarty & Carroll, 1999), and its development in Australia was also relevant to the context of this study (Forlin et al., 1999). The IDP demonstrates strong psychometric properties with high reliability coefficients, good test-retest reliability, high internal consistency and construct validity (Gething, 1991; Gething & Wheeler, 1992). The IDP has previously been extensively used with health and medicine students (Brown et al., 2009).

The IDP is a self-administered, pencil-and-paper measure framed in the first-person (Gething, 1991), that asks respondents to rate how much each of a series of 20 statements fit their reactions when meeting and interacting with a person with disability (Gething, 1991). Responses for each item range from 1 being “I disagree very much” to 6 being “I agree very much”. The scale has

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six factors; Discomfort; Sympathy; Uncertainty; Fear; Coping; and Vulnerability (Brown et al., 2009; Forlin et al., 1999). When scoring the IDP, polarity has been reversed on three statements to eliminate possible response bias (Gething, 1991). Item 19 was also eliminated prior to scoring as its factor analyses was not found to consistently cluster with other variables (Gething, 1991). A lower score on the scale indicates a more positive attitude, as expressed in terms of perceived discomfort during personal interactions with someone with disability, with total scores ranging from 19-114 (Gething, 1991; Gething & Wheeler, 1992).

Procedure

Prior to commencing this study, ethics approval to conduct the research was obtained from the Deakin University Human Ethics Advisory Group – Faculty of Health (HEAG-H) on 2 July 2013. Architecture students in the targeted classes received a brief oral presentation from the student researcher 20 minutes prior to the conclusion of the class, outlining the research and inviting them to participate. A Plain Language Statement and a copy of the IDP (as part of a more extensive questionnaire that included demographic and other information) were distributed to all students attending the class. Completed questionnaires were deposited in a box placed at the exit of the classroom as the student departed. Consent was assumed if participants returned their questionnaires and all information provided was non-identifiable. The researchers were not employed by the School of Architecture, and had no relationship with the students prior to contact with them for this study.

Data Analysis

Following data collection, the IDP scale responses were scored according to the instruments manual. The research team visually checked 10% of the data to ensure accuracy of entry (Portney & Watkins, 2009). The data were transferred to and analysed by the Statistical Package for Social Sciences (SPSS) Version 21.0. Quantitative demographic data obtained from the questionnaire were analysed using descriptive statistics to summarise the

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characteristics of each sample. A two-tailed Mann-Whitney U-Test was performed to determine if a significant difference between participant groups existed in regards to attitudes towards people with disability. A parametric ANCOVA was also completed for the IDP total score. For all statistical tests, the significance level was set to p=<.05.

Results

Table 1 highlights the characteristics of the two groups of students who participated in this study. A two-tailed Mann-Whitney U-Test was completed to determine if the two groups were statistically significantly different, but no significant differences were found apart from age (U-Test=.000, p=<.05). This difference would be most likely to have occurred as participants in the group without universal design education are all likely to be older as they are more senior students.

Table 1. Sample Characteristics.

Sample Characteristics	Arch. Students with UD Education	Arch. Students without UD Education
Number of students	82	52
Age	Mean = 24.5	Mean = 26.5
Gender	Male 64.6% (n=53) Female 35.4% (n=29)	Male 65.4% (n=34) Female 34.6% (n=18)
Personal Experience with temporary or permanent health condition	13.4% (n=11)	17.3% (n=9)

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Sample Characteristics	Arch. Students with UD Education	Arch. Students without UD Education
Knowing someone with temporary or permanent health condition	52.4% (n=43)	62.7% (n=32)

The participants' total scores on the IDP across both groups ranged from 42-88, with no extremely high or low scores recorded. These raw scores are provided in Appendix 1. Descriptive statistics were also calculated for factor scores on the IDP, and are displayed for both groups in Table 2.

Table 2. Participant IDP Factor Scores (Mean and Standard Deviation).

Item	Arch. Students with UD Education	Arch. Students without UD	Possible Range
Discomfort	9.83 (±3.22)	10.48 (±3.55)	4-24
Sympathy	17.90 (±3.06)	18.06 (±2.61)	4-24
Uncertainty	12.62 (±3.06)	12.58 (±2.94)	4-24
Fear	7.65 (±1.84)	8.42 (±1.90)	2-12
Coping	7.56 (±2.00)	7.77 (±2.08)	2-12
Vulnerability	7.63 (±1.66)	8.21 (±2.08)	2-12

A two-tailed Mann-Whitney U-Test was performed to determine if there was a statistically significant difference between the groups on attitudes to disability. The results of an initial analysis of the total scores identified that there were no statistically significant differences (.136, p=<.05). A further U-Test was completed for each item of the IDP scale, and significant differences were identified for Item 5; "*I wonder how I would feel if I had this disability*" (.014, p=<.05) and Item 7; "*I am grateful that I do not have such a burden*" (.009, p=<.01). In each case, the group of architecture

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students who had received universal design education had significantly less negative attitudes to interactions with people with disability.

A Mann-Whitney U test was also completed for factors scores on the IDP. Only one statistically significant difference was identified on Factor 4, *Fear* (.037, p=<.05). Once again, the group of architecture students who had received universal design education was significantly less fearful of interactions with people with disability.

An Analysis of Covariance (ANCOVA) was also completed for the entire sample to identify any confounding variables. As can be seen in Table 4.15, age, gender, personal experience of a temporary or permanent health condition and knowing someone with a permanent or temporary health condition were not identified as factors influencing attitudes to universal design as scores did not reach p=<.05.

Table 3. Analysis of Co-Variance

Confounding Variable	Gender	Age	HC-Pers	HC-Other
UD-Pub	.109	.514	.296	.152
UD-Priv	.163	.885	.459	.382
UD-Tot	.112	.704	.316	.228
UD-Imp	.370	.258	.851	.994
Visibility Reqs	.222	.804	.418	.592
AS Fam	.809	.464	.446	.337

Note. UD-Publ=Attitudes to universal design of public buildings and built environments

UD-Priv=Attitudes to universal design of private buildings and built environments

UD-Tot=Total of both attitudes to universal design scales

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UD-Imp=Valued importance of universal design to participant future professional career

Visitability Req=Support for implementation of proposed visitability requirements

HC-Pers =Personal experience of a temporary or permanent health condition

HC - Other=Knowledge of someone with a temporary or permanent health condition

AS Familiarity=Familiarity with the Australian Standards 1428.1 – 2009 Design for Access and Mobility

Conclusion

This study is the first to address architecture students' general attitudes to disability and as such addresses a significant gap in the literature. Initial findings indicated that overall, no statistically significant differences existed between groups on total scores to interaction with people with disability. However significant differences were identified on two single items of the IDP; "*I wonder how I would feel if I had this disability"* and *"I am grateful that I do not have such a burden"* and on one factor, *Fear*, of the IDP. Given the findings of this study, the alternative hypothesis is supported, limited to two items and one factor on the IDP, with architecture students who received universal design education possessing significantly more positive attitudes about some aspects of interacting with people with disability.

To explore the significance of these findings, they were compared to those of health professionals and the standardized norms of the IDP. In relation to an international sample of occupational therapy students (Brown et al., 2009), the mean scores of the architecture students in this study were slightly but not significantly higher. This indicates the occupational therapy students had more positive attitudes to interaction with people with disability than the architecture students, which is consistent with the findings of previous studies comparing architects with health professionals (Vilchinsky & Findler, 2004; Franco, Cardosa & Neto, 2012).

