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ACCELEROMETER-BASED COMPUTER MOUSE FOR PEOPLE WITH SPECIAL NEEDS

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Abstract: A great deal of human-machine interaction depends on hands, and so does access to information technology services. People unable to use hands do require special devices that replace computer mice or touchscreens. In this paper we present a building kit for a full-featured computer mouse that is controlled by head movements. The resulting kit includes an easy-to-find bill of materials, instructions to build the device and to use it. The experiments conducted with already built devices showed that it works pretty well for most people after a short period of adaptation.

Keywords: DIY (Do It Yourself) accessibility device, HCI (Human Computer Interface), interfaces and techniques for information access, user adaptability.

Introduction

Computer mice and other interface devices rely mostly on hand movements thus becoming useless to those with impaired hands (section on target users).

Fortunately, there are several interface gadgets that partially or totally cover the functionality of traditional computer mice through the use of elements that can be operated by body parts other than hands (section on mice and mouse-like devices).

Unfortunately, they are expensive, require software installations, lack of some of the functions of a regular computer mouse, and, besides, are difficult to adapt to a wide range of users.

On one hand, these mouse-replacing devices are rare and expensive because of the inexistence of a big market able to generate enough return. On the other hand, we all have the possibility of building devices adapted to our needs thanks to the large-scale market of everything related to the information and communication technologies and, specifically, of DIY electronic components.

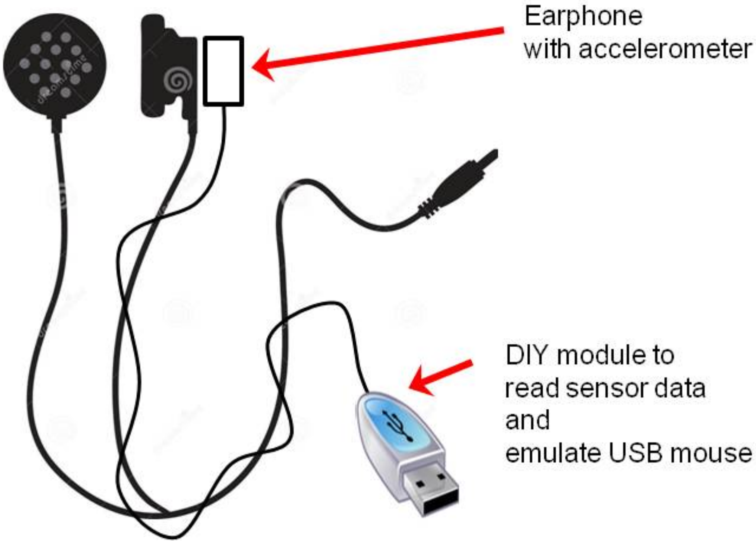
In a similar way than proposed by Hurst and Tobias (2011), ATSolutions (atsolutions.org) or DIYAbility (www.diyability.org), in this work we have taken advantage of the availability of DIY components to build an open-source, hands-free computer mouse at an affordable prize. Hence, potential users can have easy access to an earphone-mounted mouse that can be adapted, i.e. programmed, to best suit their needs.

Most of the already existent mouse-replacing devices sense head movements instead of hand and finger ones to determine pointer displacements and mouse actions. To do so, an accelerometer can be placed onto an earphone and data from it read and processed on an electronics board such as Arduino, BeagleBone or Raspberry Pi, to mention a few. At its turn, the electronics board emulates a conventional USB computer mouse so that no special drivers or software has to be installed (see Fig. 1.)

The result earphone-mounted computer mouse can significantly improve the life quality of those who cannot use their arms and hands, temporarily or permanently, providing an alternative to accessibility to computers and similar devices.

Therefore, the main goal of this work is to make available all the necessary elements to build a “computer mouse earphone” to anyone, and so, make it available to any other person in need of it, without any other requirements.

Figure 1. Earphone-mounted mouse emulator. Source: authors.



The proposed device (section on the accelerometer-based computer mouse) is inexpensive, with components commercially available and easy to buy. Its assembly is straightforward, with no need to have any technical knowledge or specific tools, and the software is downloadable for free on the Internet. It does not need any further software installation on any computer or portable device it is used with.

In this paper, a second version of the device is presented, that takes into account the first users' opinions of the original one. The changes in the embedded software for the improved version consisted, basically, of replacing the original "head position mirroring cursor" (Ribas-Xirgo & López-Varquiel, 2015) by a "head pushing cursor" (subsection on principles of operation). The idea of the last one is that the user moves the cursor on the screen by virtually pushing it with the head. For example, if he or she moves the head upward, then the pointer moves to the top of the screen.

The resulting device is easy to use so that the user does not need any particular, long training (subsection on user's guide).

Some devices were built to be able to test them with real users to determine its user-friendliness and to be able to adjust both the head movement tracking and the identification of gestures of the users to their intentions (concluding section.)

Target users

Anyone that may take advantage of using a head-tracking mouse instead of a conventional one can use it. However, the focus of such kind of devices is on people with special needs willing to access to computing devices and applications like people without disabilities. Unfortunately, diversity of impairments makes it difficult to know the number of potential users.

According to the Instituto Nacional de Estadística (Spanish National Statistics Institute), almost four million people (out of 47 million Spaniards) have some disability type and almost a 40% of these have problems with bones and articulations (Instituto Nacional de Estadística, 2008). Many of these people are potential users of the proposed device.

A more specific segment of population that might be candidate users consists of those people having paraplegias, which account for fifty thousand people in Spain (Jara, 2011). By extrapolating Mexican statistics from a Bahena-Salgado and Bernal-Márquez (2007) work, approximately half of them have tetraplegias and are possible users of this kind of devices.

However, it is worth noting again that the diversity of people's conditions makes it difficult for a single product to suit all specific needs and only a fraction of them might be really taking profit of the proposed device. In fact, is designed for people with good control on head movements, i.e. able to keep it still, but slight tremors should not greatly affect its functioning. Among them, anyone willing to use common software on any device may find this gadget useful. Take into account that, apart from computers, mice can be connected to mobile devices with Android (Hoffman, 2013), iOS (Karns, 2011) and, even, Microsoft Windows Phone (Schenck, 2014).

Furthermore, as people is getting used to interfaces other than mice, keyboards and touchscreens, a head movement tracking mouse can be used by any person that might find it interesting to. In fact, the use of, for example, Wiis from Nintendo or Kinects from Microsoft, have familiarized people with new ways of interaction with computers. And this contributes to see hands-free mice as a complementary form of man-machine interaction.

To sum it all up, the target users of the proposed device are some of those people that cannot access computer applications because of a temporal or permanent disability to use hands and fingers to manipulate a pointing and selection device such as mice or touchscreens, and some of those that might look for a different user experience with computers.

It is also important to highlight that, by using the proposed full-featured mouse and virtual keyboards, any user can have access to regular computer applications without further ado. Therefore, users are able to establish and maintain social relations through Facebook, Twitter, or any other social network system, can play games and work with computer applications, regardless of their possible disabilities.

Mice and mouse-like devices

The idea of substituting mice by more "natural" alternatives for pointing and clicking is not new. For example, back in 2006, Microsoft had foreseen a special glove (Ranta & Bathiche, 2006) to replace mice and, more recently, Leap Motion offers a device to be used like a touchpad (Panneta, 2013). In fact, touchpads and touchscreens have made mice obsolete to most people. However, these "mouse substitutes" still rely on hands and fingers.

Fortunately, there are more and more machines that have frontal cameras, and they can execute programs that transform users' gestures in front of the camera into mouse movements and actions (Graveleau, Mirenkov & Nikishkov, 2005; Palleja, Rubion, Teixidó, Tresánchez, Fernández del Viso, Rebate & Palacín, 2014; Pereira, Neto, Reynaldo, Luzo & Oliveira, 2009). Free cam-based virtual mice include EyeMouse (Mónaco & Ponieman, 2008), HeadMouse (Teixidó, Palleja, Tresánchez, Font, Moreno, Fernández del Viso, Rebate & Palacín, 2013) and Enable Viacam (Mauri Loba, 2008). However, they do not implement all the features of conventional computer mice. EyeCan (Kee, 2012) also uses computer cameras, but requires extra components.

With the success of the video game consoles like the Wii of Nintendo and with the commoditization of accelerometers, there are also solutions that incorporate them to build computer mice or devices alike. Many of them are commercial and protected by patents (Tong, 2000; Breen & Gerasimov, 2008; Ishimatsu, Irie & Takami, 1997; Schmid, Baettig & Schmid, 2003; Rodgers, Higgins, Gagnon & Farr, 2010). However, commercial or not, these solutions require user adaptation and, besides, have accuracy (LoPresti, 2001) and fatigue (Bureau, Azkoitia, Ezmendi, Manterola, Zabaleta, Pérez & Medina, 2007) problems.

Anyway, special needs people do require hands-free mice and there are commercial products that offer a similar functionality (see table 1 for a short list of them.) Unfortunately, they are pricey and limited to some platforms. Another important drawback of previous mouse replacement options is that they need installing software, which limits the number and type of computers and other devices they can be used with.

Table 1. Pointer devices.

Device	Sensor	Body part	Price
Computer mouse	Optical, others	Hand	< 100€
FootMouse (Hunter Digital)	Electromechanical	Feet	250€
SmartNav (Natural Point)	IR camera	Head	400€
LaZee Mouse (LaZee Tek)	Accelerometer	Head	500€
QuadMouse (Quadadapt)	Electromechanical	Lips, tongue, chin	550€
IntegraMouse (Adapt-it)	Electromechanical	Mouth	2150€

The proposed device emulates an USB mouse so it can be used with any computer, tablet or, even, smartphone. Moreover, there's no particular software installation, and, to make it cheap, i.e., under 100€, it is released as a DIY project open to even electronics or computer unskilled-people.

The accelerometer-based computer mouse

The idea of the work is to provide the information for anyone motivated to build a hands-free mouse for someone else needing it. Such information includes the bill of materials for the proposed device, instructions to build it, including how to embed the control program, and the user's guide. Before detailing the previous aspects, we shall comment how this device works.

Principles of operation

To make the device simple and easily mountable on any flat surface of a headphone or an earphone set, only one accelerometer is used.

By using a single accelerometer it is possible to obtain its (x, y, z) position. For accelerometers on the head, (x, y, z) ranges are quite narrow. For instance, a nodding movement gave a maximum span of 63 units for the X axis (see Fig. 2), and the maximum spans for tilting to the left or the right (see Fig. 3) were of 32 and 39 units, respectively, at the Z axis.

These ranges make it difficult to accurately translate head position to cursor location in screen coordinates. In fact, the first experiments with the device had proven that this mapping is only suitable for trained people that have good control on head movements.

However, while this might be interesting for some applications, it is not the case for mouse emulation.

Mimicking mice implies translating accelerometer position shifts to (x, y) displacement units. In this case, head tilting will be converted into vertical cursor movements, and nodding into horizontal ones.

Figure 2 shows that only one accelerometer axis changes significantly when moving the head up and down. Consequently, it is the axis to be used to obtain the y displacements for the cursor.

Figure 2. Recorded accelerometer values for an up-down head movement. Source: Authors.

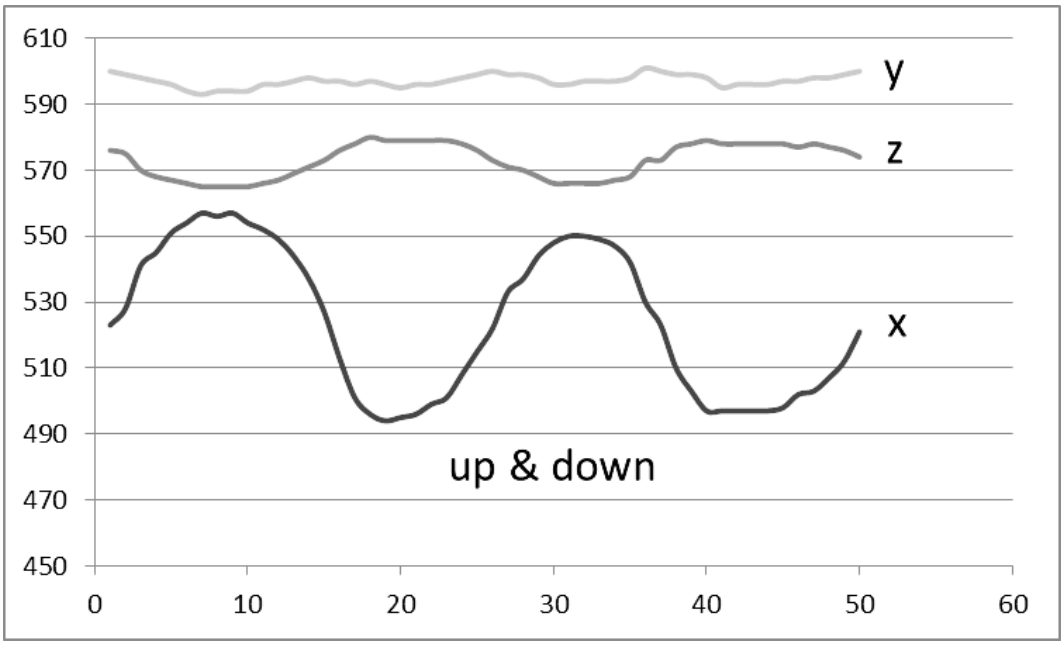
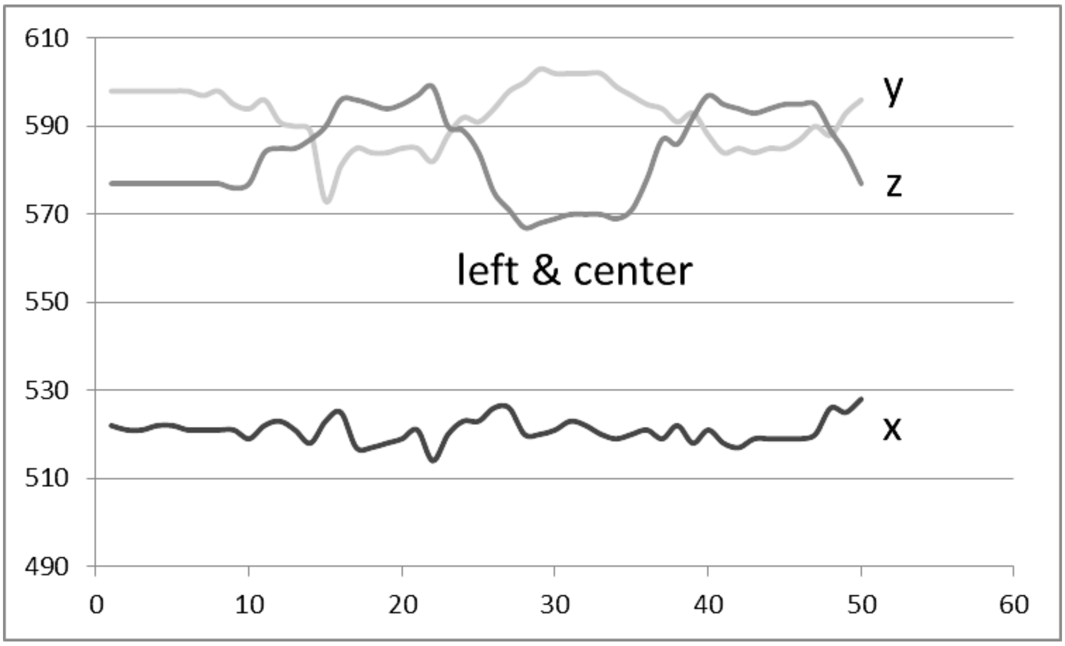


Figure 3 shows that the Z-axis data from the accelerometer is the one with the maximum sensitivity to head tilting, even this sensitivity is lower when leaning the head leftwards because the accelerometer is mounted in the left earphone.

Figure 3. Recorded accelerometer values for left and right head tilting. Source: authors.

a)Left



b)Right

Because the accelerometer can be mounted with different orientations and at different places around the head, accelerometer data ranges for head movements must be computed before any mapping to mouse (x, y) data and actions are done. This implies that the device requires a setup procedure for proper calibration of the mapping methods before being usable.

Mapping accelerometer data to mouse movements and actions is performed by first mapping them into a 2D space M. For the test devices,

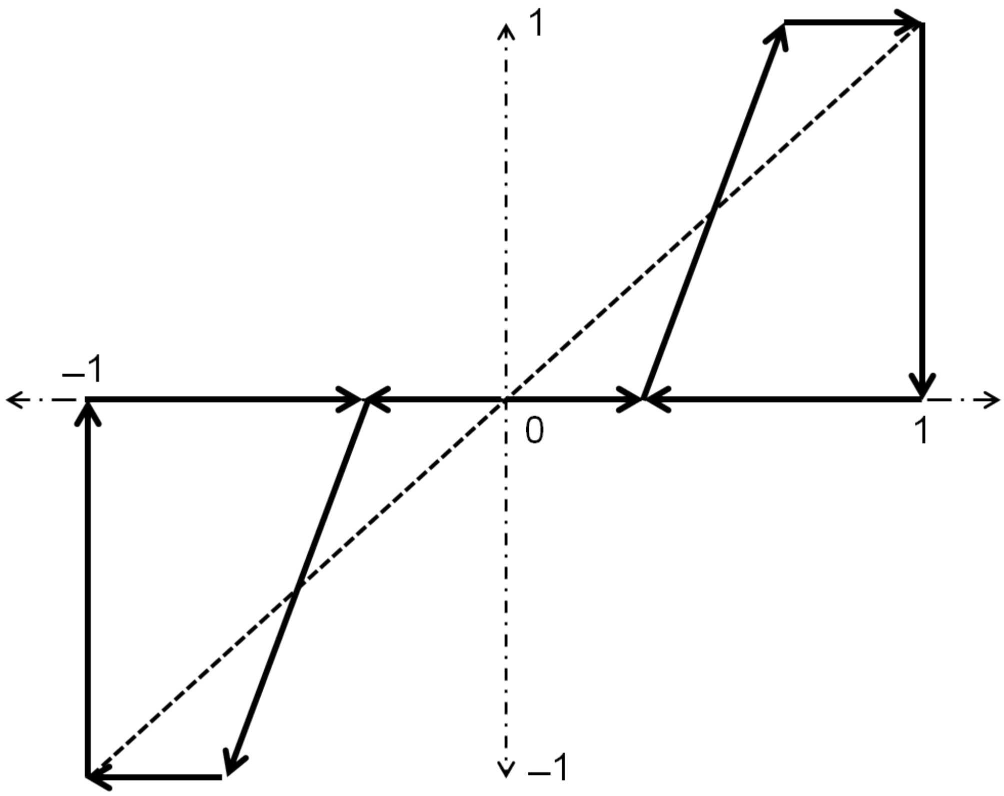
$$(x, y)_M = ((z-z_{min}) / (z_{max}-z_{min}), (x-x_{min}) / (x_{max}-x_{min}))_{accelerometer}$$

where maximum (z_{max}, x_{max}) and minimum (z_{min}, x_{min}) values are determined by calibration.