The findings of this current study also identified higher scores, indicating more negative attitudes, predominantly within the Sympathy factor of the

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IDP. While not statistically significant, these scores indicated that architecture students had particularly negative attitudes to sympathising with people with disability. In regards to this finding, it is useful to reflect upon developments in societal views of disability, with a move from providing sympathy to empathy. While it is imperative that architects understand the implications of built environment design for people with disability, sympathy may no longer be an appropriate response - rather empathy and understanding are required. An exploration of attitudes towards people with disability could be overtly addressed as part of architectural education around universal design, as it often is in health course to encourage reflective practice. Overt consideration of the architecture students existing assumptions and perspectives, and their impact on the design process, could assist in challenging misconceptions based on misunderstandings and prejudices.

In relation to the standardized norms of the IDP, which are drawn from the general public, further similarities and differences were identified. An analysis of covariance (ANCOVA) determined that the demographic characteristics of gender and age were not confounding variables of scores on the IDP within the current study. These findings are supported by Gething (1991), in which 10 out of 11 studies identified that gender and age did not have a significant effect on IDP scores. However, the finding from this study that personal experience of a temporary or permanent health condition was not a confounding variable is not consistent with the existing empirical research. A considerable body of evidence supports the idea that people who have experienced regular close personal contact, tend to possess more positive or accepting attitudes towards people with disability (Gething, 1991).

The implementation of simulation activities in the Design 4 Diversity initiative was used to enhance the architecture students' exposure to people with disability, which is a strategy previously used in similar initiatives (Altay & Demirkan, 2013; Bernardi & Kowaltowski, 2010; Paulsson, 2005). However greater exposure, over longer time periods may be required to substantially shift attitudes, which could explain why there were few statistically

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significant findings in this study. Introducing weekly simulation tasks (i.e. taking a shower and dressing one handed, doing shopping on crutches) as part of a unit could provide this prolonged exposure and a greater range of experiences. Another strategy to achieve this could be to encourage architecture students to seek employment that increases their contact with people with disabilities or diverse needs to support their studies. With most students needing to work throughout their study (Devlin, James & Grigg, 2008), it is possible universities could encourage architecture students to work in such roles or organisations to create greater awareness of end user needs and aspirations, thus preparing them after graduation with a greater understanding of user diversity.

The statistically significant changes in attitude found in this study indicate that Design 4 Diversity as an educational intervention may have had a positive impact. While no prior research is available for architecture students, this is somewhat consistent with prior studies with interior design students. Chang et al. (2000) found a statistically significant difference in interior design student attitudes to disability before and after a six-week universal design education program ($t=-2.24$, $p<.03$) (Chang et al., 2000). Altay and Demirkan (2013) also reported changes in design student attitudes to disability following a semester-long subject relating to diversity and inclusive design via theoretical and practical education. In the study by Altay and Demirkan (2013), 17% of students reported the feeling of increased responsibility to consider the needs of diverse people and people with disability during their design process. However, these findings only relate to changes in attitudes in the immediate aftermath of educational interventions, and the magnitude of the changes are relatively modest.

It may also be possible the IDP was not effective in measuring architecture student attitudes to interaction with people with disability. As discussed previously, the IDP was standardised using samples from health and disability fields. As no research has previously investigated its use with architecture and design students, it is difficult to establish whether it is effective in measuring the attitudes to disability more broadly. The time since publication may also be an influence on results. While extensive research

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investigating the reliability and validity of the scale has been completed (Gething, 1991; Gething & Wheeler, 1992), clear changes to society and the related constructs of disability have occurred over the last 20 years. These changes are evidenced through the political and legislative developments including the Human Rights Legislation Amendment Act (1999), introduction of the National Disability Standards for Education (2005), International Day of People with Disability, United Nations Convention on the Rights of Persons with Disabilities and the introduction in Australia of the NDIS in 2013 (Australian Human Rights Commission, 2013). These developments may suggest that further investigation of the IDP's suitability to current social and disability constructs is necessary, as is an introduction to these developments and frameworks for the architecture students. This lack of further updates and understanding of the IDP's current day suitability may also explain why no significant differences on total scores of the IDP were found between groups of the current study. Indeed one may question why there has been so little research in recent years in relation to measuring attitudes to people with disability.

Limitations

There were a number of limitations associated with this study. As the questionnaire was voluntary and participants could choose whether to complete and return it, there was the potential for a self-selection bias where students particularly interested in the topic may be more likely to participate. However, due to ethical issues, students enrolled in the targeted classes could not be required to complete the questionnaire. The completion of the questionnaire within the classroom setting could also be considered a limitation. Due to the nature of the study and the setting it was conducted in, it was not possible to ensure all participants completed the questionnaire independently without discussing with their peers. Therefore it is not possible to determine if leakage may have occurred and how this may have impacted on results.

The generalisability of the study is also limited. Purposive sampling was utilised to ensure participants had received the appropriate education and

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were a representative sample for the study. However, this also meant that the sample, which was from one university in Australia, is not generalisable to the architecture student population. The statistically significant differences were identified on only three aspects of the IDP, so further investigation of attitudes and methods that enhance more generalized positive attitudes is needed. This study also cannot be generalized to practicing architects, and this is an important population to include in future research in this area.

Recommendations for Future Research

It would be valuable for future studies to include a qualitative aspect that would allow for greater in-depth understanding of architecture student attitudes to universal design in the longer term, particularly post-graduation and in the context of professional practice. As the small amount of literature currently assesses attitudes immediately following an educational intervention, it would also be beneficial to complete a longitudinal or follow-up study to investigate the retention and application of knowledge long-term. A study comparing the associated costs of designing with universal design in mind and the costs associated with retrofitting buildings at a later stage would also be beneficial. For universal design and visitability requirements to be taken seriously in the building industry and its related professions, investigation on the impact of this on the bottom line would enhance our understanding and potentially move this discourse from a moral and legal imperative to a business imperative. A greater understanding of methods to assess attitudes toward people with a disability and the development of appropriate and updated assessment tools are also necessary.

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Appendices

Appendix 1. Participant IDP Raw Scores (Mean and Standard Deviation).