Any change in the position of the accelerometer is recorded as a change in the position of the map M. To filter out ‘mouse movements’ that cause unwanted cursor movements on the screen, only centrifugal movements on M are translated into mouse position shifts or mouse actions.

Abscissas in Fig. 4 correspond to one coordinate in M (x or y) and ordinates, to the normalized mouse shift counts values (horizontal or vertical) in the range [0, 1]. Note that the correspondence function forms a hysteresis loop, as it depends on the former values to know the direction of the movement.

Figure 4. Hysteresis of the mouse (x, y) functions with respect to the normalized 2D accelerometer position. Source: authors.



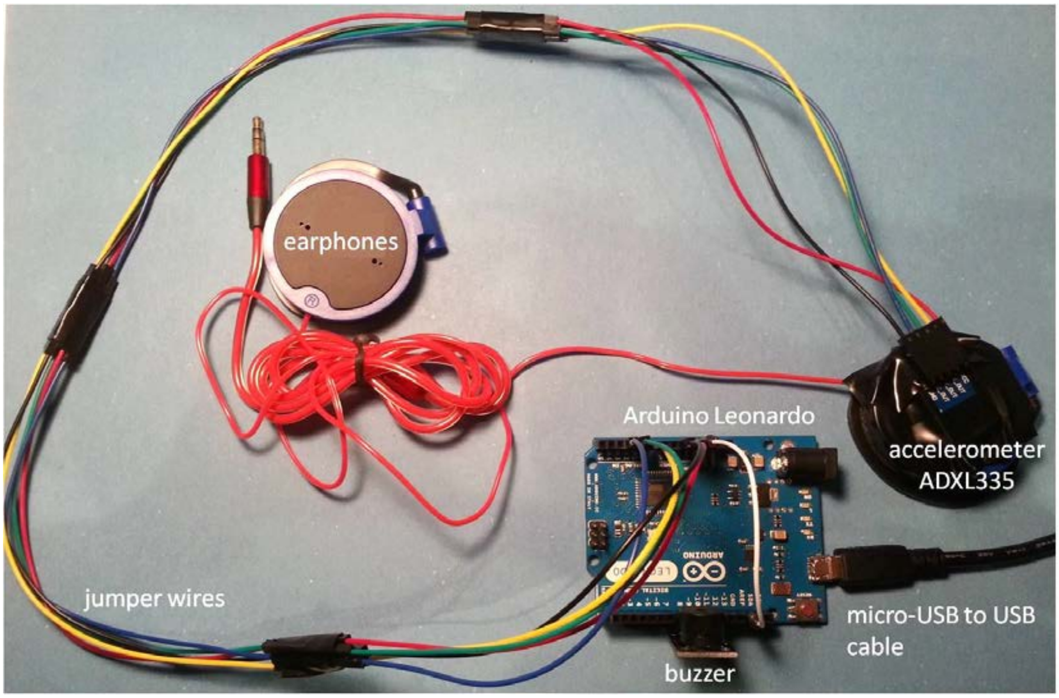
The idea is that the user only moves the cursor when pushing it. The more outwards, the more rapid it goes, up to a maximum. When he or she moves his/her head towards the resting position, the cursor stays still. Note that there is a region around the center where changes in $(x, y)_M$ are mapped to (0, 0), i.e. not taken into account. This makes it easy for users to keep the cursor still at a position on the screen.

In fact, keeping the pointer still for a while is the way to tell the device's embedded software to start a gesture-interpreting routine that checks the changes on $(x, y)_M$ to generate mouse actions. If no change is detected after a short period, it returns to the main “map-to-mouse-x-y-counts” translation routine.

Bill of materials

In order to build the device, you need to buy the material, which includes a pair of earphones, an accelerometer and an Arduino board (Fig. 5). Typically, all materials cost less than 80€.

Figure 5. Already built earphone mouse kit. Source: authors.



The Arduino Leonardo board processes the data from the accelerometer about the head movement and transforms them into mouse movements and actions. A buzzer is required to emit sounds to help the user during initial calibration of the device and to indicate when gesture recognition is on. The board connects to computers through a standard USB to micro-USB cable.

The accelerometer ADXL335 (board GY-61) is used to detect head movements. This very board can be directly powered from the Arduino board because it includes a voltage regulator on its own. Therefore, jumper cables link it with the Arduino board for power supply and data transmission.

The earphones are used as a support for the accelerometer and can normally be used, too.

Apart from the previous component set, scissors and insulating tape are the only extra elements to build a mouse.

Assembly guide and software installation

The first step is to attach the accelerometer board to one of the earphones with the tape, and the last one consists of programming the Arduino board. In between, jumper cables have to be connected among them to form longer cables that connect the Arduino board with the accelerometer, and the buzzer must be mounted.

To program the Arduino board, people must go to the Arduino's official web page to download the appropriate software, and to the earphone mouse web to download the program to be embedded into the Arduino board.

The device shall be ready to use when a message saying “download complete” appears on the Arduino programming application.

User’s guide

Upon connecting the earphone-mounted mouse to a PC, it starts a calibration procedure. After that, the device is ready to emulate a mouse controlled by the head movements.

Calibration

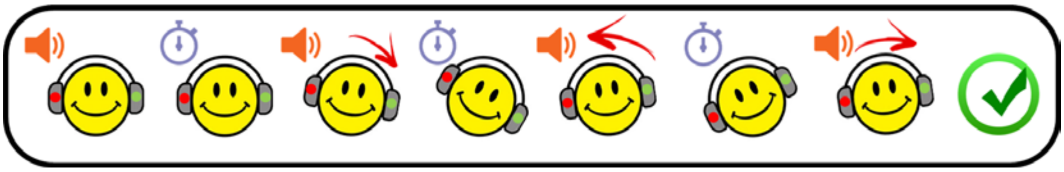
The calibration procedure determines head movement range and is required to correctly interpret the gestures that will become mouse actions. It is automatically done every time the device is plugged.

An accompanying person, possibly the same that has put the device on the user, must wait until the calibration process is completed. Take into account that in case of an incidence, the device must be reset. Once the calibration is correct, the user can continue to use it in a fully autonomous way.

The procedure is quite simple: the user has to keep his/her head in a rest position for 5 seconds, then lean it to the left for 5 seconds more and, finally, lean it to the right for other 5 seconds. Every step ending is signaled by a sound from the buzzer and by a blinking LED on the board. (The 5-second wait has been experimentally determined to be OK, but can be changed by re-programming the device with this value changed: it is one line of code, only.)

Figure 6 illustrates the calibration procedure by using smileys. The strip describes, step by step, what users should do by following the action shown by the smiley at every frame. The loudspeaker icon stands for hearing a buzz and the chronometer, for waiting a period of time in the smiley's position.

Figure 6. Calibration procedure. Source: authors.



Note that the rest position is the one in which the user feels comfortable looking at the screen. The movements and actions of the mouse will be achieved through the change of this position.

Operation

It is convenient to consider that this device has two operation modes: as a pointer and as a gesture interpreter. In the pointer mode, it transfers the head movement to the pointer movement on the screen. In the gesture interpreter mode, it transforms given head movements into mouse actions.

To switch from pointer mode to gesture interpreter mode you need to stop the pointer in the desired position. Each time the pointer stops on the screen, the buzzer module will emit a sound to show it. From this moment on, the user will have 2 seconds to make a movement that matches a mouse action. It is important that the head movement to perform the gesture starts when the sound is over.

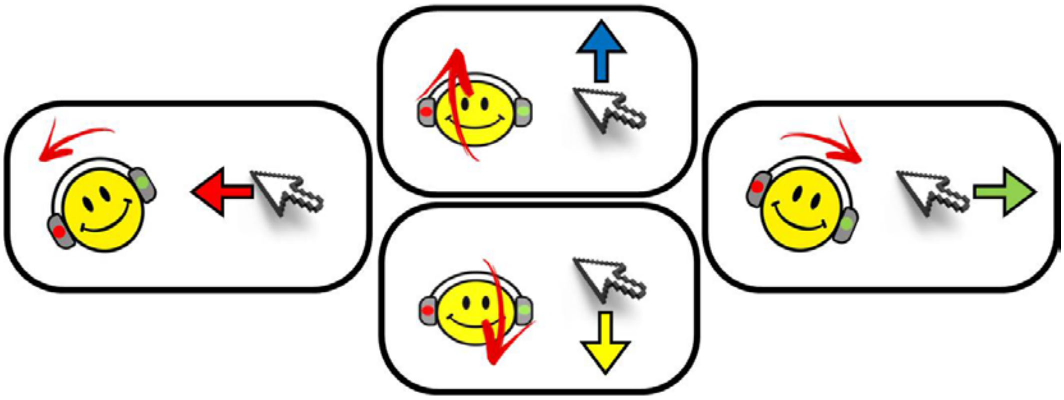
If no motion is detected, the mouse will return to the pointer mode and the user will be able to move the pointer through the screen following the head movements. To do so, he or she must move the head towards the direction in which he or she wants to push the screen cursor, as shown in Fig. 7.

By default, the device is in the pointer mode.

In the gesture interpreter mode, the device senses the head movement so to produce the corresponding mouse action (see Fig. 8.)

All gestures involve moving the head from the resting position and going back to this position once finished.

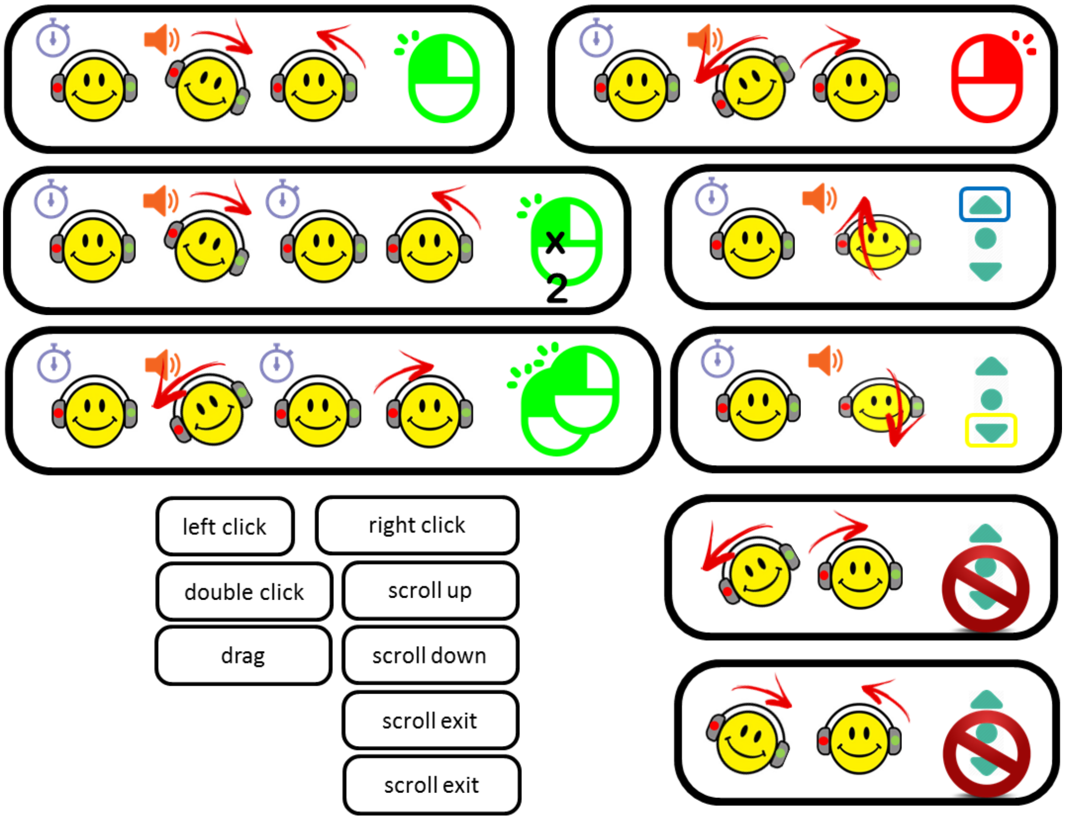
Figure 7. Pointer mode options. Source: authors.



Single left and right clicks, which are the most frequent mouse actions, are obtained by tilting the head leftwards or rightwards (graphic instructions on top of Fig. 8.)

Holding the head leant to the left causes a double click (upper long strip in the middle of Fig. 8) and by holding the head leant to the right the click and hold for a dragging effect is obtained (lower long strip in the middle of Fig. 8.) In both cases, the user must return to the resting position when the action is achieved.

Figure 8. Gestures and related mouse actions. Source: authors.



The gesture to scroll up or down consists of moving the head upwards or downwards (Fig. 8, middle right instruction strips.) Holding the head nodded up or down keeps the scrolling effect. To exit the up and down scroll movements (lower right corner on Fig. 8,) tilt the head to either side so that the device switches to pointer mode and the pointer starts moving again on the screen.

Results and conclusion

The aim of this work is to provide anyone in need for a hands-free mouse with an inexpensive, full-featured mouse. Particularly, it is addressed to special needs people so that they could have access to information technologies just as average people.

The proposed earphone-mounted, accelerometer-based, USB mouse has been designed to be like any other regular computer mouse, ready to use with any application on any platform.

The resulting device fully emulates a conventional computer mouse and it is the first of its class that does not require any specific driver or software installation.

In fact, this is one of the main differences with other devices such as the well-known SmartNav. The other is that it is an open device that can be built by following the instructions on the web http://www.earmouz.org, which also contains the embedded software to download, the user's guide, and complementary information about the project.

The device has been validated with a series of informal, empirical tests at exhibits and specialized centers. Tests consisted of asking users a few tasks like following a link on a web page already opened on the screen or opening an application just after being guided through the device setup.

The first round of tests with real devices had been carried out at our lab, at the Barcelona Mini Maker Faire (2014) and at a center that work with disabled people. People were asked to wear the device, guided through the calibration procedure and told how to use it. After observation of tests, they were asked to give their opinion about the device. At our lab and at the fair, all volunteers managed to use the devices after less than a minute but found some operations like scrolling and dragging a bit difficult.

In the case of the center for the disabled people, we found out that the version that mimicked the head movement was not suitable for those who couldn't control it (e.g. could not manage to click on an icon on the screen because they could not keep the cursor still) or who had to move it slowly. In fact, people suffering from nervous illnesses that led to hand impairment have several degrees of tremors that hinder the usage of any pointing device, including ours.

An added difficulty for testing the device with special needs' people is that, among the ones that can use some mouse-like device, most of them were already using one such device and were not keen to using a new one. Indeed, depending on their capabilities, learning how to use a new device is a long and hard process, hence something worth a second thought.

Anyway, we had taken their opinions into consideration for creating the second version of the embedded software, which changed the way the device worked from the head movement tracking mode to the “move-by-pushing” behavior. In this case, the user moves the head to virtually push the cursor on the screen up, down, left or right, and can make other actions (such as clicking, scrolling or dragging) by doing a virtual push within a few seconds after the cursor has been left still on the screen.

The second round of tests proved this last operation mode more tolerant to “movement noise” caused by tremors and to different head movement speeds. Tests have been carried out at the VI International Congress on Design, Research Networks and Technology for all, DRT4ALL (2015), as well as in private demos.

With this upgrade, however, casual testers got a bit confused at the beginning because they expected the cursor on the screen following their head movements. Anyway, once they were told about the “cursor pushing” mode, they adapted quickly and had fewer problems with mouse actions than with the former version. Therefore, the new one proved to be more easy-to-learn and robust.

Further improvements that were suggested by users include skipping the setup procedure and having an audible feedback of the mouse movements and actions. Consequently, we have plans to have a third version of the software to make calibration as seamless as possible and to provide users with sounds related to mouse operation. Anyway, all the information about the device is open so that anyone can adapt it to his or her needs. In the end, we expect that the proposed mouse can be helpful and improve the quality of life of its users.

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References

[1] Bahena-Salgado, Y., & Bernal-Márquez, J.N. (2007, January-February). Calidad de vida de los pacientes con paraplejía secundaria a lesión vertebral traumática. *Acta Ortopédica Mexicana*, 21(1), 3-7.

[2] Breen, R., & Gerasimov, V. (2008). *Inertial Sensor Input Device*, Pat. App. 20080211768. 09/04/2008.

[3] Bureau, M., Azkoitia, J.M., Ezmendi, G., Manterola, I., Zabaleta, H., Pérez, M., & Medina, J. (2007, June). Non-Invasive, Wireless and Universal Interface for the Control of Peripheral Devices by Means of Head Movements. In *Proceedings of the IEEE 10th International Conference on Rehabilitation Robotics*, (pp. 124-131).

[4] Graveleau, V., Mirenkov, N., & Nikishkov, G. (2005). A head-controlled user interface. In *Proceedings of the 8th International Conference on Humans and Computers* (pp. 306–311).