Item	Arch. Students with UD Education	Arch. Students without UD
It is rewarding when I am able to help	4.72 (±1.00)	4.77 (±1.13)
It hurts me when they want to do something and can't	4.37 (±1.04)	4.45 (±1.24)
I feel frustrated because I don't know how to help	4.22 (±1.02)	4.06 (±0.93)
Contact with a disabled person reminds me of my own vulnerability	3.56 (±1.00)	3.88 (±1.09)
I wonder how I would feel if I had this disability	4.06 (±0.99)	4.51 (±1.10)
I feel ignorant about disabled people	2.75 (±1.14)	2.52 (±1.18)
I am grateful that I do not have such a burden	4.31 (±1.08)	4.79 (±1.09)
I try to act normal and to ignore the disability	3.95 (±1.21)	3.69 (±1.45)
I feel uncomfortable and find it hard to relax	2.72 (±1.14)	2.94 (±1.16)
I am aware of the problems that disabled people face	4.06 (±1.15)	4.13 (±0.86)
I can't help staring at them	2.43 (±0.98)	2.69 (±1.21)

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Item	Arch. Students with UD Education	Arch. Students without UD
I feel unsure because I don't know how to behave	2.96 (±1.07)	3.19 (±1.21)
I admire their ability to cope	4.69 (±1.16)	4.96 (±0.82)
I don't pity them	3.44 (±1.36)	3.56 (±1.36)
After frequent contact, I find I just notice the person not the disability	4.15 (±1.22)	4.31 (±1.14)
I feel overwhelmed with discomfort about my lack of disability	2.61 (±1.15)	2.84(±1.09)
I am afraid to look at the person straight in the face	2.41 (±1.18)	2.54 (±1.39)
I tend to make contacts only brief and finish them as quickly as possible	2.33 (±1.13)	2.69 (±1.32)
I feel better with disabled people after I have discussed their disability with them	3.78 (±1.15)	3.73 (±1.17)
I dread the thought that I could eventually end up like them	3.46 (±1.13)	3.59 (±1.36)
IDP Total Score	65.05 (±8.97)	67.47 (±9.14)

Journal of Accessibility and Design for All

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EXPLORING THE STAGES OF INFORMATION SEEKING IN A CROSS-MODAL CONTEXT

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Abstract: Previous studies of users with visual impairments access to the web have focused on human-web interaction. This study explores the under investigated area of cross-modal collaborative information seeking (CCIS), that is, the challenges and opportunities that exist in supporting visually impaired (VI) users to take an effective part in collaborative web search tasks with sighted peers. We conducted an observational study to investigate the process with fourteen pairs of VI and sighted users in co-located and distributed settings. The study examined the effects of cross-modal collaborative interaction on the stages of the individual Information Seeking (IS) process. The findings showed that the different stages of the process were performed most of the time individually; however it was observed that some collaboration took place in the results exploration and management stages. The accessibility challenges faced by VI users affected their individual and collaborative interaction and also enforced certain points of collaboration. The paper concludes with some recommendations towards improving the accessibility of cross-modal collaborative search.

Keywords: Collaborative information seeking; cross-modal interaction, information seeking process; accessibility; web search.

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Introduction

In the context of Information Seeking (IS), observational studies reveal that group members often collaborate when searching for information, even if they were not explicitly asked to do so (Large et al. 2002; Morris, 2008). The activity that involves a group of people collaborating in a common information seeking task is called Collaborative Information Seeking (CIS). Over the past few years, research in this area has been gaining much interest. This attention on multi-user IS has always assumed all group members are using visual displays. This focus on the visual modality limits the relevance of previous research to users employing other interaction modes for accessing and managing retrieved results. This paper presents the results of an exploratory study conducted to investigate the effect of the presence of two different modalities on the process of IS. We term the process under investigation cross-modal, Collaborative Information Seeking (CCIS). The purpose of this study is to better understand the CCIS process and its effects on stages of the individual IS process as presented by Marchionini and White (2008).

To date, very few studies (Shah, 2009; Shah and González-Ibáñez, 2010) have examined the process of CIS or have attempted to draw a framework or derive a model that describes its processes. Therefore in this paper we take the Marchionini and White (2008) model of individual information seeking and map its processes to the individual and collaborative IS activities performed. The way their model introduces the IS activity as a process that includes discreet stages helps to inform our understanding of how users employing different modalities go about performing each stage of the IS process both individually and collaboratively. The work here is motivated by the observation that many activities in both educational and work settings involve teamwork, and that internet searching often forms an important component of such activities. Specifically, we wish to understand what barriers may exist to visually impaired searchers taking part in CCIS, and what approaches are currently employed by CCIS participants to overcome or work around these barriers.

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The paper starts with a brief overview of related work on the accessibility of the single user IS process and a summary of the current research on CIS. We then present our motivation and research questions, before describing the details of the study and results obtained. The effects of cross-modality on the awareness and division of labour in CIS involving visually impaired (VI) and sighted have been reported elsewhere (Al-Thani et al., 2013), where the patterns of behavior to achieve awareness and strategies to divide labor are described. This paper focuses on the effects of cross-modality on the structure of the IS process and on identifying the stages in which collaboration occurs and the reasons for it taking place. This paper concludes by discussing the implications of our findings and providing design recommendations for CCIS system features.

Related background

Accessible information seeking

Despite the fact that issues surrounding web accessibility have attracted increased attention (Harper and Yesilada, 2008) the area of accessible IS is rarely examined. The sequential nature of screen reader output imposes many challenges on VI web users. These challenges range from the lack of context to overload of short-term memory. Studies have highlighted these challenges and proposed a set of guidelines to be considered when designing an accessible search engine (Andronico et al., 2006; Craven et al., 2003). While these studies focused on the usability aspects of the problem, a study by Sahib et al. (2012) examined the challenges that this problem imposes on the different stages of the IS process and hence on the behaviour of the VI information seeker.

In the comparative analysis of Sahib et al. (2012) an observational user study was conducted with 15 VI and 15 sighted participants. The participants were asked to perform a complex task which required a fairly high level of cognitive effort (i.e., detailed planning of a vacation). The results of the comparative study identified major differences between the IS behaviour of

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VI and sighted participants. These differences were particularly apparent in the query formulation and results exploration stages. One of the main barriers highlighted was the inaccessibility to screen reader users of query-level support features provided by search engines at the query formulation phase. Also, in the search exploration stage, the number of results viewed by VI participants (mean of 4.27 (SD= 2.15) web search results viewed) was considerably lower than the number of results viewed by sighted participants (mean of 13.40 (SD= 7.39)). These findings led to the development and evaluation of a search interface (Sahib et al., 2013) that aim to tackle the issues identified in their study with special attention to the results exploration and management stages.

Collaborative Information Seeking

Collaborative information seeking is defined as the activity performed by a group of people with a shared information need or 'goal' (Morris, 2008). A survey by Morris (2008) was one of the earliest studies that encouraged increased attention in this area. Her survey, which she revisited lately (Morris, 2013), did not attempt to examine users' behavior, yet it provided a wealth of data regarding the prevalence of collaborative web search and the tasks, motivation and tools involved.

Despite the extensive research in this field in the past few years, there is no consensus over a single model or framework that describes the CIS process. Though there have been a number of research attempts to develop models either to describe the CIS environment (Shah, 2009) or to classify the systems supporting it (Golovchinsky et al., 2008). Shah (2009) proposed a layered model of information seeking. The model contains four layers which are information, tools, users, and results. The information layer refers to the different resources and formats of information contained in the entire search space. The tools basically refer to the search engines and the functionality they provide. The user layer includes the users, their profiles and any mechanisms available for personalization. The final layer is the results, ultimately the product of the search process, including all relevant information, users' comments and metadata.

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Studies by Hyldegard (2009) and Shah and González-Ibáñez (2010) examined the applicability of Kuhlthau's (1991) process of individual information seeking in the context of a group. Hyldegard (2009) observed a group of 10 students over 14 weeks when performing information seeking activities and Shah and Gonzalez-Ibanez (2010) conducted a laboratory study involving 42 pairs performing a general exploratory search task. Both concluded that though there are evident similarities in the general stages of the process between individual and collaborative behaviours in information seeking, there were also important differences. The differences are related to the contextual aspects associated with social factors. The results of the studies were similar and both concluded that Kuhlthau's (1991) process did not completely address the social dimension of CIS.