[5] Hoffman, C. (2013). How to Connect Mice, Keyboards, and Gamepads to an Android Phone or Tablet. *How-To Geek*. Retrieved from http://www.howtogeek.com/164783/

[6] Husrt, A., Tobias, J. (2011, October). Empowering individuals with do-it-yourself assistive technology. In *The proceedings of 13th international ACM SIGACCESS conference on Computers and accessibility* (pp- 11-18). ACM.

[7] Instituto Nacional de Estadística. (2008, November). *Encuesta de Discapacidad, Autonomía personal y situaciones de Dependencia (EDAD)*. Retrieved from http://www.ine.es/prensa/np524.pdf

[8] Ishimatsu, T., Irie, N., & Takami, O. (1997, August). Computer interface device for handicapped people using head movement. In *1997 IEEE Pacific Rim Conference on Communications, Computers and Signal Processing* (pp. 273-276). IEEE.

[9] Jara, M. (2011). Afirman que los nervios dañados de la médula espinal ¡pueden recuperarse! *Discovery DSalud*, No. 139. Retrieved from http://www.dsalud.com/index.php?pagina=articulo&c=1616

[10] Karns, J. (2011). How to Connect a Bluetooth Mouse and Keyboard to your iPad (or iPhone)! *Tablets, Wonder How To*. Retrieved from http://tablets.wonderhowto.com/how-to/connect-bluetooth-mouse-and-keyboard-your-ipad-or-iphone-0118475/

[11] Kee, E. (2012, February). Samsung eyeCAN mouse for disabled folk. *Übergizmo*. Retrieved from http://www.eyecanproject.org/p/english.html

[12] LoPresti, E.F. (2001). Effect of Neck Range of Motion Limitations on the Use of Head Controls. *Extended abstracts on Human factors in computing systems* (CHI'01). ACM, New York, NY, USA, 75–76.

[13] Mauri Loba, C. (2008). *Enable Viacam*. Retrieved from http://viacam.org

[14] Mónaco, N.A., & Ponieman N.B. (2008). *Emulador de Mouse – EyeMouse*. Degree thesis. ORT Argentina. Belgrano. Retrieved from http://ticbelgrano.blogspot.com/2008/12/eye-mouse-6-ao.html

[15] Palleja, T., Rubion, E., Teixidó, M., Tresánchez, M., Fernández del Viso, A., Rebate, C., & Palacín, J. (2008). Using the Optical Flow to Implement a Relative Virtual Mouse controlled by Head Movements. *Journal of Universal Computer Science*, 14, 3127–3141.

[16] Panneta, K. (2013, August). Why the computer mouse will soon be obsolete. *ECN Magazine*. Retrieved from http://www.ecnmag.com/articles/2013/01/why-computer-mouse-will-soon-be-obsolete

[17] Pereira, C.A.M., Neto, R.B., Reynaldo, A.C., Luzo, M.C.M., & Oliveira, R.P. (2009). Development and evaluation of a head-controlled human-computer interface with mouse-like functions for physically disabled users. *Clinics*. 64(10), 975-981.

[18] Ranta, C.S., Bathiche, S.N., & Chatterjee, M. (2006, October). *Wearable computer pointing device*. Microsoft Corp. US Pat. App. 20080084385.

[19] Ribas-Xirgo, Ll., & López-Varquiel, F. (2015, September). DIY computer mouse for special needs people. In *Proceedings of the XVI International Conference on Human Computer Interaction* (p. 27).

[20] Rodgers, A.G., Higgins, R.F., Gagnon, S.T., & Farr, J.C. (2010, May). *Head-mounted pointing and control device*. Alken, Inc. Pat. No. US 7,710,395 B2.

[21] Schenck, S. (2014). Windows Phone 8.1 could support USB HID class; get your accessories ready. *PocketNow*. Retrieved from http://pocketnow.com/ 2014/02/13/wp8-1-usb-hid-support

[22] Schmid, O., Baettig, A., & Schmid, C. (2003, May). *Dispositif a fonction de souris d'ordinateur*. Pat. WO2002EP12091, Pri. CH20010002024.

[23] Teixidó, M., Palleja, T., Tresánchez, M., Font, D. Moreno, J., Fernández del Viso, A., Rebate, C., & Palacín, J. (2013). Optimization of the virtual mouse HeadMouse to foster its classroom use by children with physical disabilities. *Advances in Distributed Computing and Artificial Intelligence Journal*, 7, 1-7. Retrieved from http://robotica.udl.cat/

[24] Tong, K. (2000, March). *Head Operated Computer Pointer*. Pat. App. WO2000017849A1.

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MUNICIPAL PRACTICES AND NEEDS REGARDING ACCESSIBILITY OF PEDESTRIAN INFRASTRUCTURES FOR INDIVIDUALS WITH PHYSICAL DISABILITIES IN QUÉBEC, CANADA

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Abstract: To create enabling environments for as many individuals as possible, including individuals with physical disabilities (IPD) who are more prone to encounter environmental barriers limiting their social participation, we need to examine current municipal practices related to accessibility. The objectives of this study were to describe existing practices supporting the design of accessible pedestrian infrastructures (API) for IPD living in Quebec (Canada), as well as to identify the perceived informational needs of the municipalities to design such infrastructures. A WEB survey was developed and validated by experts (i.e., municipal/provincial entities, IPD advocacy organisations, public transportation society, and researchers) and was sent to 507 municipalities. Descriptive statistics and recursive partitioning were performed, which allowed for the analysis of predictive variables through an arborescence (e.g. the characteristics of the municipality that predict the implementation of various accessible design practices). A total of 186 respondents (representatives of 184 of 507 municipalities) completed the survey (37%). Few municipalities have measures, resources, and tools to ensure the design of API for IPD. However, many respondents perceived the need for such resources. The presence of an action plan for individuals with visual disabilities and their consultation, availability of human resources, and knowledge of tools for the design of API favor the implementation of other accessibility practices and should be targeted to favor the presence of accessibility practices. Results of this study highlighted the need for conceptualization and implementation of guidelines to ensure API, and identified potential measures to improve practices that favor social participation of IPD.

Keywords: Pedestrian infrastructures, accessibility, physical disabilities, survey, municipal practices.

Introduction

For individuals with physical disabilities (IPD), environmental barriers or facilitators can make a difference between handicap situations and social participation. (P. Fougeyrollas et al., 2014) As mapped out in the *Human development model - Disability creation process* (HDM-DCP), the interaction between personal factors (identity factors, organic systems, capabilities), environmental factors (social and physical, considered either as facilitators or obstacles at various scales (micro, meso, macro)) as well as life habits (daily activities and social roles) constitute the interacting elements resulting in a handicap situation or social participation depending on the level of adequacy and of congruence between these factors. (Patrick Fougeyrollas, 2010) To ensure access to the built environment (a critical component in the interaction for social participation), standards, and practices in place need to reinforce the need of IPD. To create enabling environments for as many individuals as possible, including IPD who are more prone to encounter barriers, we need a systematic assessment of what municipalities do to favour accessibility. As of now, no literature describes the practices in Quebec's municipalities regarding the level of accessibility of pedestrian infrastructures. Some authors have studied walkability in Canada but not specifically for IPD. Walkability was mostly explored for older adults (Chaudhury, Campo, Michael, & Mahmood, 2016; Grant, Edwards, Sveistrup, Andrew, & Egan, 2010; Mitra, Siva, & Kehler, 2015; Negron-Poblete & Lord, 2014) and able-bodied individuals (Clark & Scott, 2016; Hajna, Ross, Joseph, Harper, & Dasgupta, 2015; McCormack et al., 2012; Thielman, Rosella, Copes, Lebenbaum, & Manson, 2015) and not really in terms of accessibility but of connectivity to destinations (Chaudhury et al., 2016; Grant et al., 2010; Hajna et al., 2015; Mitra et al., 2015; Negron-Poblete & Lord, 2014), traffic(Grant et al., 2010), subjective appreciation of the neighborhood (Chaudhury et al., 2016; Grant et al., 2010; Mitra et al., 2015; Negron-Poblete & Lord, 2014) and physical activity (de Sa & Ardern, 2014; Hajna et al., 2015; McCormack et al., 2012; Mitra et al., 2015; Thielman et al., 2015). Since Quebec (Canada) is a northern province with particular climatic conditions, and that municipal practices and governance are of great importance in the implementation of accessibility practices, knowing what are the current practices and desires of municipalities in Quebec's context is of prime importance as a first step to improve existing practices for the benefit of IPD.

The literature shows that IPD experience many obstacles related to pedestrian infrastructures, such as curb cuts (e.g., absence of (Gray, Hollingsworth, Stark, & Morgan, 2008; Hoehner, Ivy, Ramirez, Handy, & Brownson, 2007; Kirchner, Gerber, & Smith, 2008; Millington et al., 2009), abruptness (Bennett, Kirby, & Macdonald, 2009; Kerr & Rosenberg, 2009), height (Bennett et al., 2009; Cunningham, Michael, Farquhar, & Lapidus, 2005; Spivock, Gauvin, & Brodeur, 2007)), sidewalks (absence of (Clifton, Livi Smith, & Rodriguez, 2007; Hoehner et al., 2007; Kerr & Rosenberg, 2009; Lee, Tudor-Locke, & Burns, 2008), narrow or cluttered (Clifton et al., 2007; Hoehner et al., 2007; Kerr & Rosenberg, 2009; Kirchner et al., 2008; Lee et al., 2008; Millington et al., 2009; Spivock et al., 2007)), the lack of drainage or uneven surfaces (Clifton et al., 2007; Gray et al., 2008; Kerr & Rosenberg, 2009; Keysor et al., 2010; Kirchner et al., 2008; Lee et al., 2008; Millington et al., 2009; Spivock et al., 2007), the lack of maintenance and snow removal (Kirchner et al., 2008; Spivock et al., 2007), crosswalks (absence of (Clifton et al., 2007; Hoehner et al., 2007; Kerr & Rosenberg, 2009; Kirchner et al., 2008; Lee et al., 2008), insufficient crossing time (Kerr & Rosenberg, 2009; Spivock et al., 2007), absence of audible (Spivock et al., 2007) and visual (Clifton et al., 2007; Hoehner et al., 2007; Kerr & Rosenberg, 2009; Lee et al., 2008; Millington et al., 2009; Spivock et al., 2007) cues), the lack of lighting (Clifton et al., 2007; Kirchner et al., 2008; Lee et al., 2008; Millington et al., 2009), the presence of steps or stairs in the pedestrian area (Giesbrecht, Ripat, Cooper, & Quanbury, 2011; Kerr & Rosenberg, 2009), inadequate topography (Clifton et al., 2007; Kerr & Rosenberg, 2009; Kirchner et al., 2008), the absence of rest areas or of benches

(Hoehner et al., 2007; Keysor et al., 2010) or inaccessible bus stops (Hoehner et al., 2007; Keysor et al., 2010; Spivock et al., 2007). Environmental inaccessibility can lead to negative social, emotional and financial consequences for IPD (Cooper, Cohen, & Hasselkus, 1991; Deliot-Lefevre, 2006; Law, 1991; McClain, Medrano, Marcum, & Schukar, 2000; Shumway-Cook et al., 2005; Tranter, Slater, & Vaughan, 1991). High social costs can be entailed by the inaccessibility of pedestrian infrastructures, namely for physical and mental health treatment related to diminished productivity related to the lack of activity, social interactions, confinement, and degradation of health status (Brownson, Hoehner, Day, Forsyth, & Sallis, 2009; Cooper et al., 1991).

Although environmental barriers can reduce accessibility, elicit additional costs, and pose safety concerns, there is no consensus on the necessary characteristics that pedestrian infrastructures should possess to ensure efficient and safe mobility for IPD. Therefore, to reduce the occurrence of environmental obstacles, and ultimately improve municipal practices related to accessibility, an analysis of current practices in municipalities is required. With the rising of movements encouraging sustainable development, intelligent cities, and efficient urban planning, the consideration of IPD should be of the outmost importance since it is part of a larger process to improve infrastructures for all which contributes to the improvement of practices in general. Thus, the objectives of this study were to describe existing supporting practices for the design of accessible pedestrian infrastructures for IPD in Quebec's municipalities (Canada), and to identify perceived needs (e.g., information for municipalities to design accessible infrastructures).

Methodology

Approach

Quebec's Ministry of Transportation identified the need to provide tools to smaller municipalities (<15,000 inhabitants) to help them ensure accessibility of the built environment for individuals with physical disabilities who encounter a greater number of barriers outside their home. Thus, to propose solutions to these municipalities and to identify good applicable practices within this context, Quebec's municipalities were targeted. This study is part of a larger project based on a partnership and participative approach (Ivey & Sanders, 2006; Morales, Rousseau, & Passini, 2015; Sanders & Stappers, 2008) between experts in the fields of accessibility, IPD and pedestrian infrastructures. The objective of this larger project is to identify appropriate design practices of pedestrian infrastructures for IPD. Two committees were created: 1) a leading committee (follow up on the project's calendar and methodologies used) and 2) a consultative committee (to encourage sharing of the experts' knowledge throughout the different steps of the project to ensure that all is done to attain the goals set by the leading committee). These committees had representatives from the same organisations, but in different numbers. These organisations were: Quebec's Ministry of Transportation (*ministère des Transports du Québec*) (n=4), municipality of Quebec City (n=1), community organizations representing IPD (*Confédération des organismes de personnes handicapées du Québec* and *Regroupement des organismes de personnes handicapées de la région 03* (n=2), a government agency defending the rights of IPD (*Office des personnes handicapées du Québec*) (n=1), groups representing Quebec's municipalities (*Union des municipalités du Québec* and *Fédération québécoise des municipalités*) (n=2), and a public transportation service (*Réseau de transport de la Capitale*) (n=1).

Design and validation of the survey

A WEB survey (de Leeuw, Jox, & Dillman, 2008; Dillman, 2000; Sue & Ritter, 2007) was created to investigate practices and perceived information needs of municipalities of different densities in Quebec with regards to the design of accessible pedestrian infrastructures for IPD. A first draft was developed by the research team (seven researchers in the fields of rehabilitation, engineering, geography, sociology, mobility, architecture, social participation, occupational therapy) according to their experiential knowledge of accessibility practices in the design of pedestrian infrastructures and municipal practices. To our best knowledge, similar surveys or literature have not been documented. The content was then reviewed by the leading and the consultative committees. Taking into account the proposed modifications, the research team reviewed and refined the content of the WEB survey. The survey was created in an online format using *FluidSurvey* and pre-tested with three representatives of municipalities of different densities. Pre-tests were think-aloud cognitive interviews (Dillman, 2000) where respondents were instructed to say everything that came to mind aloud (comments/interpretations) while answering the survey.

Structure of the survey

The structure of the survey (contents of interest) is summarized here.

1. Municipality
    a. Number of inhabitants
2. Respondent
    a. Type of professional training
    b. Training domain
    c. Work title
3. Action plan
    a. Is there one and for whom
4. Responsible for accessibility
    a. Work load
    b. Work title
5. Hiring

   a. Knowledge of accessibility as a prerequisite

6. Associations
   a. Member of associations favouring access

7. Training
   a. Activities on accessibility
   b. Targeted work titles
   c. Type of activities
   d. Targeted subjects

8. Tools to design accessible pedestrian infrastructures
   a. Knows tools
   b. Tools used
   c. Advantages of the tools used
   d. Disadvantages of the tools used

9. Human resources
   a. Municipality
   b. Use of external resources (for which type of pedestrian infrastructure, work title, use of interventions and why)

10. Citizens' consultation
    a. Groups consulted

11. Particular practices
    a. Regarding pedestrian infrastructures and climate

12. Chose three factors influencing the most the implantation of accessibility
    a. Costs

b. Availability of expertise

c. Human resources

d. Material resources

e. Time

f. Topographic configuration

13. Importance of accessible pedestrian infrastructures

a. Curb cuts

b. Curbs

c. Tactile paving

d. Drainage grates

e. Lighting

f. Audible cues

g. Crossing islands

h. Urban furniture

i. Signage and traffic lights

j. Crosswalks

k. Sidewalks

Only for municipalities of less than 15,000 inhabitants

14. Pedestrian infrastructures present

a. Curb cuts

b. Curbs

c. Tactile paving

d. Drainage grates

e. Lighting

f. Audible cues

g. Crossing islands

h. Urban furniture

i. Signage and traffic lights

j. Crosswalks

k. Sidewalks

15. Complaints in the last five years

a. Damaged infrastructures

b. Lack of sidewalk

c. Snow removal

d. Drainage

e. Lighting

f. Defective equipment

g. Obstacles

h. Abrupt slope

i. High thresholds

j. Signage

k. Work area

l. Lack of time to cross the crosswalk

Depending on the type of respondent, not all questions were presented. For example, for questions on the types of infrastructures present in the municipalities and on complaints made in the last five years, it was assumed that larger municipalities had all these infrastructures and had received complaints regarding all proposed accessibility problems. In order to reduce the length of the questionnaire, it was decided that these questions were not to be asked to municipalities of 15,000 inhabitants or more.

It is important to recognize a distinction between smaller and larger municipalities. According to the Quebec governmental policy regarding the rights of individuals with disabilities (*À part entière: pour un véritable exercice du droit à l'égalité*) (Office des personnes handicapées [OPHQ], 2009), Quebec's municipalities of 15,000 inhabitants or more are required to have an action plan for individuals with disabilities. Those action plans, elaborated by the municipalities themselves, aim to reduce barriers of social integration for individuals with disabilities in their sector of activity and employment, ensure access to documents and services, guarantee access to goods and services, and provide sensitivity to the needs of individuals with disabilities (Office des personnes handicapées [OPHQ], 2009). Any modification made or planned to the environment or to services are documented in the action plan. This information was considered when developing the survey to reflect the reality of the different municipalities, as not all municipalities are required to apply the same actions.

Recruitment

The municipalities' classification of Quebec's ministry in charge of municipal affairs and of land use (*ministère des Affaires municipales et de l'Occupation du territoire (MAMOT)*) (Folcher, 2012) was used to classify municipalities into four groups by number of inhabitants (< 2,000 inhabitants (n=729), 2,000–9,999 inhabitants (n=292), 10,000–24,999 inhabitants (n=57), ≥ 25,000 inhabitants (n=45)). A total of 200 municipalities per group received the survey, or the total number of municipalities in the group if it contained less than 200 municipalities. The expected response rate was of 40 completed surveys per group. For the groups with more than 200 municipalities, the selection of the targeted municipalities was made by subcategorizing each group: for each increment of 1,000 inhabitants for municipalities of 2,000 to 9,999 inhabitants and each increment of 100 inhabitants for the municipalities of less than 2,000 inhabitants. Within these groups, municipalities were randomly chosen proportionally to the number of municipalities per subgroup to obtain a total of approximately 200 municipalities. For example, the group of municipalities of less than 2,000 inhabitants included 729 municipalities. In the subgroup including municipalities of 100 to 199 inhabitants, there were 25 municipalities. If translated to find the proportional number of municipalities required to obtain 200 municipalities within the 729-municipalities group: 25 / 729 x 200 = 7 municipalities. Seven municipalities were then randomly chosen among the subgroup, but the proportion of municipalities per administrative region, as described by the MAMOT's classification, was respected.

Procedure

The *Tailored Design Method* (Dillman, 2000) was used to deploy the survey. The selected municipalities were contacted through the general e-mail address of the municipality which was provided by the *MAMOT*. The first contact was made on November 10th 2014, to inform the municipalities about the goals of the upcoming survey, and then the link to complete the survey was sent on November 12th 2014. A total of three e-mail reminders were sent, approximately every two to three weeks (November 26th 2014, December 12th 2014, January 7th 2015), when municipalities had not completed the survey.

Data analysis

Descriptive statistics and recursive partitioning analyses (Strobl, Malley, & Tutz, 2009; Zhang & Singer, 1999) (SPSS 23, proc TREE) were used. Recursive partitioning is recommended for heterogeneous samples, such as small rural towns mixed with larger urban agglomerations, and is useful for analyses of nominal, ordinal and missing data. Once the most discriminative predictor was identified, the sample was split into two subsamples. Each subsample was then analyzed separately. The next discriminative predictor may not be the same for both subsamples. Consequently, the resulting tree may reveal variability between branches. (Strobl et al., 2009; Zhang & Singer, 1999) Contrary to regression, the resulting classification tree can detect conditional predictors that are effective only for a subsample. Regression is almost blind to these situations. It assumes that all predictors are more or less active by the same dynamic on every case put into the analysis.

Recursive partitioning is also recommended for detecting interaction between predictors. The tree growing algorithm was Exhaustive CHAID and no split was allowed unless a node contained at least 30 respondents (parent node) and the following child node should include at least 10 respondents.

With the expectation to achieve at least three levels within each branch, six times the parent node criterion (6 x 30 = 180) were selected as the targeted overall sample size (Rosner, 2006). For each significant split ($p \leq .05$ after Bonferroni adjustment), a phi coefficient was calculated based on the frequency table of the child nodes. This effect size estimate indicates the level of discrimination of the split (Field, 2009). A phi coefficient of .25 was indicative of a noticeable difference between proportions. Below this value, although statistically significant, a split may be useless. A valuable effect size of the whole tree is the percentage of correct classification between the real outcome and the estimated outcome, based on the information provided by the predictors. It is to be noted that the branching does not allow determination of whether the predictors have a causal relationship on the dependent variables; it only shows the difference in dynamics that each variable can provide regarding the variable of interest. Ideally, all categories of outcome should have a high correct classification percentage. However, one category is usually better predicted than the others. This may reflect a poor potential of prediction of an observed event in comparison to a non-event. This is the case when the non-event is better predicted. Therefore, the percentage of anticipated answers determining whether the branching represents what could be anticipated according to the respondents' answers was also calculated.

Recursive partitioning analyses were performed with the entire group of respondents. Too few larger municipalities (≥15 000 municipalities, n=50) were present to allow the inclusion of this type of municipality as predictor. Recursive partitioning analyses were performed for several dependent variables including: (a) the implementation of action plans for motor, (b) visual and (c) hearing disabilities, (d) having an employee responsible for ensuring accessibility, (e) knowledge transfer activities for employees, (f) knowing about and (g) using tools to ensure accessible pedestrian infrastructures, (h) the consultation of external resources and (i) of citizens, in the implementation of accessibility practices by including all other variables in the analysis. All the variables present in the survey were analyzed, but only those with significant results are presented in this paper (for the entire set of data of descriptive statistics, including variables that were not identified as variables of interest see supplementary files provided).

Results

Municipal practices

A total of 186 municipal representatives from 184 municipalities completed the survey. The majority of respondents have a university background (n=92/182) or have a technical professional degree (n=49/182). In municipalities of <15,000 inhabitants, many have a high school diploma as their highest diploma (n=13/132). Municipalities of <15,000 inhabitants' respondents were mainly accountants (n=33/131) or urbanists (n=16/131). Municipalities of ≥15,000 inhabitants' respondents were mainly civil engineers (15/50). Many respondents were also from a leisure, community life and recreational domain (n=17/181). The job title that was the most represented was manager (n=51/183) from various domains. Here are the descriptive statistics of the sample.

1. ≥ 25,000 inhabitants
    a. Number of contacted municipalities: 45
    b. Number of municipalities in total: 45
    c. Number of completed surveys: 33
        i. Percentage of those contacted which completed the survey: 73.3%
        ii. Percentage of completed surveys on the total number of municipalities: 73.3%
2. 10,000 – 24,999 inhabitants
    a. Number of contacted municipalities: 57
    b. Number of municipalities in total: 57
    c. Number of completed surveys: 34
        i. Percentage of those contacted which completed the survey: 59.7%
        ii. Percentage of completed surveys on the total number of municipalities: 59.7%

3. 2,000 – 9,999 inhabitants
    a. Number of contacted municipalities: 204
    b. Number of municipalities in total: 292
    c. Number of completed surveys: 60
        i. Percentage of those contacted which completed the survey: 29.4%
        ii. Percentage of completed surveys on the total number of municipalities: 20.6%
4. < 2,000 inhabitants
    a. Number of contacted municipalities: 201
    b. Number of municipalities in total: 729
    c. Number of completed surveys: 59
        i. Percentage of those contacted which completed the survey: 29.4%
        ii. Percentage of completed surveys on the total number of municipalities: 8.1%

In the following subsections we present and interpret the results regarding municipal practices. These results represent the variables of interest presented above as the content of the survey, which we will present as outcomes in the following text (e.g. action plans); the descriptive statistics and the associated recursive partitioning analysis for each will be presented. Table 1 shows one of the eight classification trees drawn from the recursive partitioning analysis. It can be used as a reference for schematizing the organization of the tree translated in a condensed format in table 2 presenting the results of all eight classification trees for each dependent variable listed above. The table identifies predictors at levels one, two and three (second, third and fourth columns of the table) of the tree. Empty cells mean that no further splits were statistically significant. The first column presents the outcomes, meaning the variables of interest in the content of the survey. The number associated to each section of the results and discussion section regarding this outcome is indicated. On the rightmost part of the table 2, the classification tables indicate how the real situation can be predicted by the predictor variables, it's the classification table for the entire tree, it's ultimate validity test. Elements in grey are predictors that are present for more than one outcome, such that each shade represents one predictor. Phi coefficients presented in bold are significant. Note that in table 2, acronyms have been used to provide a simpler presentation of the information. Here are the correspondences for these acronyms: IHD = Individuals with hearing disabilities, IMD = Individuals with motor disabilities, IPD = Individuals with physical disabilities, IVD = Individuals with visual disabilities. Other information gathered with the survey, other than what is related to the variables of interest which provided significant results for recursive partitioning analyses can be found in the supplementary file provided.

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Table 1. Example of recursive partitioning: Responsible for ensuring accessibility (see table 2)

Outcome		Level 1- Predictor		Level 2 - Predictor No branch		Level 2 - Predictor Yes branch	
Variable	Responsible for ensuring accessibility	Action plan for motor disabilities		Knowing the UMQ's recommendations		Consulting individuals with motor disabilities	
Branch		No	Yes	No	Yes	No	Yes
No	59/153 (38.6%)	53/109 (48.6%)	6/44 (13.6%)	52/98 (53.1%)	1/11 (9.1%)	6/23 (26.1%)	0/21 (0.0%)
Yes	94/153 (61.4%)	56/109 (51.4%)	38/44 (86.4%)	46/98 (46.9%)	10/11 (90.9%)	17/23 (73.9%)	21/21 (100%)
p		0.000		0.023		0.047	
Chi^2		16.196		7.654		6.343	
phi		0.325		0.265		0.380	

Table 2. Recursive partitioning results for the variables of interest in the survey

Outcome		Level 1- Predictor	Level 2 - Predictor		Level 3 - Predictor		Classification			
Implementing an action plan	For IMD	Consult IVD	IF YES		IF YES		Observed	Anticipated		
					Phi					
		0.439 (p=0.000)	Phi		IF NO			No	Yes	Correct %
					Phi					
			IF NO	Know the *Guide pratique d'accessibilité universelle of Quebec City*	IF YES		No	123	8	93.9
					Phi		Yes	29	26	47.3
			Phi	**0.274 (p=0.002)**	IF NO	Know the Ministry of Transportation's norms	Global %	81.7	18.3	80.1
					Phi	0.212 (p=0.036)				
	For IVD	Consult orientation and mobility specialists	IF YES		IF YES		Observed	Anticipated		
					Phi			No	Yes	Correct %
		0.564 (p=0.000)	Phi		IF NO		No	151	7	95.6
					Phi					
			IF NO	Consult IVD	IF YES		Yes	9	19	67.9
					Phi					
			Phi	**0.462 (p=0.000)**	IF NO	Civil engineering technician on the team	Global %	86.0	14.0	91.4
					Phi	**0.375 (p=0.000)**				
	For IHD	Consult IHD	IF YES		IF YES		Observed	Anticipated		
					Phi					
		0.518 (p=0.000)	Phi		IF NO			No	Yes	Correct %
					Phi		No	164	3	98.2
			IF NO	Know the *Guide pratique d'accessibilité universelle of Quebec City*	IF YES		Yes	11	8	42.1
					Phi					
			Phi	**0.401 (p=0.000)**	IF NO	Know the *INLB* and *Société Logique*'s recommendations	Global %	94.1	5.9	92.5
					Phi	**0.518 (p=0.000)**				

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Outcome	Level 1- Predictor	Level 2 - Predictor		Level 3 - Predictor		Classification			
Have a responsible for ensuring accessibility	Action plan for IMD	IF YES	Consult IMD	IF YES Phi		Observed	Anticipated		
	0.325 (p=0.000)	Phi	**0.380 (p=0.047)**	IF NO Phi			No	Yes	Correct %
		IF NO	Know the *Union des municipalités du Québec*'s guidelines	IF Yes		No	45	14	76.3
				Phi		Yes	1	93	98.9
		Phi	**0.265 (p=0.023)**	IF NO Phi		Global %	30.1	69.9	90.2
Have knowledge transfer activities regarding accessibility	Civil engineering technician on the team	IF YES	Site supervisor on the team	IF YES		Observed	Anticipated		
				Phi			No	Yes	Correct %
	0.471 (p=0.000)	Phi	**0.436 (p=0.010)**	IF NO Phi		No	121	3	97.6
		IF NO	Project manager on the team	IF YES Phi		Yes	15	10	40.0
		Phi	**0.363 (p=0.001)**	IF NO Phi		Global %	91.3	8.7	87.9
Know tools regarding accessibility of pedestrian infrastructures	Action plan for accessibility in general	IF YES	No complaints about damaged pedestrian infrastructures (last 5 years)	IF YES		Observed	Anticipated		
				Phi			No	Yes	Correct %
	0.378 (p=0.000)	Phi	**-0.319 (p=0.006)**	IF NO	Part of *Ville amie des enfants*	No	70	24	74.5
				Phi	**0.387 (0.004)**				
		IF NO	Urbanist on the team	IF YES	Have an action plan IHD				
				Phi	**0.303 (p=0.040)**	Yes	23	58	71.6
		Phi	**0.366 (p=0.002)**	IF NO Phi		Global %	53.1	46.9	73.1
Consult external resources regarding accessibility of pedestrian infrastructures for IPD	Action plan for IVD	IF YES		IF YES Phi		Observed	Anticipated		
	0.482 (p=0.000)	Phi		IF NO Phi			No	Yes	Correct %
		IF NO	Use of tools others than those proposed	IF YES		No	104	9	92.0
				Phi		Yes	21	35	62.5
		Phi	**0.230 (0.024)**	IF NO Phi		Global %	74.0	26.0	82.2

<table>
<tr><th>Outcome</th><th>Level 1- Predictor</th><th colspan="2">Level 2 - Predictor</th><th colspan="2">Level 3 - Predictor</th><th colspan="5">Classification</th></tr>
<tr><td rowspan="9">Consult citizens</td><td rowspan="2">Action plan for IVD</td><td rowspan="2">IF YES</td><td rowspan="2"></td><td>IF YES</td><td></td><td rowspan="4">Observed</td><td colspan="4" rowspan="2">Anticipated</td></tr>
<tr><td>Phi</td><td></td></tr>
<tr><td rowspan="2">0.372 (p=0.000)</td><td rowspan="2">Phi</td><td rowspan="2"></td><td>IF NO</td><td></td><td rowspan="2">N</td><td rowspan="2">S</td><td rowspan="2">A</td><td rowspan="2">Correct %</td></tr>
<tr><td>Phi</td><td></td></tr>
<tr><td rowspan="3"></td><td rowspan="3">IF NO</td><td rowspan="3">Know the INLB and Société Logique's recommendations</td><td rowspan="2">IF YES</td><td rowspan="2"></td><td>No</td><td>104</td><td>7</td><td>0</td><td>93.7</td></tr>
<tr><td>Sometimes</td><td>35</td><td>19</td><td>0</td><td>35.2</td></tr>
<tr><td>Phi</td><td></td><td>Always</td><td>5</td><td>0</td><td>0</td><td>0.0</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">Phi</td><td rowspan="2">0.150 (p=0.000)</td><td>IF NO</td><td>Manager on the team</td><td rowspan="2">Global %</td><td rowspan="2">84.7</td><td rowspan="2">15.3</td><td rowspan="2">0</td><td rowspan="2">72.4</td></tr>
<tr><td>Phi</td><td>0.096 (p=0.008)</td></tr>
</table>

****Abbreviations: IHD: Individuals with hearing disabilities, IMD: Individuals with motor disabilities, IPD: Individuals with physical disabilities, IVD: Individuals with visual disabilities*

Action plans

A total of 102 respondents (54.8%) indicated that their municipality did not have an action plan for individuals with disabilities and 16 did not know (8.6%). This mainly applies to small municipalities (<15,000 inhabitants) (NO=95/102, DON'T KNOW=14/16), which are not required to have an action plan by law. Of those who mentioned having an action plan, 13 (7.0%) did not know about its content, 55 (29.6%) had one for individuals with motor disabilities (IMD), 28 (15.1%) had one for individuals with visual disabilities (IVD), and 19 (10.2%) had one for individuals with hearing disabilities (IHD). Therefore, it seems that very few municipalities have taken action to inform their decisions to ensure access to citizens with physical disabilities, especially smaller municipalities (<15,000 inhabitants).

Action plans for individuals with motor disabilities. The most discriminative predictor presented in the recursive partitioning for the **implementation of an action plan for IMD** was the consultation of IVD to ensure accessibility of pedestrian infrastructures. This suggests that, if a municipality consults IVD, it is most likely to have an action plan for IMD. Considering IVD goes beyond the usual consideration of IMD in terms of accessibility, and considering other disabilities may lead to more inclusive practices, it is logical to presume that municipalities consulting IVD also have an action plan for IMD that may correspond to more considerations for individuals with disabilities in general. Otherwise, knowledge of the *Guide pratique d'accessibilité universelle* of *Quebec City* *(Service de l'aménagement du territoire de la Ville de Québec, 2010)*, and the characteristics public infrastructures should have, should be used to implement an accessibility action plan for IMD. In the absence of consultation of IVD and, knowledge of Quebec's Ministry of Transportation's norms (Transports Québec, 2007) favored implementation of such an action plan. The first and second nodes (i.e., consultation of IVD (0.439) and knowledge of the *Guide pratique d'accessibilité universelle* of *Quebec City* (0.274)) had a significant phi coefficient (in bold on table 2), thus are the only two variables that may influence the implementation of an action plan for IMD. The correct percentage for the anticipation of the answer 'NO, do not have an action plan for IMD' was high (93.9%), but low for 'YES' (47.3%). The resultant tree, therefore, may predict the municipalities who do not have an action plan. The small number of municipalities that had an action plan (n=55) might influence the small percentage for the anticipation of the answer 'YES'. Since the group is smaller, it is harder to predict whether a positive answer is truly positive or if it is positive by chance.

Action plans for individuals with visual disabilities. The most important discriminative predictor for the **implementation of an action plan for IVD** was the consultation of orientation and mobility specialists to ensure accessibility. Mobility specialists have an expertise related to visual disabilities, and their input assisted with consideration for IVD. Otherwise, consulting IVD also favored the implementation of an action plan for such individuals. In the absence of these conditions, having a civil engineering technician also favored the implementation of such an action plan. This type of resource is found less frequently in smaller municipalities, where there are fewer employees and less presence of action plans for IVD. This might be the reason why the presence of a civil engineering technician seems to be related to the implementation of an action plan for IVD. Phi coefficients for each node were significant (0.375-0.564) and may predict the presence of an action plan for IVD. The correct percentage for the anticipation of the answer 'NO, do not have an action plan for IVD' was high (95.6%) and lower, but in the majority, for 'YES' (67.9%). However, these indicators seem to show that the tree adequately classifies the factors influencing the implementation of an action plan for IVD, even if the number of municipalities which answered YES was smaller (n=28).