Golovchinsky et al. (Golovchinsky et al., 2008) proposed a taxonomy of CIS collaboration. The focus of this taxonomy is on technical models of collaboration rather than social models; they proposed four different dimensions of collaboration: intent, depth of mediation, concurrency, and location. (1) Intent: Explicit vs. Implicit: When implicit collaboration is supported, the search engine uses data from previous anonymous users with similar information needs or similar behaviour to offer recommendations to users. Recommender systems thus support implicit collaboration. In contrast, in systems that support explicit collaboration, users explicitly work together in the query formation and results exploration stages. Microsoft's SearchTogether (Morris and Horvitz, 2007) system is an example of an application that supports explicit collaboration. (2) Depth of Mediation: This dimension refers to the level in which the mediation of information seeking is applied in a system. Pickens et al (2008) introduced Cerchiamo, in which CIS is mediated at the algorithmic level. The Cerchiamo collaborative search engine divides the labour between two collaborators. One collaborator is the "preceptor" who investigates new fields of information, while the other collaborator is the "surveyor," who looks at and explores each new field in detail. (3) Concurrency: Synchronous vs. Asynchronous: Concurrency, which does not actually relate to time, means that the system should allow the actions of a user to be conveyed in some way to other team members. In other words, systems should support awareness among collaborative users

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within a group engaged in different information seeking activities. (4) Location: Co-located vs. Distributed: Distributed collaboration may require additional communication channels such as instant messaging, offline messaging services and voice chat.

Research questions and motivation

The increased interest in CIS reflects the fact that it is a more frequent activity in our daily lives. However, there has not previously been any attempt to consider the way CIS activities may be different when collaborators use different interface modalities, which is the focus of the current study. The questions we wished to examine are as follows:

Q1: What stages of the information seeking process are done by the VI and sighted participants and how?

Studies have revealed that though IS stages are typically done individually. Nevertheless, collaborators may choose to work together at many points in the process (Hyldegard, 2009; Shah and González-Ibáñez, 2010). In addressing this question, we aim to explore how often collaboration occurs at each stage, how much collaboration takes place and what techniques are used to support it? Furthermore, we wish to examine the effects of cross modality on group performance and techniques employed to address issues arising from the use of different interaction modes. For example, previous research on VI users IS behaviour has highlighted that most challenges are encountered during the results exploration phase (Sahib et al., 2013). These difficulties arise because examining large search result sets using a screen reader can be a lengthy process, due to the sequential nature of speech and other limitations relating to the navigation of complex information with a speech-based screen reader (Murphy et al., 2007; Stockman and Metatla, 2008).

Q2: What are the strategies and techniques employed to manage search results by VI and sighted participants?

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This question also explores the management of search results in the presence of a common goal between group members who use different access modalities. It seeks to identify approaches and techniques used to organize, exchange and manage search results.

Observational study

We observed 14 pairs of users, each pair comprising one sighted and one VI partner, performing two CCIS tasks. For one of the tasks the partners were co-located, while in the other they were located separately. Task order and location were balanced to counter learning effects.

Participants

We recruited 28 participants, 14 sighted and 14 VI, via mailing lists; table 1 contains their demographic data and the technologies they used. Three VI users employed headphones for speech output, while the other 11 used speakers. All the VI users used the speech-only version of the JAWS screen reader. Two pairs were colleagues for more than two years. None of the other pairs had worked together on a regular basis.

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Table 1. Demographic and technology information about participants

	Visually Impaired Participants	Sighted Participants
Age	2(21-29), 4 (30-39), 3(40-49), 5 (50-59)	2(18-20), 3(21-29), 3 (40-49), 5 (30-39),1(50-59)
Gender	8 Male,6 Female	8 Male, 6 Female
Browser Used (Multiple Answers)	12 IE, 8 Safari, 5 Firefox	6 IE, 4 Firefox 3 Safari, 1 Chrome
Frequency of CIS Activity	3 Daily, 2 Once a week, 5 once a month 1 Once in the past six months, 3 Never	2 Weekly, 3 once a month, 6 Once in the past six months, 3 Never

Tasks

Previous CIS research has identified that simple information look-ups and fact finding tasks do not benefit from CIS activity, while multi-faceted and exploratory search tasks are likely to be more appropriate for use in CIS investigations (Morris and Horvitz, 2007). Therefore, participants were asked to collect relevant information for two exploratory tasks that were designed to be realistic work and leisure tasks respectively. The task used in the co-located session was to organize a business trip to the United States while the task in the distributed session was to organize a holiday trip to Australia. They were given dates of engagements in different cities and times when leisure or work activities needed to be identified. Participants were asked to organize the travel, accommodation, and activities in these cities. In advance of each study we made sure that participants had not visited the cities before. The complexity of the two tasks was counterbalanced to make them approximately equal in their level of difficulty. They were balanced for subtasks and amount of information retrieved.

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Sessions

Both the co-located and distributed sessions took place at the VI participants' workplace as the intention was to observe the participants in real world settings. For the same reason, they were asked to use their own PCs and the web browser and search engines they normally used. In the distributed sessions, participants were seated in remote locations and told that they could use one or more of the following methods to communicate: email, instant messaging, shared documents, or any tool they found suitable. While in the co-located setting, participants were seated in the same room and asked to communicate verbally, though they were free to use additional methods if desired.

During the first session, participants were briefed about the purpose of the study and asked to fill a pre-study questionnaire which collected their demographic data, information about the technologies they use for this type of task and their level of experience with web searching. In each session, they were provided with a brief document giving information about the trip they were required to organise, including dates when they needed to be in different places and details of the types of activities they were required to book.

Following that, participants were asked to perform the tasks and about 35 minutes into their work the principle researcher asked them to stop. We intentionally did not inform them in advance about the amount of time they have to perform the task as we were not interested in examining the influence of time pressure in this study. We concluded each session with a brief semi-structured interview to discuss the participants' experience of the task.

All sessions were videotaped, having obtained the approval of the participants. During the tasks, the screens of both participants were captured using screen recording software. The VI participants' screens were captured using a video camera, as we noticed in a pilot of the experiment that screen recording software sometimes reduced the responsiveness of

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screen readers. Additionally, the principle researcher made notes of observations during the sessions.

Data Collection

The main source of data was the video recordings of the interactions between partners and their interactions with the search engines and the post-study interviews. After transcribing the videos, we used the Open and Axial coding phases of grounded theory (Corbin and Strauss, 2008). Open coding is the process of generating initial concepts from the data while axial coding is when the data is put together to establish connections between the different concepts and categories. The selective coding process includes the formalisation of the data into theoretical frameworks. However, for this study, we stopped our data analysis after open and axial coding as we wanted only to explore the behaviour of the collaborating searchers, as opposed to developing a new theory.

The coding scheme captured indicators of each IS process stage. In relation to the interactions between partners, the coding scheme captured instances of collaborative IS activities and the reasons for these taking place. Semi-structured interviews were conducted individually with each participant to complement the data collected during the study. On the quantitative data, we carried out statistical testing at $p<0.05$ with a two-tailed unpaired t-test.