Action plans for individuals with hearing disabilities. The most important discriminative predictor for the **implementation of an action plan IHD** was the consultation of IHD. Otherwise, knowing about the *Guide pratique d'accessibilité universelle* of *Quebec City* *(Service de l'aménagement du territoire de la Ville de Québec, 2010)* favored the implementation of an action plan for IHD, similar to the results for predicting action plans for IMD. In the absence of these two conditions, knowing the recommendations from *INLB and Société Logique* (Institut Nazareth et Louis-Braille & Société Logique, 2012) for IVD favored the implementation of an action plan for IHD. Although these variables might seem unrelated, similar to how knowledge of IVD influenced actions plans for IMD, knowledge of the necessary tools for accessibility for IVD may also provide more insight into accessibility issues for IHD. Therefore, knowledge of IVD tools implies that the municipality might be more sensitive to accessibility for individuals with sensory disabilities. Phi coefficients for each node were significant (0.401-0.518) and may therefore influence the implementation of an action plan for IHD. The correct percentage for the anticipation of the answer 'NO, do not have an action plan for IHD' was high (98.2%), and low for 'YES' (42.1%). As previously explained for the implementation of an action plan for IMD, the answer NO might be well estimated because the group was larger (n=167), but too few respondents answered YES (n=19) to predict whether a positive answer is truly positive or if it is positive by chance.

Responsible for ensuring accessibility

Most respondents mentioned not having or not knowing who is responsible for ensuring accessibility in their municipality (n=59, 33 missing data). Many smaller municipalities (<15,000 inhabitants) did not have such resources (n=55, 21 missing data). Of those who mentioned having a person responsible for ensuring accessibility in their municipality, most said the person did not have a full-time job (n=4/103).

The most important discriminative predictor for **having a person responsible for ensuring accessibility in the municipality** was having an action plan for IMD. This might be due to the fact that a more structured accessibility measure, such as an action plan, might imply that someone needs to be in charge of its development, implementation and follow up. Moreover, if IMD were consulted to ensure accessibility, the likelihood of the municipality having a person responsible for accessibility was higher. Consultation of citizens needs to be planned, which is a job that may be done by the person responsible for accessibility. Otherwise, knowing about the Union of Quebec's municipalities' (*Union des municipalités du Québec*) guidelines (Union des municipalités du Québec & Culture Communications et Condition féminine Québec, 2009) also predicted having someone responsible for accessibility in the absence of an action plan for IMD. Phi coefficients for each node were significant (0.265-0.380), and these variables might influence the presence of a responsible for accessibility. The correct percentage for the anticipation of the answer ‘NO, do not have a person responsible for ensuring accessibility in the municipality’ (76.3%) and ‘YES’ (98.9%) were high, indicating the capacity of the tree to efficiently predict whether there is someone responsible or not.

Knowledge transfer activities regarding accessibility

Few respondents mentioned that their municipality offers knowledge transfer activities regarding accessibility for IPD (n=25/149). Of those who stated that their municipality does, many did half a day theoretical training (n=15) or sensitization activities (n=10).

The most important discriminative predictor to **having knowledge transfer activities regarding accessibility** was having a civil engineering technician on the team. Moreover, if there were site supervisors on the team, the likelihood of the municipality having knowledge transfer activities regarding accessibility was higher. Otherwise, having project managers on the team predicted having such activities in the absence of a civil engineering technician. Having all these specialized resources, most often found in larger municipalities where there were more knowledge transfer activities, is then logical. Phi coefficients for each node were significant (0.353-0.471), meaning that the variables in the tree were most likely to truly influence the presence of knowledge transfer activities. The correct percentage for the anticipation of the answer (NO, do not have knowledge transfer activities regarding accessibility’ (97.6%) was high and low for ‘YES’ (40.0%). As mentioned previously, the low count of YES answers (n=25) might not allow the discrimination between a true YES and the fact that it can be rated as YES by chance, explaining the low anticipation percentage for this answer.

Tools to create accessible pedestrian infrastructures for IPD

Some respondents mentioned knowing tools to help design accessible pedestrian infrastructures for IPD (n=81/175). However, smaller municipalities (<15,000 inhabitants) knew less about such tools (43/129).

The most important discriminative predictor to **knowing tools regarding accessibility of pedestrian infrastructures** was <u>not having an action plan regarding accessibility in general</u>. Without an action plan, it is likely that some municipalities employed other tools to structure their practices. Moreover, if there were <u>urbanists on the team</u> (mostly present in larger municipalities where tools and <u>action plan for IHD</u> have more chances of being known) there were even more chances for the respondent to know such tools. Otherwise, when there was an action plan, having had no complaints about damaged pedestrian infrastructures in the last five years (probably indicating that accessibility measures proposed in these tools are used), and being part of the association *Ville amie des enfants* (association for access of the municipalities for kids, being a measure grouping municipalities around various access issues which are discussed in various tools), also favored the knowledge of tools regarding accessibility of pedestrian infrastructures. Phi coefficients for each node were significant (0.303-0.387), showing the true influence of the presented variables on the knowledge of tools regarding accessibility. The correct percentage for the anticipation of the answer 'NO, do not know tools regarding accessibility of pedestrian infrastructures' (74.5%) and 'YES' (71.6%) were moderate, still indicating that the tree predicts the answer related to the variable of interest well.

Consultation of external resources regarding accessibility of pedestrian infrastructures for IPD

Few respondents consult external resources for recommendations (n=56/169). The most solicited professionals were orientation and mobility specialists (n=14), engineers (n=13) and representatives of disability groups (n=13). For those who had consulted external resources, when asked to evaluate the usefulness of these consultations, most mentioned that they were useful (n=22/54) or very useful (n=23/54).

The most important discriminative predictor for municipalities to **consult external resources** was that the municipality had an action plan for IVD, a more advanced measure of accessibility most likely to be present when other accessibility measures were present. Otherwise, the use of tools others than those proposed in the survey (not from Canada), which is a more advanced strategy to ensure accessibility, also favored the presence of this variable (consultation of external resources). Only the Phi coefficient of the second node (0.230) was not significant, indicating that the implementation of an action plan for IVD might be the only influential factor in the consultation of external resources by the municipality. Regarding the consultation of external resources, the correct percentage for the anticipation of the answer 'NO, do not consult external resources' (92.0%) was high and lower for 'YES' (62.5%), but the tree seemed to efficiently predict whether the municipality consults external resources or not.

Consultation of citizens

Most respondents mentioned that they have never consulted citizens when designing or redoing pedestrian infrastructures (n=111). Smaller municipalities (<15,000 inhabitants) consulted citizens more rarely (94/126 never do, the rest sometimes does). However, some always did (n=5) and a large proportion sometimes did (n=54) (n=170 answered the questions). For those who mentioned consulting citizens, most consulted IMD (n=33), and some consulted IVD (n=21) and IHD (n=17).

The most important discriminative predictor for **consulting citizens** was having an action plan for IVD. The fact that implementing an action plan for IVD is an advanced measure of accessibility, it is most likely to be associated to other accessibility measures. Otherwise, knowing the recommendations from *INLB and Société Logique* (Institut Nazareth et Louis-Braille & Société Logique, 2012) for IVD favored the consultation of citizens, and again considering IVD is associated with a more advanced consideration of accessibility and is more likely to be association with the presence of a greater number of accessibility measures. Even if these two conditions were not met, having managers on the team favored the consultation of citizens, which is logical since the managers can take action after the consultation of citizens to orient practices. Only the Phi coefficient from the first node was significant (0.372), while others were low (node 2=0.150, node 3=0.096), indicating that implementing an action plan for IVD was influential. The correct percentage for the anticipation of the answer 'NO, do not consult citizens' (93.7%) was high and low for 'YES' (35.2%). Here again the answer YES was rarely used (n=59) and it is difficult to determine if this choice of answer was true or due to chance.

Need for information regarding accessibility of pedestrian infrastructures

When asked about the importance of accessibility for a list of pedestrian infrastructures (see table 3), most respondents rated each structure as important to very important. An exception to this rule was tactile tiles, for which smaller municipalities did not give much importance as compared to larger municipalities. Such a pedestrian infrastructure is considered more specialized and focuses on access for IVD. They might, therefore, not be the main concern of smaller municipalities. Another exception was refuge islands. Both smaller and larger municipalities provided answers across the whole spectrum, with a tendency of being rated as less important as the other proposed pedestrian infrastructures. This might be due to the fact that very few could or were being installed in most municipalities. The smaller municipalities (<15,000 inhabitants) tended to rate some infrastructures as less important when compared to bigger municipalities. This might be due to the fact that in some smaller municipalities, such pedestrian infrastructures were not implemented. Some municipalities also provided other answers:

- None of the infrastructures is a preoccupation (n=2, ≤2,000 inhabitants);
- Hard to answer, all pedestrian infrastructures are not present (n=3, ≤2,000 and 10,000-14,000 inhabitants);
- Color contrast for surface finishes (n=1, 15,000-24,999 inhabitants);
- Important where there is a need (n=1, ≤2,000 inhabitants);

- Models of maintenance of accessibility for detours and other paths in work areas (n=1, ≥100,000 inhabitants);
- Cycling paths and shared spaces (n=1, 25,000-99,999 inhabitants).

Table 3. Level of importance of various pedestrian infrastructures according to the respondents (<15,000 inhabitants (n=136): left column and ≥15,000 inhabitants (n=50) : right column)

Infrastructure	Level of importance (frequency)													
	Not important		A little important		Moderately important		Important		Very important		I don't know		Missing data	
Crosswalk	4	0	5	0	11	0	38	9	51	32	12	0	15	9
Curb cut	5	0	2	0	9	0	42	2	50	39	13	0	15	9
Drainage grate	3	1	4	3	16	1	48	20	36	13	14	3	15	9
Furniture	0	0	5	2	23	12	55	12	29	14	10	1	14	9
Lighting	0	1	0	1	14	3	51	13	47	23	7	0	17	9
Pedestrian lights	19	1	13	1	8	1	30	15	32	23	18	0	16	9
Refuge island	26	1	21	0	25	12	21	11	6	14	20	3	17	9
Sidewalk	4	0	3	0	12	2	40	18	49	21	13	0	15	9
Surfacing	8	1	7	1	20	11	59	19	14	7	13	2	15	9
Tactile tile	24	3	27	6	16	8	19	8	8	10	27	6	15	9

Legend: Light colored cells represent answers with a higher response rate for smaller municipalities (<15,000 inhabitants) and dark colored cells represent those for larger municipalities (≥15,000 inhabitants).

Here is a summary of the different practices that should be favored for the outcome practices presented above to be implemented. These should be favored to improve accessibility practices in general for the design of pedestrian infrastructures.

1. Implementation of an action plan for individuals with motor disabilities (IMD)
    a. Consultation of individuals with visual disabilities (IVD)
    b. Knowing the Guide pratique d'accessibilité universelle Quebec City
    c. Knowing Quebec's ministry of Transportation's norms
2. Implementation of an action plan for individuals with visual disabilities (IVD)
    a. Consulting orientation and mobility specialists
    b. Consulting individuals with visual disabilities (IVD)
    c. Having a civil engineering technician on the team
3. Implementation of an action plan for individuals with hearing disabilities (IHD)
    a. Consulting individuals with hearing disabilities (IHD)
    b. Knowing the Guide pratique d'accessibilité universelle of Quebec City
    c. Knowing INLB and Société Logique's recommendations
4. Having a responsible for ensuring accessibility
    a. Action plan for individuals with motor disabilities (IMD)
    b. Consulting individuals with motor disabilities (IMD)
    c. Knowing the Union des municipalités du Québec's guidelines
5. Having knowledge transfer activities regarding accessibility
    a. Having a civil engineering technician on the team
    b. Having a site supervisor on the team

    c. Having a project manager on the team

6. Knowing tools regarding accessibility of pedestrian infrastructures
    a. Having an action plan regarding accessibility in general
    b. Having had no complaints about damaged pedestrian infrastructures in the last five years
    c. Being part of the association Ville amie des enfants
    d. Having an urbanist on the team
    e. Having an action plan individuals with hearing disabilities (IHD)
7. Consulting external resources regarding accessibility of pedestrian infrastructures for individuals with physical disabilities (IPD)
    a. Having an action plan for individuals with visual disabilities (IVD)
    b. Use of tools others than those proposed in the survey
8. Consulting citizens
    a. Having an action plan for individuals with visual disabilities (IVD)
    b. Knowing INLB and Société Logique's recommendations
    c. Having a manager on the team

Limits

The sample was only representative of the practices in Quebec's municipalities. The generalizability of the results should, therefore, be explored in other geographic contexts. Individuals who completed the survey were not necessarily representative of all employees within their municipality, and answers remain personal rather than a consultation of all employees in the municipality. However, consultation with colleagues was suggested. Such a study could be replicated within other contexts to explore practices in other settings.

Conclusions

The objectives of this study were to describe existing supporting practices for the design of accessible pedestrian infrastructures for IPD in Quebec's municipalities (Canada) as well as to identify the perceived informational needs of the municipalities to design accessible infrastructures. As previously mentioned, the built environment is a critical component in the interaction for social participation (Patrick Fougeyrollas, 2010), and standards and practices in place should be described to determine if IPD are considered to provide them with equal changes of accessing environments. This study has shown that few municipalities have measures in place to ensure access to their pedestrian infrastructures for IPD, especially smaller municipalities of less than 15,000 inhabitants who are not required by law to have an action plan regarding accessibility. However, certain factors have proven to be closely related to the presence of many positive accessibility measures, such as the consultation of and an action plan for IVD. These are more advanced considerations of access that go beyond the usual consideration of IMD, which also allow for the consideration of a greater number of users. Moreover, having access to a greater number of varied resources and tools favors the implementation of a greater number of accessibility measures. As for the need for information regarding accessibility of pedestrian infrastructures, most municipalities mentioned the importance of accessibility of most pedestrian infrastructures proposed in the survey (crosswalk, curb cut, drainage grate, furniture, lighting, pedestrian lights, sidewalk, surfacing). In order to ensure access to such infrastructures, it is critical to provide municipalities with the information that is required for ensuring an adequate design process. Adequate design measures for accessible pedestrian infrastructures for IPD should not only be recommended, but should be part of construction norms and legislations for equity of access and social inclusion. These findings provide greater knowledge on what to target in order to improve access in municipalities and provide suggestions for replication in other geographic regions. However, external factors might also influence the applicability of certain accessibility practices, such as the receptivity, implication and sensitivity of stakeholders in decisions regarding IPD and their expertise in the field, and have not been treated in the present study but are of great importance in ensuring the consideration of all citizens, regardless of their capabilities.

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References

[1] Bennett, S., Kirby, R. L., & Macdonald, B. (2009). Wheelchair accessibility: descriptive survey of curb ramps in an urban area. *Disability and rehabilitation. Assistive technology, 4*(1), 17-23.

[2] Brownson, R. C., Hoehner, C. M., Day, K., Forsyth, A., & Sallis, J. F. (2009). Measuring the built environment for physical activity: state of the science. *American Journal of Preventive Medicine, 36*(4 Suppl), S99-123 e112.

[3] Chaudhury, H., Campo, M., Michael, Y., & Mahmood, A. (2016). Neighbourhood environment and physical activity in older adults. *Social Sience & Medicine*(149), 104-113.

[4] Clark, A. F., & Scott, D. M. (2016). Barriers to Walking: An Investigation of Adults in Hamilton (Ontario, Canada). *International Journal of Environmental Research and Public Health, 13*(179), 1-12.

[5] Clifton, K. J., Livi Smith, A. D., & Rodriguez, D. (2007). The development and testing of an audit for the pedestrian environment. *Landscape and Urban Planning, 80*(1-2), 95-110.

[6] Cooper, B. A., Cohen, U., & Hasselkus, B. R. (1991). Barrier-free design: a review and critique of the occupational therapy perspective. *American Journal of Occupational Therapy, 45*(4), 344-350.

[7] Cunningham, G. O., Michael, Y. L., Farquhar, S. A., & Lapidus, J. (2005). Developing a reliable Senior Walking Environmental Assessment Tool. *American journal of preventive medicine, 29*(3), 215-217.

[8] de Leeuw, E. D., Jox, J. J., & Dillman, D. A. (2008). *International handbook of survey methodology*: European Association of Methodology.

[9] de Sa, E., & Ardern, C. I. (2014). Neighbourhood walkability, leisure-time and transport-related physical activity in a mixed urban-rural area. *PeerJ, 2*, e440.

[10] Deliot-Lefevre, P. (2006). L'accessibilité des cadres bâtis, des lieux publics et des transports. *Gérontologie et Société, 4*(119), 11-23.

[11] Dillman, D. A. (2000). *Mail and internet surveys - The tailored design method* (2nd ed.). New York: Wiley.

[12] Field, A. (2009). *Discovering Statistics Using SPSS* (3rd edition ed.). London: SAGE Publications Ltd.

[13] Folcher, V. L., N. (2012). Accessibilité pour et dans l'usage : concevoir des situations d'activité adaptées à tous et à chacun. *Le travail humain, 75*, 89-120.

[14] Fougeyrollas, P. (2010). *Le funambule, le fil et la toile*: Les Presses de l'Université Laval.

[15] Fougeyrollas, P., Boucher, N., Fiset, D., Grenier, Y., Noreau, L., Philibert, M., et al. (2014). Handicap, environnement et droits humains : du concept d'accès à sa mesure. *Revue Développement humain, handicap et changement social*(November), 5-28.

[16] Giesbrecht, E. M., Ripat, J. D., Cooper, J. E., & Quanbury, A. O. (2011). Experiences with using a pushrim-activated power-assisted wheelchair for community-based occupations: a qualitative exploration. *Canadian Journal of Occupation Therapy, 78*(2), 127-136.

[17] Grant, T. L., Edwards, N., Sveistrup, H., Andrew, C., & Egan, M. (2010). Inequitable walking conditions among older people: examining the interrelationship of neighbourhood socio-economic status and urban form using a comparative case study. *BMC Public Health, 10*, 677.

[18] Gray, D. B., Hollingsworth, H. H., Stark, S., & Morgan, K. A. (2008). A subjective measure of environmental facilitators and barriers to participation for people with mobility limitations. *Disability & Rehabilitation, 30*(6), 434-457.