Analysis

Stages of the Collaborative Process

In general, the process started with a stage in which the pair divided the tasks to be performed. At this stage, usually one of the participants took the lead and assigned tasks to themselves and their partner. During this process, the other partner might either agree on the task she or he is being given or suggest another task. For instance, visually impaired experienced web users sometimes anticipated that certain tasks were likely to require a longer time for them to complete. Therefore they sometimes suggested they performed

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other tasks. Seven VI participants in the co-located setting and 10 VI participants in the distributed setting preferred searching for a tourism site to booking a hotel room, because the latter task involved filling an online form. In the interviews, VI participants explained that from previous experience of filling web forms, they knew that this process can sometimes be lengthy or not feasible or difficult due to the presence of inaccessible form elements.

In the co-located sessions, an iterative process was observed. This process mainly involved three stages. In the first stage, the pair spent from 2 to 5 minutes looking into and discussing the task. The discussion at this stage mainly related to an initial division of labour. At this stage, the task was divided into smaller sub-tasks. However in the majority of cases, partners only decided on who would do each of the first sub-tasks. In stage 2, after each partner had been assigned a sub-task, each participant started to perform the information seeking process individually. Once a piece of information was found (e.g. once a sub-task was completed), the participants usually paused and notified their partner about the completion of this sub-task by discussing the outcome and search results found (Stage 3). The discussion in stage 3 always revolved around three main aspects: division of labour, making sense of the results and reviewing the remaining sub-tasks. Stages 2 and 3 were then repeated until the task was completed. However, in some cases a participant interrupted his/her partner during a task. Two main reasons were noticed for such behaviour. One reason was that the participants would need to browse search results together either to collaboratively make sense of the retrieved information, or, in some cases, VI participants would face difficulties in viewing large volumes of search results, due to the limitations of speech-based screen readers, and so asked their sighted partners for assistance. The other reason was that some websites were inaccessible and it was impossible for the VI partner to complete the task individually. In the observed sessions, a sum of 17 instances were recorded where the VI participants asked for assistance from their sighted partners in the co-located setting. 13 of these cases were accessibility issues while four of them were related to navigating large result sets.

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In all distributed sessions, a common pattern for the execution of the stages was observed. After the initial division of labour, both participants performed the Information seeking tasks individually and shared the results via email or instant messages. Unlike the process in the co-located session, in the distributed sessions there was no evidence that participants discussed division of labour later in the process. It was observed. However, if one participant completed all the tasks assigned to him/her, they would decide to complete their partner's outstanding tasks. Additionally, there were virtually no interactions between partners relating to making sense of retrieved results. There were only three requests for assistance recorded and all were access related.

Stages of the Information Seeking Process

For the most part, the separate stages of the information seeking process were done individually. Nevertheless, in the co-located sessions, a number of instances were recorded in which query formulation, results exploration, query reformulation and the search result management stages were accomplished collaboratively.

Query formulation

When a participant was assigned a particular task, he/she immediately opened a search engine and entered a query keyword. Usually, the initial query would be broad and once a relevant result set is found, the participant might choose to narrow down the search to a more specific query with more keywords to obtain the information they need. However, this was not the case with VI users, as shown in Table 2, in both settings, the average length of queries by sighted participants is shorter than that of VI users. The result was statistically significant in the co-located setting at ($t(26)$)=2.11, $p=0.04$) and not statistically significant in the distributed setting at ($t(26)= 1.28$, $p= 0.21$). This result agrees with a previous comparative study (Sahib et al., 2012) of the search behavior of VI and sighted users. In interviews conducted as part of (Sahib et al., 2012), VI users confirmed that they often try to express their complete information need in a relatively long, precise query,

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in an attempt to reduce the number of results they need to browse to reach the desired result.

Table 2. Mean length of initial query (SD)(a-b)

a. Co-located Setting

	VI participant	Sighted participant
Length of initial Query	3.37 (0.96)	2.64 (0.84)

b. Distributed Setting

	VI Participant	Sighted Participant
Length of initial Query	3.31 (0.95)	2.93 (0.54)

Returning to the present study, a number of instances of collaboration were observed at this stage; participants sometimes suggested query keywords for his/her partner. In all co-located sessions, the average of 0.36 (SD= 0.66) instances of suggesting query terms were recorded, while only one case was recorded in the distributed setting. In situations where the participant was unable to find results that satisfied the information need, his/her partner usually suggested another query keyword. This suggestion was either based on prior knowledge or based on the context of the task. For instance, in the conversation extract below, one participant was finding a hotel in Los Angeles (L.A). This participant suggested the query keyword for her partner, who was looking for a restaurant to dine in L.A. She suggested that the restaurant had to be near the hotel, as shown in the excerpt below:

From Study #6, Sighted Participant: "I will look for a place to dine in L.A."

VI participant: "You can Google restaurants near Beverly Hills."

Search Result Exploration

As shown in Table 3, the number of search results explored by sighted users is statistically significantly higher than that for VI participants with (t(26)=

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2.79, p=0.009) in the co-located setting. In the distributed setting, although the difference was smaller, it was still statistically significant (t(26)= 2.32, p= 0.03). Collaboratively exploring a set of search results was commonly observed in the co-located setting only. In all sessions, an average of 3.75 (SD= 1.25) instances of exploring results collaboratively were recorded. The average number of search results viewed collaboratively is 0.5(SD= 1.38).

Table 3. Mean number of search results explored (SD)(a-b)

a. Co-located Setting

	VI participant	Sighted participant
Search results explored	3.92 (2.12)	7.14 (3.37)

b. Distributed Setting

	VI Participant	Sighted Participant
Search results explored	4.71 (2.64)	6.79 (2.38)

All such collaboratively obtained results were triggered by the VI partner needing to explore more results faster. An example of comments taken from two different sessions in which the VI partner asked the sighted partner to assist when exploring the search results is shown below:

From Study #3 co-located session, VI Participant: "Could you just glance at these results yourself?!"

From Study #2 co-located sessions, VI Participant: "It is listing a number of places, can you see L.A. there?"

Query Reformulation

This stage occurs when the user is not satisfied with the initial retrieved set of results and chooses to submit a new query. The new query might be a term from prior knowledge or from information that was just found. Table 4

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shows the average number of query reformulation by VI and sighed participant in each settings.

Table 4. Mean number of query reformulation (SD)

a. Co-located Setting

	VI participant	Sighted participant
Query reformulation	1.07 (1.14)	2.93 (2.47)

b. Distributed Setting

	VI Participant	Sighted Participant
Query reformulation	0.7 (1.24)	1.29 (1.98)

Additionally, it was observed that this stage was performed collaboratively in only 3 instances in the co-located setting. In these instances, the partner interrupts and suggests a query term when one partner is not satisfied with the set of results. An excerpt of a conversation that captures query reformulation accomplished collaboratively is shown below:

From Study #4, Sighted Participant:" I think, perhaps Virgin Atlantic doesn't have direct flights to Las Vegas".

VI Participant: "Yes, this is what I was thinking about".

Sighted Participant: "Let us try another keyword; perhaps you can Google direct flights to Las Vegas".

Managing Search Results

Since the task was conducted in one session, users did not employ favorites or bookmarks to keep track of required information. Sighted users tended to open multiple tabs within a browser window, whereas VI users tended to open multiple windows to keep track of retrieved information. In the co-located setting, the most used note taking tool was Microsoft word. In most of the conducted sessions, both participants would store the retrieved

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information. However, in three sessions only one participant noted down the retrieved information, and the other participants entirely depended on their partners. In two sessions it was the sighted users who kept track of the retrieved information and stored it, while in one session it was the VI user who organized and stored the retrieved information in a word file.