[19] Hajna, S., Ross, N. A., Joseph, L., Harper, S., & Dasgupta, K. (2015). Neighbourhood walkability, daily steps and utilitarian walking in Canadian adults. *BMJ Open, 5*(11), e008964.

[20] Hoehner, C. M., Ivy, A., Ramirez, L. K., Handy, S., & Brownson, R. C. (2007). Active neighborhood checklist: a user-friendly and reliable tool for assessing activity friendliness. *American Journal of Health Promotion, 21*(6), 534-537.

[21] Institut Nazareth et Louis-Braille & Société Logique. (2012). *Critères d'accessibilité répondant aux besoins des personnes ayant une déficience visuelle*. Retrieved from http://www.inlb.qc.ca/wp-content/uploads/2015/02/Criteres-AU-AmenagementsExterieurs-nonAccessible.pdf.

[22] Ivey, M., & Sanders, E. B.-N. (2006). *Designing a physical environment for co-experience and assessing participant use*. Paper presented at the Wonderground, Design Research Society International Conference 2006.

[23] Kerr, J., & Rosenberg, D. E. (2009). Walking route audit tool for seniors [WRATS]. Retrieved 2010-12-15, from www.activelivingresearch.org/files/WRATS_AuditTool_07.17.09.pdf

[24] Keysor, J. J., Jette, A. M., LaValley, M. P., Lewis, C. E., Torner, J. C., Nevitt, M. C., et al. (2010). Community environmental factors are associated with disability in older adults with functional limitations: the MOST study. *Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 65*(4), 393-399.

[25] Kirchner, C. E., Gerber, E. G., & Smith, B. C. (2008). Designed to deter. Community barriers to physical activity for people with visual or motor impairments. *American Journal of Preventive Medicine, 34*(4), 349-352.

[26] Law, M. (1991). 1991 Muriel Driver lecture. The environment: a focus for occupational therapy. *Canadian Journal Of Occupation Therapy, 58*(4), 171-180.

[27] Lee, S. M., Tudor-Locke, C., & Burns, E. K. (2008). Application of a walking suitability assessment to the immediate built environment surrounding elementary schools. *Health Promotion Practice., 9*(3), 246-252.

[28] McClain, L., Medrano, D., Marcum, M., & Schukar, J. (2000). A qualitative assessment of wheelchair users' experience with ADA compliance, physical barriers, and secondary health conditions. *Topics in Spinal Cord Injury Rehabilitation, 6*(1), 99-118.

[29] McCormack, G. R., Friedenreich, C., Sandalack, B. A., Giles-Corti, B., Doyle-Baker, P. K., & Shiell, A. (2012). The relationship between cluster-analysis derived walkability and local recreational and transportation walking among Canadian adults. *Health & Place, 18*(5), 1079-1087.

[30] Millington, C., Ward Thompson, C., Rowe, D., Aspinall, P., Fitzsimons, C., Nelson, N., et al. (2009). Development of the Scottish Walkability Assessment Tool (SWAT). *Health Place, 15*(2), 474-481.

[31] Mitra, R., Siva, H., & Kehler, M. (2015). Walk-friendly suburbs for older adults? Exploring the enablers and barriers to walking in a large suburban municipality in Canada. *Journal of Ageing Studies, 35*, 10-19.

[32] Morales, E., Rousseau, J., & Passini, R. (2015). Using a Co-Design Methodology for Research on Environmental Gerontology. *Journal of Gerontology & Geriatric Research, 01*(03).

[33] Negron-Poblete, P., & Lord, S. (2014). Marchabilité des environnements urbains autour des résidences pour personnes âgées de la région de Montréal : application de l'audit MAPPA. *Cahiers de géographie du Québec, 58*(164), 233-257.

[34] Office des personnes handicapées [OPHQ]. (2009). « À part entière : pour un véritable exercice du droit à l'égalité », Politique gouvernementale pour accroître la participation sociale des personnes handicapées. Retrieved 2011/08/05, from http://www.ophq.gouv.qc.ca/fileadmin/documents/Politique_a_part_entiere_Acc.pdf

[35] Rosner, B. (2006). *Fundamentals of biostatistics* (6th ed.). California: Duxbury.

[36] Sanders, E. B.-N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. *CoDesign: International Journal of CoCreation in Design and the Arts, 4*(1), 5-18.

[37] Service de l'aménagement du territoire de la Ville de Québec. (2010). Guide pratique d'accessibilité universelle [Quebec City's Practical guide to universal accessibility].
from www.irdpq.qc.ca/communication/publications/guide_accessibilite/acces_Manuel_utilisation_2010.pdf

[38] Shumway-Cook, A., Patla, A., Stewart, A. L., Ferrucci, L., Ciol, M. A., & Guralnik, J. M. (2005). Assessing environmentally determined mobility disability: self-report versus observed community mobility. *Journal of the American Geriatrics Society, 53*(4), 700-704.

[39] Spivock, M., Gauvin, L., & Brodeur, J. M. (2007). Neighborhood-level active living buoys for individuals with physical disabilities. *American journal of preventive medicine, 32*(3), 224-230.

[40] Strobl, C., Malley, J., & Tutz, G. (2009). An introduction to recursive partitioning: rationale, application, and characteristics of classification and regression trees, bagging, and random forests. *Psychological Methods., 14*(4), 323-348.

[41] Sue, V. M., & Ritter, L. A. (2007). *Conducting online surveys*: SAGE publications.

[42] Thielman, J., Rosella, L., Copes, R., Lebenbaum, M., & Manson, H. (2015). Neighborhood walkability: Differential associations with self-reported transport walking and leisure-time physical activity in Canadian towns and cities of all sizes. *Preventive Medicine, 77*, 174-180.

[43] Transports Québec. (2007). Normes de la construction routière MTQ – Normes [Construction norms of Quebec's ministry of Transport]. Retrieved 2011/10/05, from www.mtq.gouv.qc.ca/portal/page/portal/accueil/publications/normes

[44] Tranter, R. T., Slater, R., & Vaughan, N. (1991). Barriers to mobility: physically-disabled and frail elderly people in their local outdoor environment. *International Journal of Rehabilitation Research., 14*(4), 303-312.

[45] Union des municipalités du Québec, & Culture Communications et Condition féminine Québec. (2009). Ma ville en toute confiance: Guide des meilleures pratiques pour un aménagement sécuritaire destiné aux minicipalités et à leurs partenaires.
from http://www.umq.qc.ca/uploads/files/pub_autres/Guide_AmenagementSecuritaire_mai09.pdf

[46] Zhang, H., & Singer, B. (1999). *Recursive partitioning in health sciences*. New York: Springer.

WALKING BEHAVIOR OF INDIVIDUALS WITH AND WITHOUT DISABILITIES AT RIGHT-ANGLE TURNING FACILITY

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Abstract: To accommodate the needs of pedestrians, urban designers need to carefully consider pedestrian walking behavior in different walking environments. Detailed studies of the walking behavior of pedestrians have been conducted and used for pedestrian simulation models. A right-angle turning facility (RATF) is found in many built environments. Hence the study of pedestrians' walking behavior in RATFs is important to build pedestrian simulation models. Previous studies have failed to address the walking behavior of individuals with visual and mobility disabilities even though they comprise a significant portion of the population in the United States. The purpose of this paper is to provide a comparative analysis of the effect of indoor RATFs on individuals with and without disabilities. The objective of this study was to determine whether there is any difference in the length of turns in the RATFS of individuals with and without disabilities and see the effect of RATFS in the walking speed of the individual with disabilities (IWDs) and individuals without disabilities (IWODs). The results show that for RATFs, individuals with visual disabilities and those with mobility disabilities have different walking behavior from each other and from IWODs. Therefore, individuals with visual and mobility disabilities should be considered differently from individuals without disabilities in simulation models.

Keywords: right-angle corners, individuals with disabilities, walking behavior, pedestrian

Introduction

With increasing urbanization, it is necessary for urban designers to understand the behavior of pedestrians in order to accommodate their mobility needs. Pedestrian simulations are increasingly powerful tools for designing suitable pedestrian environments (Gorrini et al., 2016; Köster et al., 2011). To support reliable pedestrian simulations, many pedestrian studies have been conducted to understand walking behavior in various. (Daamen and Hoogendoorn, 2003; Helbing et al., 2005; Seyfried et al., 2009; Sharifi et al., 2015; Sharifi, 2016; Sharifi et al., 2016). However, there have been few empirical studies on the walking behavior of IWDs even though they comprise a large part of the population in the United States (Rubadari et al. 1997; Wright et al. 1999; Christensen et al., 2013). The percentage of people with disabilities has increased from 11.9% in 2010 to 12.6 % in 2014 (Kraus, 2015). Thus, IWDs are not well represented in pedestrian simulations or the subsequent design of pedestrian environments. Therefore, this study compared the walking behavior of individuals with and without disabilities in RATFs, to gain a better understanding of the walking behavior of IWDs.

Due to the lack of information about the walking behavior of IWDs, the ADA Standards for Accessible Design's technical specifications for designing public turning are based on the standard dimensions of a wheelchair (ADA Standards for Accessible Design, 2010). Powered wheelchairs require more space than manual wheelchair for making turns (Koontz et al., 2010). The Highway Capacity Manual (HCM), which is generally consulted for the design of walking facilities, does not consider IWDs in its guidelines for building walking facilities. The HCM has some provisions for the design of the pedestrian facilities but does not include IWDs in the provisions. ADAAG provides guidelines for the design of the pedestrian facilities taking IWDs into account but does not consider interactions among IWDs and IWODs. To design safe and comfortable walking facilities that support a diversity of pedestrians, it is necessary to understand the walking behavior of diverse individuals in such facilities. Presently, pedestrian simulation models fail to adequately include individuals with disabilities, primarily by reducing the speed of individuals with disabilities when they are included, which contributes to a lack of designed environments that accommodate the behavior of individuals with disabilities (Shi et al., 2015). Existing simulation model methods include cellular automata, social force models, activity choice models, velocity-based models, network models, continuum models and others as well (Duives et al., 2013).

Several controlled experiments have been conducted to study the walking behavior of pedestrians in different indoor facilities. Daamen and Hoogendoorn (2003) conducted an experiment to analyze pedestrian flow in the narrow bottleneck of a facility. The microscopic walking behavior of pedestrians was studied considering different variables like free speed, walking direction, density, and effect of bottlenecks. Helbing et al. (2005) also conducted experiments on various pedestrian aspects in the built environment, from which the self-organizing phenomenon found in the walking behavior of pedestrians was derived. Similarly, Seyfried et al. (2009) conducted a unidirectional pedestrian flow experiment in the narrow bottleneck of a facility under laboratory conditions. The collection of pedestrians' walking behavior data led to the microscopic analysis of the walking behavior of the individuals at different facilities.

Turning facilities, found in many built walking facilities, have been examined previously; the results of which suggest that general population pedestrians when encountering turning facilities tend to move in a curved path determined by biomechanical factors and the geometric features of the path

(Hicheur and Berthoz, 2005). When pedestrians encounter a turning corner, they walk a circular path of around a 50cm radius around the corner (Lami et al., 2001). The change in the direction is not sudden but has to be planned before to reduce the acceleration of the body (Patla et al., 1991). Yanagisawa et al. (2009) investigated the decrease in pedestrians' walking speed while turning by relating it with turning friction (Ʈ), the decrease in walking speed when there is a change in direction. The effect of angled corridors on the flow of pedestrians has been statistically studied (Gorrini et al., 2013) by conducting a controlled experiment with 68 subjects which concluded that the flow rate is decreased with the introduction of angled corridors. Turning facilities are also found in merging angles. The study by Shiwakoti et al. (Shiwakoti et al., 2015), suggests the occurrence of weaving with reduced speed in these merging areas. Likewise, Dias et al. (2014) used numerical simulations that were then implemented to study pedestrians' walking behavior in angled corridors. Force based models (Helbing et al. 2000; Shiwakoti et al. 2011) have also been used to study pedestrians' walking characteristics in these walking environments. Shi et al.'s (2015) review on the study of turning movements found that not many studies have been conducted regarding the turning behavior shown by the pedestrians in angled situations. Although there were some studies of pedestrians' movement in turning facilities, not many studies have been found in the right angle turns, even though they are found in almost all building facilities. The experimental study by Dias et al. (2014) at right angle corridors with a total of 16 participants, under three scenarios (typical speed walking, high speed walking and slow running), concluded that the pedestrians tend to form a horizontal curve with reduced speed at the vicinity of angled corridors. Understandably, discrete pedestrian simulations model lower speeds during right-angle turns described by pedestrians yielding their movement (Bandini et al., 2014).

None of the studies above examined the walking behavior of the individuals with disabilities. There has been some study concerning the walking behavior of individuals with disabilities, but these tend to focus on evacuation routes and conditions (Rubadari et al. 1997; Wright et al. 1999; Christensen et al., 2013). An experimental study on the evacuation behavior of individuals with visual impairments revealed that there was mixed behavior among them (Sorensen et al., 2013). The effects of white canes, guide dogs, handrails and walls on the navigation of the exit were studied. Not many studies have been found on the typical walking behavior of the IWDs in the built environment. One study has shown that the space required by the powered mobility scooters for the IWDs to make turn is more than that necessary to avoid a counter or work surface from the side (Dutta et al., 2011). Comparative study of the standards for those relying on wheeled mobility in different walking environments suggests that these standards should be revised for easier access of the wheelchairs (Steinfield et al., 2010). Another study to differentiate walking speed among homogeneous and heterogeneous groups showed that the mean walking speed of heterogeneous groups is lower than the homogeneous group in different walking facilities and other small differences were found in their walking behavior (Sharifi et al., 2015; Sharifi, 2016; Sharifi et al., 2016).

It seems clear that the study of individuals with disabilities' walking behavior has found very little attention in the literature. Further, no studies have been found on the walking behavior of IWDs in RATFs. Therefore, the purpose of this study was to compare the walking behavior of individuals with and without disabilities in RATFs. The first objective of this study was to determine whether there is any difference in the length of the turns of individuals with and without disabilities when they encounter RATFs. The second objective of this study was to examine the effect of turns in RATFs on the walking speeds of individuals with and without disabilities. The results from this study will provide information about the differences in walking behavior of individuals with and without disabilities, which could be used to improve pedestrian simulation models.

Methodology

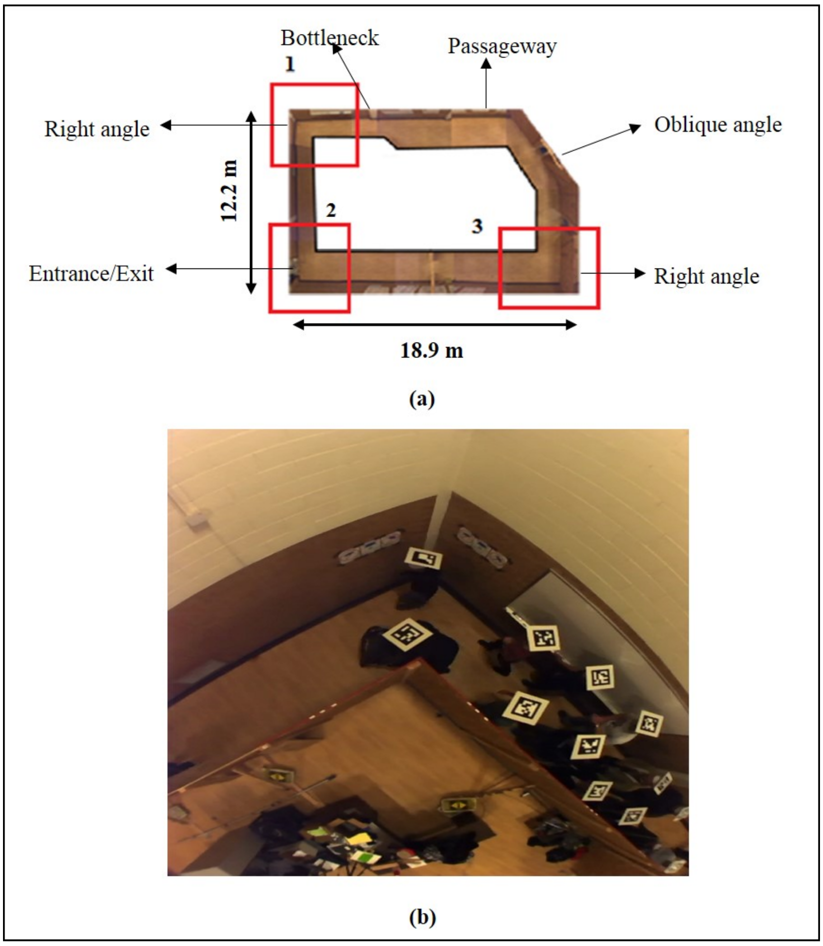
Experiment Design

With a focus on examining the behavior of different types of pedestrians, including IWDs, in different indoor walking environments, a controlled indoor experiment was carried out at Utah State University (USU). Different walking facilities (passageways, RATFs, oblique angle corridors, and bottlenecks) were considered. As shown in Figure 1, the experiments were conducted in a temporary circuit using self-standing wall panels constructed according to Americans with Disabilities Act Accessibility Guidelines (ADAAG) for door and passageway widths, etc. IWDs were recruited in collaboration with the Center for Persons with Disabilities (CPD) at USU. Participants represented individuals having physical disabilities (individuals with motorized wheelchairs, individuals with non-motorized wheelchairs, individuals walking with the use of crutches), visual disabilities and other disabilities. Unique markers were worn by the participants using mortar boards or graduation caps, which were read by cameras above the experimental area to allow the tracking of their movement. The walking trajectory of the individuals was collected using the automated video identification and tracking technology (Sharifi et al. 2015). Readers are referred to (Sharifi et al. 2015) for the detailed information about the experimental setup.

This study uses the data collected during the unidirectional portion of the experiment to understand the difference in walking pattern of individuals with and without disabilities in RATFs. For the unidirectional portion of the circuit experiment, a total of 170 people participated, which included 146 people without disabilities and 24 with different types of disabilities. People with disabilities consisted of 9 with visual impairment (all of which required the use of a white cane, 5 with motorized wheelchair, 6 with non-motorized wheelchair and 4 individuals walking with forearm crutches. Walking experiments were divided into 10-minute multiple lap experiment sessions, during which participants were asked to move at their maximum comfortable speed, resulting in about 2 hours of data collection. To acquire the data across congestion levels, the entry and exit of the participants were controlled during the experiment. The participants (both individuals with and without disabilities) were entered from the entry door at controlled times, walked in one direction around the circuit, and after the participant completed about 2 to 4 laps, they were taken out from the same exit door.

Figure 1 shows the layout of the experiment area. There were three different right-angle turning facilities in the layout of the experiment. The analysis was done for the RATF 1 as shown in Figure 1. RATF number 2 (see Figure 1) was omitted because the facility also had the door facility where the movement of the pedestrians would be affected by the entry and exit of the other individuals. Similarly, RATF number 3 in Figure 1 was avoided because of its closeness to the oblique angle facility.

Figure 1. (a): Experiment circuit indicating the various facilities: bottleneck, passageway, oblique angle, entrance/exit, and RATFs; (b): RATF with pedestrians walking according to one scenario. Source: authors.



Methods

The unidirectional flow trajectory data for every individual was examined at 0.2 second intervals, and their individual trajectory was analyzed, at the RATF between the individuals with and without disabilities. Also, the walking speed of the individuals at the right-angle periphery was calculated to analyze the walking speed pattern in the RATF per instantaneous speed for 0.2 second intervals.

Turn Initiation and Completion

When observing the trajectory of the individuals in the RATFS, individuals do not change their direction abruptly, but they change their direction gradually to the desired direction. The tangent length formed by the intersection of the two tangents were named as turn initiation length and turn completion length as shown in Figure 2.

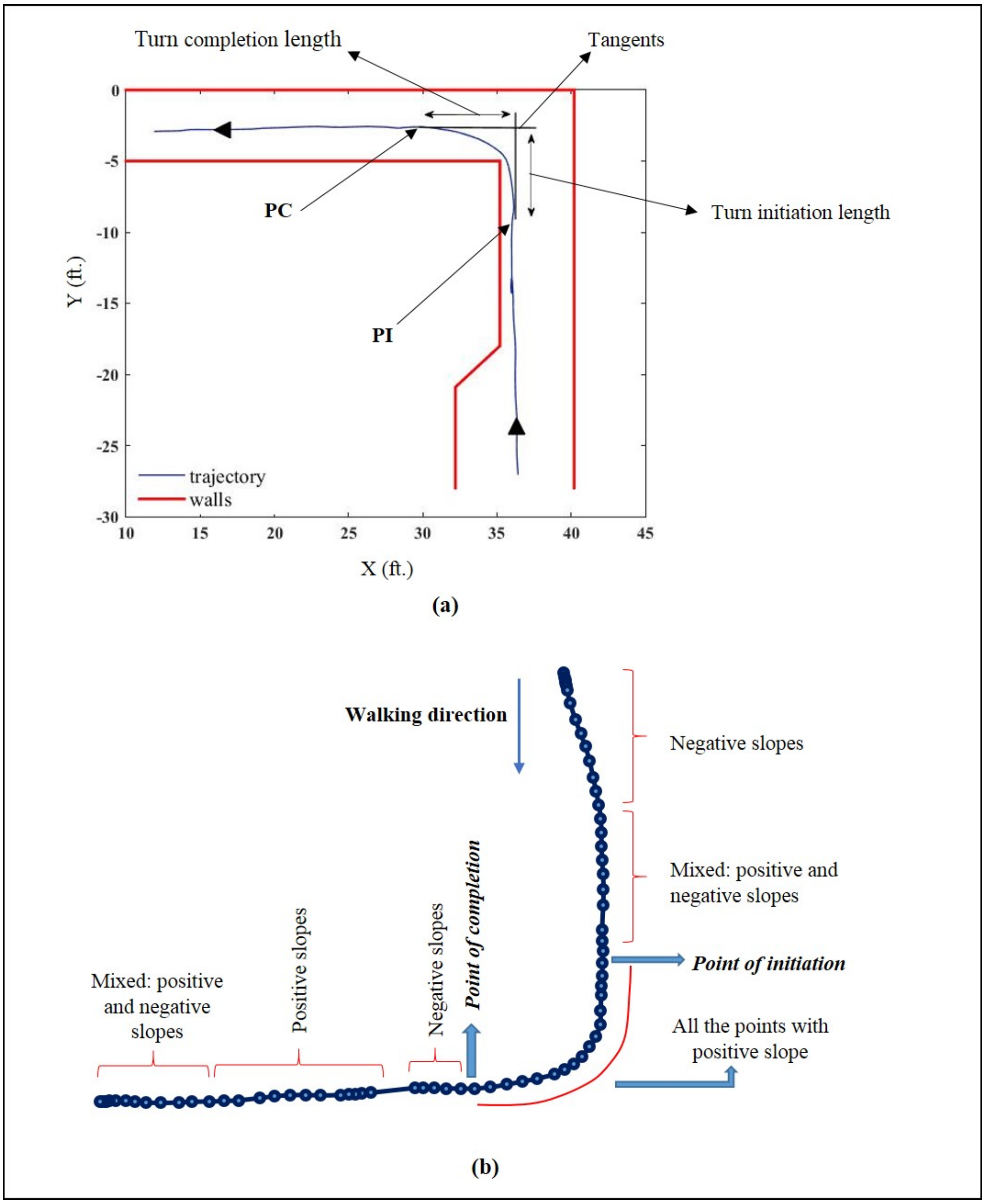
To find the point of initiation and point of completion, orientation of the individuals was examined. Using the slope equation between two adjacent points (x_1, y_1) and (x_2, y_2) in the trajectory of the individual, the trajectory slope of the individual in different points were calculated.

$slope = \frac{y_2 - y_1}{x_2 - x_1}$ where,

(x_1, y_1) and (x_2, y_2) are the coordinates of consecutive points in the trajectory of individuals.

After calculating the slope of the individual's trajectory, the direction of the individuals in the vicinity of RATFS was examined, and the point where the individuals start to change direction was named as turn initiation point. If the orientation of the individuals at the RATF was examined, they have same the sign of slope (positive) throughout the curve. The point they change the direction after making the curve is the point where the curve ends. This point where they change the direction was named as turn completion point.

Figure 2. (a): Trajectory of an individual traveling through a RATF; (b): Diagram of how turn initiation and completion points were determined from an individual's trajectory changes. Source: authors.



As shown in Figure 2, the trajectory of the individual contains both negative and positive slopes. The portion of the trajectory containing consecutive points with positive slope is the turning curve. As shown in Figure 2, not only the does the curved portion in the vicinity of RATF consists of points with positive slope, but other portions also do have consecutive points with positive slope. To automate the process, the curve portion was differentiated from other portions with consecutive positive slopes by fitting a circle at very portion of curve containing consecutive points with positive slope. The radius of circle for doing this differentiation was taken as 8 ft., which was determined by sensitivity analysis for some trajectories. Hence, the curve at the RATF was distinguished and intersecting tangents drawn to the curve at the points of turn initiation and completion gives us turn initiation and completion lengths.

Deceleration Pattern in Right-angle turning facility

The walking speed of all the individuals at the RATFS was analyzed to see whether there is any difference between IWDs and IWODs. The walking speed of all the individuals was calculated for a 0.2 second interval and the walking speed diagram was constructed.

Analysis and Results

Turn Initiation and Completion

For the following analysis individuals with visual disabilities were excluded as their turning curve pattern was distinct from that of other individuals with disabilities. A total of 161 individuals, 146 without disabilities and 15 with different types of mobility disabilities, were included in this analysis.

Table 1 provides information about the turn initiation and completion length for 2 groups: without disabilities and with disabilities. IWODs consisted of 146 different trajectory samples, whereas individuals with mobility disabilities consisted of 35 different trajectory samples. Individuals with mobility disabilities have been sub-divided into different categories according to the different mobility disability types in Table 2. As the mean length for the turn initiation and turn completion for different types of mobility disabilities were not significantly different, they were considered in a single group for the evaluation. The mean length of turn initiation and turn completion was calculated along with the standard error for each sample.

Table 1. Average values of turn initiation and completion lengths at right-angle turning facility.

Ids	Turn initiation (meters)	Turn completion (meters)
Without Disabilities (146 Samples)	1.44 (+-0.27)	1.57 (+-0.31)
With Disabilities (35 Samples)	2.13 (+-0.2)	2.14 (+-0.19)

Table 2 provides comparative information about the turn initiation and turn completion length for individuals with different types of disabilities.

Table 2. Average values of turn lengths for individuals with mobility disabilities.

Ids	Turn initiation (meters)	Turn completion (meters)
Motorized (11 Trajectories)	2.11 (+-0.19)	2.15 (+-0.22)
Non-Motorized (14 Trajectories)	2.2 (+-0.16)	2.14 (+-0.16)
Crutch (10 Trajectories)	2.06 (+-0.2)	2.13 (+-0.2)

Hypothesis testing was done to analyse the difference in turn initiation and turn completion lengths for different types of individuals.

Hypothesis 1: There is no difference in turn initiation length (μ) for individuals with mobility disabilities and individuals without disabilities.

$$Ho: \mu_{\text{individuals with mobility disabilities}} = \mu_{\text{individuals without disabilities}}$$

$$Ha: \mu_{\text{individuals with mobility disabilities}} \neq \mu_{\text{individuals without disabilities}}$$

This hypothesis testing was done to evaluate whether there is a significant difference in terms of the mean turn initiation length for individuals with mobility disabilities and without disabilities at the right-angle turning facility. The mean turn initiation length for individuals with mobility disabilities and without disabilities was tested at a 95% confidence interval. The results from the Z-test rejected the null hypothesis indicating that there is a significant difference in turn initiation length for the individuals with and without disabilities.

Hypothesis 2: There is no difference in turn completion length (μ) for individuals with mobility disabilities and individuals without disabilities.

$$Ho: \mu_{\text{individuals with mobility disabilities}} = \mu_{\text{individuals without disabilities}}$$

$$Ha: \mu_{\text{individuals with mobility disabilities}} \neq \mu_{\text{individuals without disabilities}}$$

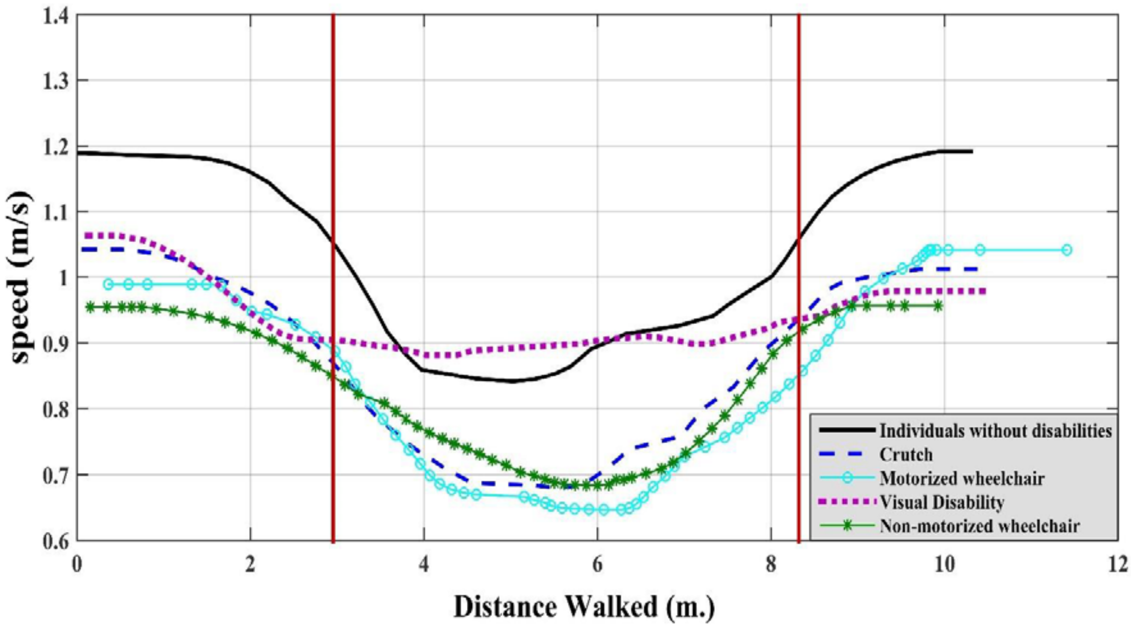
The mean turn initiation length for individuals with mobility disabilities and without disabilities was tested at a 95% confidence interval. The results from the Z-test rejected the null hypothesis indicating that there is also a significant difference in turn completion length between individuals with and without disabilities.

Deceleration Pattern in Right-angle turning facility

As the pedestrians had circular motion at the periphery of the RATFS, it was necessary to see whether this circular motion had any effect on the walking speed of the individuals. If the walking speed of the individuals is analyzed properly, it shows that individuals tend to reduce their walking speed before they encounter the turn and regain their normal walking speed after they complete the turn. This region where they reduce their speed can be termed as the “turning region.”

The walking speed of different IDs was analyzed on different laps for a single individual to study whether there is any difference in the deceleration pattern. For the IWDs other than individuals with visual disabilities, the deceleration pattern was found to be similar (speed decreases as they approach the RATF and increases after they complete their turn) as shown in Figure 3. The speed reduction pattern is found in all the individuals (both with and without disabilities) other than individuals with visual disabilities. For individuals with visual disabilities, walking speed pattern was found to be different than all other types of individuals. Hence, in the next section, an analysis of individuals with visual disabilities only will be performed, and the reasons will be examined.

Figure 3. Walking speed pattern of different types of individuals near RATFs, showing the U profile with the exception of individuals with visual disabilities whose profile is generally flat. Source: authors.



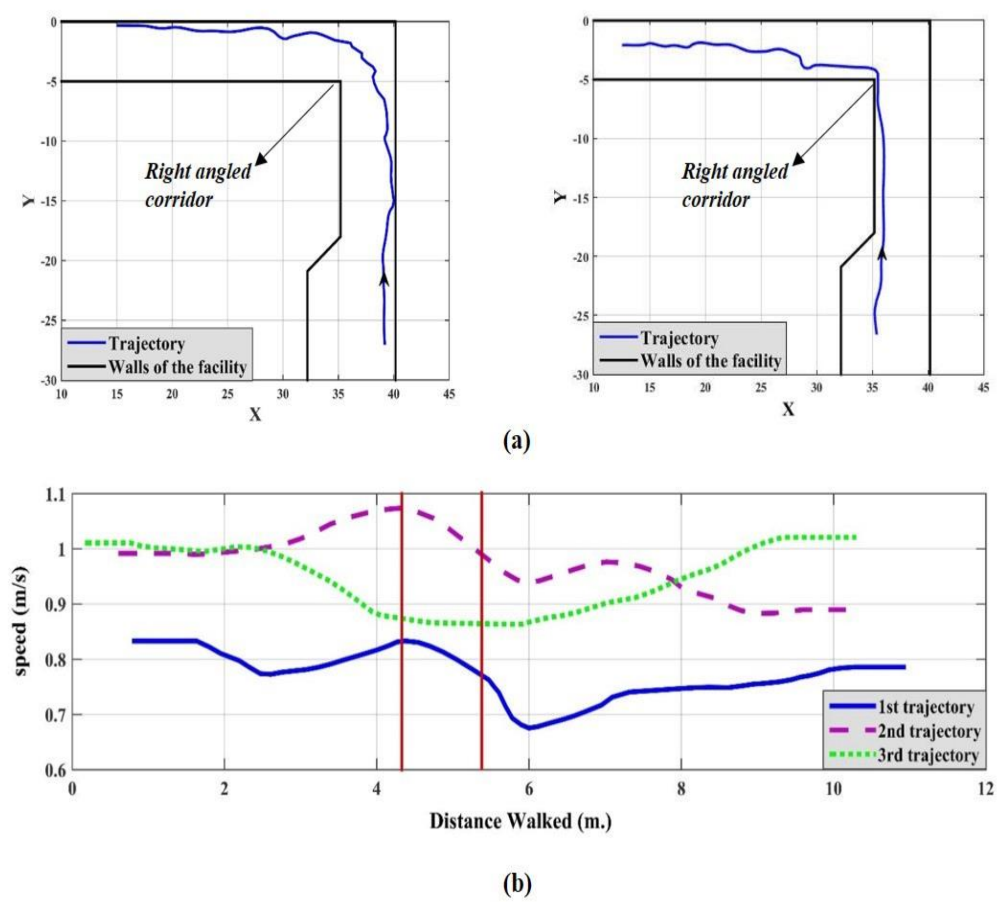
Analysis on Individuals with Visual Disabilities

After analyzing both turning behavior and speed pattern for all individuals, it was found that individuals with visual disabilities do not follow the same pattern as other individuals do. They do not have a distinct turning curve and turn initiation and completion points at the RATF.

Figure 4. Individual with visual disability at right-angle turning facility; (a): walking near the wall; (b): navigating the wall; (c): walking along the wall after making the turn. Source: authors.

(a) (b) (c)

Figure 5. Example walking behavior of individuals with visual disabilities; (a): trajectory of two different individuals with visual disabilities showing the abrupt change in trajectory; (b): walking speed patterns of three individuals with visual disabilities for the entire circuit indicating the shared drop in speed for the RATF. Source: authors.



The trajectory pattern of individuals with visual disabilities does not have distinct turning curve (Figure 4). But some of the individuals who were walking with the assistance of the IWODs show the turning curve, but it is not as distinct as the other individuals. This pattern can be seen in Figure 4. This walking behavior leads to two results. The first result is that individuals with visual disabilities do not a have distinct turning curve around RATFs. As individuals with visual disabilities move alongside the wall, they do not tend to make a curve before and after encountering the turn as was found for all other types of individuals. The second result was that they do not have the deceleration pattern near RATFS as found in all other types of individuals as shown in Figure 4. This is because they walk only with the reference of the wall and when they encounter the turn, they reduce walking speed afterwards, as shown in Figure 5.