In the distributed setting, the most used note taking tool was Microsoft word. Three VI participants and four sighted participants preferred storing their notes and retrieved information using the communication tool, which was either email or chat messaging. In these situations, one team member usually kept track of the information shared in the communication tool by storing them in a word processing application. Four VI participants and three sighted participants kept track of the retrieved information received from their partners and stored it in a Microsoft Word file.

It was observed that the information noted down or exchanged by participants was of five types: a website link, a website link with details, details about the sub-task, keywords that refer to the information or copying a part of the web page. Figure 1 shows the percentage of each identified category in the co-located and the distributed settings. The majority of information kept by both sighted and VI users in both settings were either website links with details (52% in the co-located setting and 59% in the distributed setting) or details only (25% in the co-located setting and 16% in the distributed setting). Moreover, the amount of information kept by VI users is nearly half the amount of information kept by sighted users. In fact in the distributed setting, sighted users exchange rate of information to VI users was 2:1. In the post-study interviews, seven VI participants highlighted the difficulties of having to switch between three different applications: the web browser, the email client and the note taking tool during the process.

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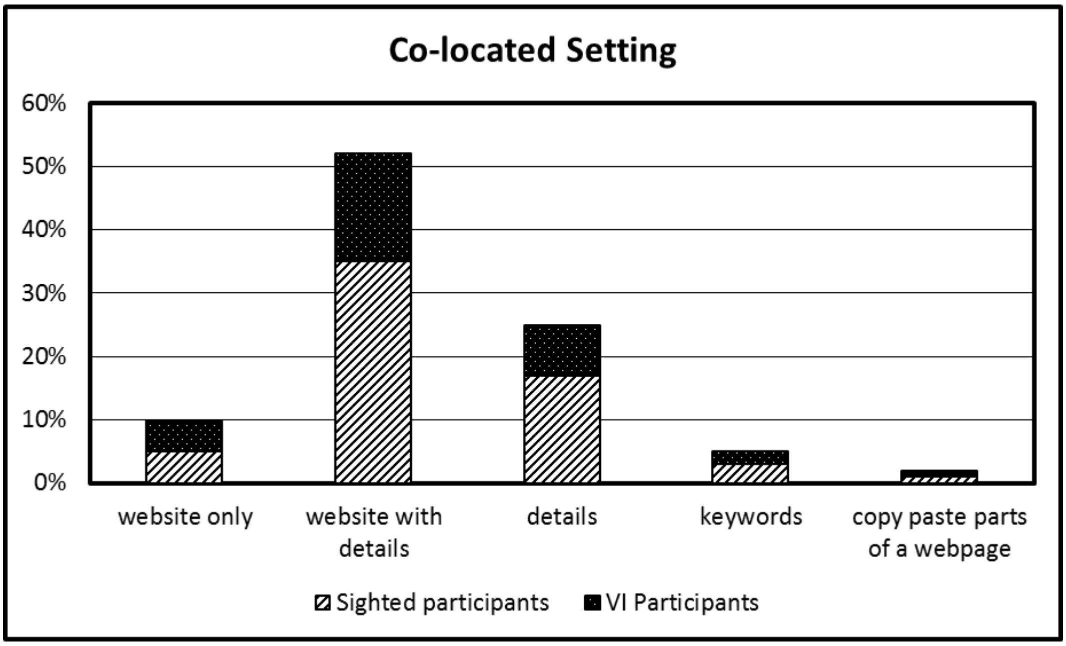
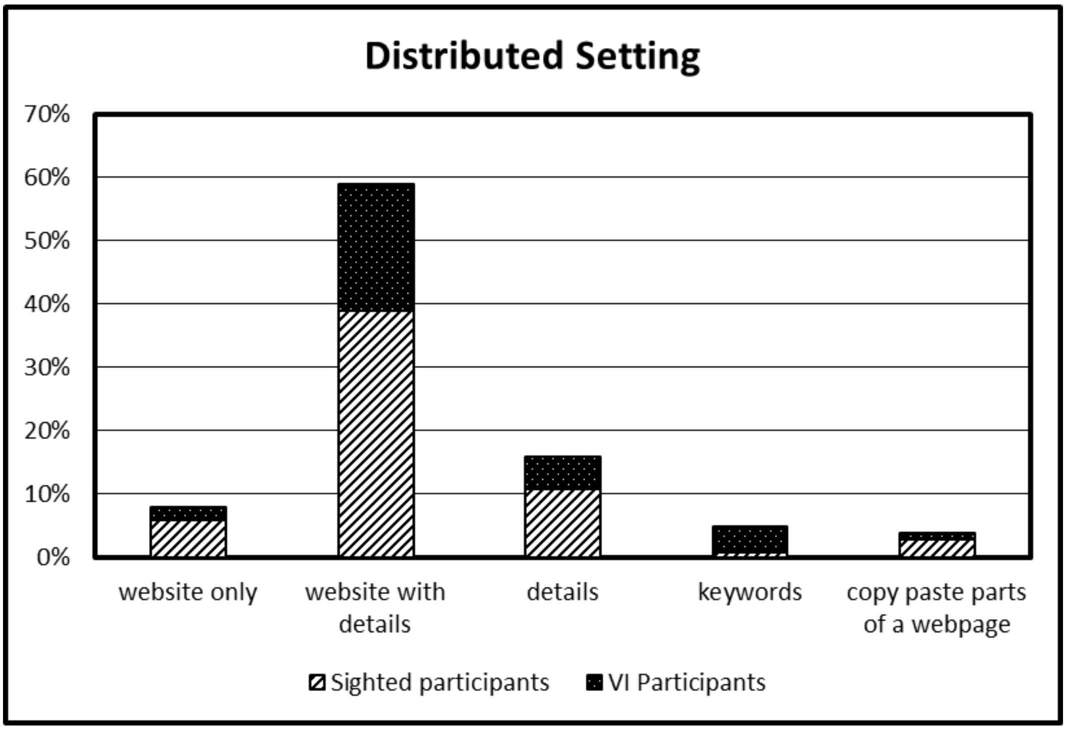
Figure 1. Percentage of occurrences of each type of information kept or exchanged in both sessions (a-b)

a. Co-located Setting



b. Distributed Setting



In the co-located setting the retrieved information was noted down but was not exchanged between the participants by any means. The participants were merely verbally notifying their partners about their progress or asking

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about their partner's progress as a means of updating their awareness information. Whilst in the distributed setting, partners exchanged information by email or instant messaging as well as using note taking tool.

The majority of participants stored the information in lists, without order or structure. However, some participants organized the stored information in a relatively structured way by creating subheadings and adding the information related to the corresponding subheadings. In total, seven participants (four VI and three sighted participants) employed this kind of structure. Five of these seven participants (three VI and two sighted participants) employed this structure in both the co-located and distributed conditions. The other two participants, one VI participant and one sighted participant, only employed this structure in the co-located condition. In the post-study interviews, all the sighted participants tended to prefer creating categories in a hierarchical way to store retrieved web information; whereas 10 out of 14 VI participants preferred storing the retrieved information in a flat list.

Time intervals

We observe the time spent by participants on each stage. This includes time spent entering a query, times spent viewing search results pages, time spent browsing websites, and time spent managing information. In addition, time spent dealing with an error (whether it is a connection error, interface error or accessibility issue) and time spent switching from one application to another. Table 5 shows the average time interval spent in each stage in both settings. The figures show that the most apparent differences between the two groups of users were in the results exploration stage, retrieved information management stage, communication stage and switching from one application to another. In the results exploration stage in both settings VI users spent on average a longer time than their sighted partners. Though the differences were not statistically significant with t-test results ($t(13) = 2.05$, $p= 0.06$) in the distributed setting and ($t(13) = 1.95$, $p=0.7$) in the co-located setting. According to our observations, the main reason that made the VI participants spend on average more time in this stage is the serial

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nature of speech that would make the process of going through search results longer.

In managing retrieved information, sighted participants spent a longer time in both settings. However, the differences are not statistically significant using at (t(13)=1.95, p= 0.72) in the co-located setting at (t(13) =2.05, p= 0.06) in the distributed setting. Additionally, it was observed that VI users spent considerably more time switching from one application to another. The applications were internet explorer, the email client or instant chat application in the distributed setting and word processing document or notepad in the co-located setting. In the post-study interviews, eight VI participants highlighted the difficulties of having to switch between the three different applications. The average time consumed browsing web search results by both groups was significantly higher in the co-located setting with t-test results (t(26)= 2.27, p= 0.03). As in the distributed setting participants spent a considerable about of time using the email client or instant chat messaging service to provide their partners with updates about their progress.

Table 5. The average time interval spent (in seconds) in each stage in both settings by both groups of users in the study (Mean [standard deviation]) (a-b)

a. Co-located Setting

	VI participant	Sighted participant
Entering query terms	02:38 [01:12]	02:08 [01:59]
Exploring search results	3:58 [02:39]	02:11 [01:49]
Browsing websites	14:29 [08:48]	14:19 [08:47]
Managing information	02:50 [02:25]	05:57 [03:06]
Chat	00:00	00:00
Encountering errors	00:23 [00:43]	00:00
Switching applications	01:45 [00:19]	00:35 [00:31]

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b. Distributed Setting

	VI Participant	Sighted Participant
Exploring search results	03:17 [01:52]	2:07 [01:17]
Managing information	01:59 [01:52]	02:50 [03:52]
Encountering errors	00:20 [00:28]	00:01 [00:02]

Findings and discussion

CIS Process

Clearly identifying the stages of the CIS process was not among the formulated research questions; however having an insight of the stages would be of benefit and can help in identifying the phases which are influenced by the presence of two different modalities. According to the literature, the process of CIS is not well-defined and can largely differ according to the task performed. London (1995) introduced a general model of collaborative activity. The model comprises three main phases: (1) the problem setting phase in which collaborators spend time understanding the problem and identifying resources required for solving it. (2) A direction setting phase which involves organizing group activities and agreeing on actions, and (3) the implementation phase in which collaborators complete the task assigned to them. He emphasizes that this stage can differ according to application area and group size.

We observed a similar structure in the current study. The pairs started by discussing and making sense of the given task. They then assigned different

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subtasks to each other and started conducting the information seeking task individually. As seen in the analysis section, it was observed that in cases when the partners were colleagues, the VI partner would delegate the task that might contain an inaccessible interaction to the sighted partner. This action contributed to enhancing the performance of the pairs and their efficiency in completing the task.

Collaboration in the Stages of IS

Q1: What stages of the information seeking process are done collaboratively and how?

There was clear evidence of similarities between the stages of the individual IS process and stages of collaborative IS. Even though participants often performed the IS task individually before sharing the results with their partners, as shown in the analysis section, some stages were performed collaboratively for various reasons. The frequency of collaboration largely differed; it occurred mostly in the search results exploration stage, the co-located sessions, and the results management stages (both settings). As described in analysis section, most of the CIS stages were conducted individually, apart from the results exploration and results management stages.

Result Exploration

Collaboration was triggered when the VI participant would ask the sighted participant to assist in going through a large volume of search results. The average number of search results viewed collaboratively was higher than the average number of search results viewed by VI participants alone. Examination of large sets of search results using a speech-based screen reader can be time consuming and imposes a number of challenges as described by the participants in the post-study interviews. Additionally, current screen readers provide almost no mechanism for overviewing a set of search results.

Results Management

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The results management stage was also done collaboratively. The motivation behind users' collaboration in this stage was that they were encouraged to collaboratively work together and produce one outcome at the end of the task. In three of the co-located sessions, only one team member took notes, while in seven of the distributed sessions, again only one team member took notes.

Q2: What are the strategies and techniques employed to manage search results by VI and sighted participants?

The observations showed that the amount of information kept and exchanged by sighted users was more than double the information kept and exchanged by VI participants, as reported in the analysis section. This is likely to be the result of two factors. The first being that sighted users viewed more results than VI users and hence they kept and exchanged more retrieved information. The second factor is related to the cognitive overhead and time delays that VI users encounter when switching between the web browser and an external application used to take notes. This itself is likely to increase the cognitive load on VI users and hence slow down the process. The effect of this factor was more apparent in the distributed setting, where VI users were required to switch between three applications: the email client or instant chat application, the web browser and note taking application.

Implications and design suggestions

The results and findings of our study clearly indicate that there are a number of ways that the CCIS process could be made more accessible and that the tools used currently do not address the CCIS process adequately. The motivation to improve this situation is strengthened by the frequency of team working both in education and employment (Morris, 2013), of which web searching often forms an important part. Therefore, in this section, we make some recommendations for the design of CCIS system features. The justification for these design recommendations is based on the evidence from the results reported in this article. Nevertheless, many of these design

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suggestions are untried, and so we offer them as potential solutions to the problems revealed by the study. We do recognise that they may be implemented in many different ways and that any specific implementation must be subject to careful evaluation, both as an effective solution to the problem that gave rise to it and for its impact on related areas of the CIS process. In this sense what we propose here is towards an agenda for research in the design of systems to support CCIS.

Improving the Accessibility of Information Seeking

Providing an Overview of Search Results

Search results exploration was mostly done collaboratively. The reason behind this sort of collaboration is that the VI participants needed help from their sighted partners to navigate through a large volume of search results. This also was highlighted by studies that compared VI individual information seeking behaviour with sighted information seeking behaviour (Ivory et al., 2004; Sahib et al., 2012). These studies have stressed that this stage is the most challenging and time consuming for VI users.

Developing a mechanism that provides VI group members with an overview of search results and the ability to focus on particular pieces of information of interest could help in increasing VI participants' independence during CCIS activities. Studies by Shneiderman (1996) and Marchionini et al. (2000) support the idea of structuring the process of visual information seeking by providing the user with an overview of information followed by the option of viewing the information in detail. Shneiderman's (1996) Visual Information Seeking Mantra is described as: "overview first, zoom and filter, then details-on-demand". The principle he presented was then extended by Zhao et al. (2004) to fit the auditory environment where they developed the Auditory Information Seeking Principle as: "gist, navigate, filter, and details-on-demand". Parente (2003) explored the idea of audio enriched links; he developed and evaluated a JAWS screen reader script which, in response to the user clicking a hyperlink, presented a speech-based summary of the web page. This summary includes the title of the web page, statistics about its content and a collection of headers available in the web page.

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Given the development of such an overview mechanism, VI web surfers are likely to perform the results exploration stage more effectively and efficiently, as they could firstly get a gist of results retrieved and can then drill down for more details as required. This could help VI collaborators to work more independently by speeding up their search exploration process, hence allowing group members to manage their resources and labour more efficiently. This will advantage both individual and collaborative information seeking activities.

Design recommendation for CCIS system features 1- Include an auditory overview of search results and possibly a mechanism to zoom into a particular subset of results.

Design recommendation for CCIS system features 2- Add mechanisms for filtering and grouping or clustering search results to make the process of navigating through results using a screen reader faster.

Design recommendation for CCIS system features 3- Facilitate sharing of search results between collaborators. The user who wishes to share results could send an alert to their partner and then share the search results currently being explored. This feature should also show the results that are already explored in an attempt to avoid any duplication of effort. This would deal with the situation where VI searchers wish to get help from their sighted collaborators to process search results, but it also more generally facilitates results sharing and sense-making.

Improving the Management of Search Results

Managing search results was one of the main obstacles faced by VI users during CCIS activities. This was more apparent in the distributed condition where the user was required to switch between three different applications and thus spent significantly more time switching between them. Moreover, the study highlighted differences in individual approaches employed by sighted and VI users when managing search results. Improved support for this stage could significantly contribute to enhancing the effectiveness of collaborative activity.

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A recent study by Sahib et al. (2013) described an integrated tool that allows VI users to keep track of search progress and manage search results. An evaluation of the tool with VI participants resulted in high satisfaction rates as they found it easier to handle search results within the tool as it removed the overhead of switching between a number of applications. Having one integrated interface has the potential for reducing workload during a CIS task.

Design recommendation for CCIS system features 4- Provide an integrated solution that allows collaborators to search the web, share and store retrieved information and communicate without the overhead of switching from one application to another.

Improving Cross-modal Collaborative Information Seeking

Improving the Sharing and Management of Search Results

There is a clear need to improve the sharing and management of information between collaborators. A utility that allows collaborators to recall visited websites and query keywords entered by their partners is clearly not sufficient, as our findings showed the majority of information exchanged regarding search results included website links and details of the information retrieved. Therefore, a tool to support CCIS needs to provide better integration of the whole process as well as supporting the sharing of websites and details of results found. A tool like SearchTeam (Zakta, 2011) which is a commercially available website for collaborative search, provides the collaborators with a common place to share details of websites, links, and comments.

We have also observed that in the distributed setting, all pairs did not rely solely on the communication tool to keep track of information. In fact, all pairs used external note-taking applications such as Notepad or Microsoft Word to keep track of results retrieved. Having a common place to save and review information retrieved can enhance both the awareness and the sense making processes and reduce the overhead of using multiple tools, especially

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in the case of VI users, who do not have sight of the whole screen at one time.

Design recommendation for CCIS system features 5- Provide a place to store and share links and comments. The mechanism to store the links and comments should be very easily available (ideally for example a hot key combination) from the point where the link was found or from where the comment was written.

Design recommendation for CCIS system features 6- Provide the ability to tag and rank search results.

A recurrent theme in both conditions is the tendency to categorize the information retrieved among sighted participants. In fact, the studies (Paul and Morris, 2011; Kelly and Payne, 2014) showed that generally participants prefer a more structured way of organizing retrieved information. Moreover, researchers found that searchers also tend to rearrange items as a part of collaborative sense-making (Tao and Tombros, 2013; Kelly and Payne, 2014).

Design recommendation for CCIS system features 7- Provide the ability to list or structure stored information.

Design recommendation for CCIS system features 8- Support a cross-modal representation of lists and hierarchically structured information. This includes adding features to sort the list of stored information chronologically and the ability to search and tag the stored information.

Design recommendation for CCIS system features 9- Support a cross-modal representation of all changes made by collaborators in the shared workspace. As changes in a visual interface can be represented in colours, changes in the audio interface might be represented by a non-speech sound or a modification to one or more properties of the speech sound, for example, timbre or pitch.

Improving the Awareness of Search Query Terms and Search Results

Allowing collaborators to know their partner's query terms and viewed results will inform them about their partner's progress during a task.

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Additionally, having a view of your partner's search results can allow sighted users to collaborate with their VI partners while going through large amounts of search results. The WeSearch system (Morris et al, 2010) provides collaborators with the means of sharing queries and comments within the group. The queries and comments are colour coded by collaborators. This could be implemented within the context of CCIS by using different screen reader voices and/or spatially distributing the auditory representations of queries and comments made by different group members.

Audio has also been used to augment mainstream CIS interfaces in the cases of co-located CIS that used table top displays (Morris et al., 2006; Morris et al., 2010). In these table top interfaces, auditory feedback is used to communicate group members' actions and render different aspects of their shared workplace. These types of interfaces are usually described to be rich in terms of awareness and attempt to decrease the dependency on verbal communication.

Very few studies have explored supporting accessible awareness information in regards to cross-modal collaboration (Winberg, 2006; McGookin and Brewster, 2007, Metatla et al., 2012). These studies primarily examined conveying information about group members' activities using audio in an attempt to improve awareness. The results of these studies indicate that a shared audio output can potentially increase individual and group awareness, thus allowing a better collaboration.

Design recommendation for CCIS system features 10- Provide cross-modal representation of collaborators' current IS activities. These activities include query terms entered, results currently viewed, and results viewed in the past. In a cross-modal context, a visual representation can be dedicated to these activities and an audio representation could have different non-speech sounds to do the same. These non-speech signals could be followed by providing the VI user the option to listen to keywords entered and explore web pages viewed by their partners. This mechanism could improve awareness of VI users of their collaborators' activities. It is important to mention here that mainstream CIS research has extensively examined approaches to providing awareness information of IS activities (such as Shah

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and Marchionini, 2010; Paul and Morris, 2009), however these approaches have not been examined in a cross-modal context.

Design recommendation for CCIS system features 11- Provide cross-modal representation of collaborators' past IS activities. By this, we mean displaying a chronological view of previous query terms and websites explored. From a visual perspective this can be a dedicated view, while from an audio perspective the user could perform wider scale navigation using shortcut keys and then use cursor keys to navigate between individual results.

Conclusions and future work

This paper describes an exploratory study that examines the effect of cross-modal collaboration on the stages of information seeking in co-located and distributed settings. The findings show that there is a clear influence of the different modalities and settings on the different stages of information seeking. The most apparent collaborative issues occurred in the results exploration and management stages. Some of these problems have an underlying accessibility issue caused by the limitations in the way information is presented and navigated using speech-based screen readers. The paper concludes by discussing the implications of the findings and providing specific design suggestions to consider when developing accessible and usable interfaces to support CCIS.

In future work, we plan to investigate the applicability of the design suggestions and experiments advocated in the previous section. We are aware that the effectiveness of the design recommendations we propose can only be evaluated through usability studies. Therefore, we aim to either design and implement these recommendations in a new system or enhance the accessibility of an existing system that supports some or all of the features recommended. Following this step, we will perform a study to investigate the usefulness of these exemple implementations to evaluate their effectiveness in supporting both individual and collaborative IS processes as recommended by Shah (2014).

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