Conclusion

Individuals encounter different walking facilities daily in buildings, public places and, mass gatherings. Designing facilities to alleviate the difficulties faced by individuals while navigating the walking facility is of prime concern for a designer. This study was focused on examining the effect of RATFs on the walking behavior of individuals with and without disabilities. Primary study of the trajectories of the individuals showed that they tend to follow a curve when they encounter RATFs. But the detailed study showed that individuals with mobility disabilities have turning lengths much larger than IWODs at the RATFS, while individuals with visual disabilities do not have such a pattern as others do at the RATFS. Further, we conclude that the walking speed pattern of different individuals decreases towards the vicinity of the RATF.

However, individuals with visual disabilities show unique characteristics from other individuals. They do not have a distinct trajectory curve at the RATFS as other individuals do. They tend to walk alongside the walls, as shown in Figure 5, and cross the RATF without making a turning curve. Also, they do not reduce speed in the periphery of the RATF as other individuals do, but only reduce speed after they navigate the RATF and walk along with the wall (Figure 5).

Existing simulation models reduce the walking speed of all individuals within a turning region defined by the yielding of their movement at these turns (Bandini et al., 2014). This study shows that individuals with visual disabilities do not have the speed reduction tendency at the RATFS as other types of individuals, which provides insight for improved simulation models. Present studies suggest that in pedestrian simulation models all individuals are considered same. As individuals with visual disabilities showed different characteristics than all other types of individuals, they should not be considered like other individuals in the simulation models. There are very few policies regarding the walking behavior of the IWDs in existing codes (HCM and ADAAG), which perpetuates the design of walking facilities not addressing IWDs' pedestrian needs. As the walking behavior differs among individuals with different disabilities, they all should be considered different in simulation models and policy making.

In future studies, the walking pattern of heterogeneous populations can be examined for bidirectional flows. The change in their direction based on the opposite flow could be useful to study their strategies during multidirectional flows. There have not been many policies regarding the walking behavior of the IWDs in the existing codes (HCM and ADAAG), which makes design of the walking facilities not being too favorable for the IWDs. Changes in the walking speed of heterogeneous populations per changes in density and direction should be analyzed, which will give better insight into how IWDs influence the walking speed of heterogeneous group when they encounter other walking towards them.

References

[1] Gorrini, A., Crociani, L., Feliciani, C., Zhao, P., Nishinari, K., & Bandini, S. (2016). Social Groups and Pedestrian Crowds: Experiment on Dyads in a Counter Flow Scenario. arXiv preprint arXiv:1610.08325.

[2] Köster, G., Hartmann, D., & Klein, W. (2011). Microscopic pedestrian simulations: From passenger exchange times to regional evacuation. In Operations Research Proceedings 2010 (pp. 571-576). Springer Berlin Heidelberg.

[3] Daamen, W., & Hoogendoorn, S. (2003). Controlled experiments to derive walking behaviour. European journal of transport and infrastructure research EJTIR, 3 (1).

[4] Helbing, D., Buzna, L., Johansson, A., & Werner, T. (2005). Self-organized pedestrian crowd dynamics: Experiments, simulations, and design solutions. Transportation science, 39(1), 1-24.

[5] Seyfried, A., Passon, O., Steffen, B., Boltes, M., Rupprecht, T., & Klingsch, W. (2009). New insights into pedestrian flow through bottlenecks. Transportation Science, 43(3), 395-406.

[6] Sharifi, M. S., Stuart, D., Christensen, K., & Chen, A. (2015). Traffic flow characteristics of heterogeneous pedestrian stream involving individuals with disabilities. Transportation Research Record: Journal of the Transportation Research Board, (2537), 111-125.

[7] Sharifi, M. S. (2016). Analysis and Modeling of Pedestrian Walking Behaviors Involving Individuals with Disabilities.

[8] Sharifi, M. S., Stuart, D., Christensen, K., & Chen, A. (2016). Time Headway Modeling and Capacity Analysis of Pedestrian Facilities Involving Individuals with Disabilities. In Transportation Research Board 95th Annual Meeting (No. 16-4732).

[9] Rubadiri, L., Ndumu, D. T., & Roberts, J. P. (1997). Predicting the evacuation capability of mobility-impaired occupants. Fire Technology, 33(1), 32-53.

[10] Wrigbt, M.S., Cook, G.K. & Webber, G.M.B. (1999). Emergency lighting and wayfinding provision systems for visually impaired people: Phase of a study. Lighting Research and Technology, 31(2), pp.35-42.

[11] Christensen, K. M., Sharifi, M. S., & Chen, A. (2013). Considering IWDsin a building evacuation: An agent-based simulation study. In 92nd Annual Meeting of the Transportation Research Board, Washington, DC.

[12] Kraus, L., 2015. 2015 Disability Statistics Annual Report. Durham, NH: University of New Hampshire.

[13] ADA Standards for Accessible Design (2010). Guidance on the 2010 ADA Standards for Accessible Design. U.S. Department of Justice.

[14] Koontz, A. M., Brindle, E. D., Kankipati, P., Feathers, D., & Cooper, R. A. (2010). Design features that affect the maneuverability of wheelchairs and scooters. Archives of physical medicine and rehabilitation, 91(5), 759-764.

[15] TRB (Transportation Research Board) (2010). Highway capacity manual, Washington, DC.

[16] Shi, X., Ye, Z., Shiwakoti, N., & Li, Z. (2015, July). A review of experimental studies on complex pedestrian movement behaviors. In CICTP 2015: Efficient, Safe, and Green Multimodal Transportation (pp. 1081-1096). American Society of Civil Engineers.

[17] Duives, D. C., Daamen, W., & Hoogendoorn, S. P. (2013). State-of-the-art crowd motion simulation models. Transportation research part C: emerging technologies, 37, 193-209.

[18] Hicheur, H., & Berthoz, A. (2005, December). How do humans turn? Head and body movements for the steering of locomotion Halim Hicheur and Alain Berthoz. In 5th IEEE-RAS International Conference on Humanoid Robots, 2005. (pp. 265-270). IEEE.

[19] Imai, T., Moore, S. T., Raphan, T., & Cohen, B. (2001). Interaction of the body, head, and eyes during walking and turning. Experimental brain research, 136(1), 1-18.

[20] Patla, A. E., Prentice, S. D., Robinson, C., & Neufeld, J. (1991). Visual control of locomotion: strategies for changing direction and for going over obstacles. Journal of Experimental Psychology: Human Perception and Performance, 17(3), 603.

[21] Yanagisawa, D., Kimura, A., Tomoeda, A., Nishi, R., Suma, Y., Ohtsuka, K., & Nishinari, K. (2009). Introduction of frictional and turning function for pedestrian outflow with an obstacle. Physical Review E, 80(3), 036110.

[22] Gorrini, A., Bandini, S., Sarvi, M., Dias, C., & Shiwakoti, N. (2013). An empirical study of crowd and pedestrian dynamics: the impact of different angle paths and grouping. Transportation Research Record, 41, 42.

[23] Shiwakoti, N., Gong, Y., Shi, X., & Ye, Z. (2015). Examining influence of merging architectural features on pedestrian crowd movement. Safety Science, 75, 15-22.

[24] Dias, C., Ejtemai, O., Sarvi, M., & Burd, M. (2014). Exploring pedestrian walking through angled corridors. Transportation Research Procedia, 2, 19-25.

[25] Helbing, D., Farkas, I., & Vicsek, T. (2000). Simulating dynamical features of escape panic. Nature, 407(6803), 487-490.

[26] Shiwakoti, N., Sarvi, M., Rose, G., & Burd, M. (2011). Animal dynamics based approach for modeling pedestrian crowd egress under panic conditions. Transportation research part B: methodological, 45(9), 1433-1449.

[27] Dias, C., Ejtemai, O., Sarvi, M., & Shiwakoti, N. (2014). Pedestrian walking characteristics through angled corridors: An experimental study. Transportation Research Record: Journal of the Transportation Research Board, (2421), 41-50.

[28] Bandini, S., Crociani, L., & Vizzari, G. (2014, May). Modeling heterogeneous speed profiles in discrete models for pedestrian simulation. In Proceedings of the 2014 International Conference on Autonomous agents and multi-agent systems (pp. 1541-1542). International Foundation for Autonomous Agents and Multiagent Systems.

[29] Sørensen, J.G., Dederichs, A.S., 2013. Evacuation characteristics of visually impaired people-a qualitative and quantitative study. Fire and Materials, 39(4), pp.385-395.

[30] Dutta, T., King, E. C., Holliday, P. J., Gorski, S. M., & Fernie, G. R. (2011). Design of built environments to accommodate mobility scooter users: part I. Disability and Rehabilitation: Assistive Technology, 6(1), 67-76.

[31] Steinfeld, E., Maisel, J., Feathers, D., & D'Souza, C. (2010). Anthropometry and standards for wheeled mobility: an international comparison. Assistive Technology®, 22(1), 51-67.

[32] Sharifi, M. S., Stuart, D., Christensen, K., Chen, A., Kim, Y. S., & Chen, Y. (2015). Analysis of walking speeds involving IWDsin different indoor walking environments. Journal of Urban Planning and Development, 142(1), 04015010.

[33] ICC (International Code Council). (2012). International building code. Washington, DC.

[34] Courtine, G., & Schieppati, M. (2003). Human walking along a curved path. II. Gait features and EMG patterns. European Journal of Neuroscience, 18(1), 191-205.

[35] Zhang, J., Klingsch, W., Schadschneider, A., & Seyfried, A. (2011). Transitions in pedestrian fundamental diagrams of straight corridors and T-junctions. Journal of Statistical Mechanics: Theory and Experiment, 2011(06), P06004.

[36] ADA Standards for Accessible Design (2010). Guidance on the 2010 ADA Standards for Accessible Design. U.S. Department of Justice.

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OPENING OUR BOOKS: UNIVERSAL DESIGN AND THE NOVEL STUDY

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Abstract: Although Universal Design (UD) was initially an architectural construct, the term is now used in a wide range of disciplines including education. Proponents believe that teachers trained in UD will be better equipped to meet the needs of the broadest range of learners through flexible curricular materials and activities.

This comparative case study explores high school English teachers' perceptions of UD aligned teaching practices and their influence on the teaching and learning of the same senior high novel unit: with one class using UD aligned practices and the other class using traditional methods. The findings of this study support the notion that the Universal Design construct may have the potential to develop the necessary talents of teachers to provide a wide range of students with greater access to the novel.

Keywords: inclusion, universal design, teachers, novels.

Introduction

With the ever-increasing job demands, high school teachers find it more difficult than ever to compete in the classrooms filled with a wide range of abilities and increased distractions. It is little wonder that a study by the Manitoba Teachers Society (2009) of 15,000 teachers determined that 73% reported that on the job stress negatively impacted their job performance. The main reason for the stress? Teachers stated that differentiating, adapting and modifying instruction was a major cause of work-related pressure.

While the majority of students seamlessly make the transition from middle years to high school, Tilleczek and Ferguson (2007) stated that some students stumble during this event. In fact, this transition is often associated with “dips in academic achievement, dips in self-esteem, and increased social anxiety” (p. 9).

It is unlikely that many high school English teachers would be surprised by these dips above. In addition to these issues, English teachers face the added challenge of promoting and improving student literacy. In order to identify some of the most prevalent challenges, Campbell and Kmiecik (2004) asked over 200 teachers from eight high schools in Chicago the question, "What are the greatest literacy challenges facing high school content area teachers?” The following five challenges were highlighted.

1. Student motivation, interests, and attitudes
2. Lack of critical thinking skills
3. Lack of study skills
4. Many students are struggling readers
5. Lack of understanding key concepts and vocabulary (Campbell & Kmiecik.2004, p.9).

As the list of challenges faced by high school English teachers seems daunting, it is easy to comprehend how some educators may continue to feel “unprepared, unsupported, or unable” to handle all they face on a daily basis (Woolfolk, 1998, p.147). As provinces like Manitoba continue to adopt and promote more inclusive educational standards in schools (Manitoba Education, Citizenship and Youth, 2006), these challenges may only increase in complexity.

The adoption of inclusive educational policies and practices is considered crucial in addressing educational equity (Roland, 2008). The rationale for inclusive schools has been around for some time. For example, Stainback and Stainback (1996) noted many years ago that inclusive school communities provide benefits to all students, reduce the ill effects of segregation, and promote equality for all children. It is little wonder that Manitoba teachers support the philosophy of inclusive education. Still, it can be at times difficult for many teachers to feel successful teaching in classrooms that have a wide range of learning needs. Teachers continuously worry that, as one Canadian educator noted, “A lot of kids’ needs are not being met” (Riva, 2016). This can be particularly true as students reach higher grade levels. Inclusion may have social and legal benefits for students of all ages, but academic inclusion for students becomes increasingly difficult to accomplish when they reach high school (Downing & Peckham-Hardin, 2007).

However, many educators believe that a concept known as “Universal Design” could provide an answer to some of the challenges of inclusion by providing access to the general education curriculum to a much larger audience, including students with a wide range of disability and diversity characteristics (McGuire, Scott, & Shaw, 2006). In doing so, Universal Design (UD) may help develop teacher talents, thereby reducing the stress levels of high school teachers challenged with the task of teaching all students in their classrooms. For high school English teachers, perhaps Universal Design can assist them in effectively “opening the books” for all of their students.

Universal Design

Universal Design was originally an architectural term, used to describe the concept that products and environments should be designed to be aesthetically pleasing and usable to the greatest extent possible, by everyone, regardless of age, ability, or status in life (The Center for Universal Design, 2007). Ron Mace, creator of the term Universal Design described it as follows:

“Universal design seeks to encourage attractive, marketable products that are more usable by everyone. It is Design for the built environment and consumer products for a very broad definition of user" (Darzentas & Miesenberger, 2005, p.407). Adelson (2004) agreed, stating, “Universal Design enables everybody not just people with disabilities to navigate, manipulate, and appreciate our world" (p.30). Thinking beyond obvious disabilities is part of this, too.

Some architectural design examples of UD that we find in everyday life include: (a) installing standard electrical receptacles higher than usual above the floor so they are in easy reach of everyone, (b) selecting wider doors, (c) making level entrances, and (d) installing handles for doors and drawers that require no gripping or twisting to operate (Universal Design, 2007). The idea of UD therefore began with the idea of creating physical environments that assisted independence for individuals who are physically challenged.

Universal Design Principles

To many people, the term Universal Design implies that a "one size fits all" solution is the goal. In fact, the essence of UD is flexibility and the inclusion of alternatives capable of adapting to the wide variety of needs, styles, and preferences (Rose & Meyer, 2000). Although flexibility is valued, Universal Design involves adherence to a set of principles that allow for people with a wide range of abilities to use them. At the Center for Universal Design at North Carolina State University, architects, engineers, and designers established the following UD principles.

1. Equitable Use
2. Flexibility in Use
3. Simple and Intuitive
4. Perceptible Information
5. Tolerance for Error
6. Low Physical Effort
7. Size and Space for Approach and Use. (The Center for Universal Design, 2007, p.1).

Universal Design Process

Burgstahler (2008) suggested that Universal Design is also a process that should adhere to the following steps: (a) identify the application of what is being designed, (b) “define the universe” (i.e., all end-users of the product), (c) involve end-users in the design process, (d) adopt inclusive guidelines or standards, (e) plan for accommodations, (f) train and support personnel, and (g) evaluate outcomes, efficacy, and impact. Based on this list, it is apparent that the process of UD requires careful consideration and the involvement of people with diverse characteristics in all phases of the development, implementation, and evaluation of any application (Burgstahler, 2008). Ostroff (2001) echoed this statement, saying, “We must move to a higher consciousness that the process of designing is not something created by ‘them’ for ‘us’ but something that we accomplish together” (p.2).

The Potential of Universal Design in Education

As an inclusive philosophy of education has become the model of choice in many provinces across Canada, including Manitoba (Manitoba Education, Citizenship, and Youth, 2006), Universal Design has become much more widely recognized as a promising educational construct, and many educators have suggested that the concept of UD is applicable to the delivery of instruction (Bowe, 2000; Curry, 2003; McGuire, Scott & Shaw, 2006; Udvari-Solner, Villa & Thousand, 2005).

The Province of Manitoba (2006) has highlighted UD in education as the “process of creating systems, environments, materials and devices that are directly and repeatedly usable by people with the widest range of abilities operating within the largest variety of situations”(p.4). Burgstahler (2007) said that UD is applicable to education, and can be related to physical spaces, information technology, instruction, and student services.

With constant concerns about issues such as academic complexity, instructional pace, attitudes of teachers, and preparation for standardized provincial exams, the secondary level often is considered to be the most challenging of all areas in education to successfully incorporate inclusive practices (Mastropieri & Scruggs, 2001). If Universal Design could measure up to such a test, its credibility would certainly rise in academic circles.

The purpose of my study (Reimer, 2010) was to investigate the potential of Universal Design in enhancing the abilities and talents of teachers and students in the high school English classroom. Specifically, I wanted to determine if the construct of Universal Design (UD) could help improve student literacy and reduce teacher stress in the high school English classroom. My 2010 study was designed to investigate these questions in a specific educational context. Using qualitative research methods, this comparative case study explored how UD aligned teaching practices influenced the teaching and learning of students in a senior high school English novel study.

Methodology

This case study was conducted between September 2009 and June 2010 following the provincial Grade 11 English Language Arts curriculum (1999) in an urban Manitoba school division. Teachers were interviewed prior to, midway, and after the novel unit was taught. The novel that the two classes were taught was the novel, Night (Wiesel, 1982).

After approval from the Education and Nursing Research Ethics Board (ENREB) at the University of Manitoba, two Grade 11 English teachers were recruited for this study. In order to recruit these classes, I received permission from the specific school division in which I planned to conduct the research. Potential participants for the study were invited by the principal to participate in the study. All participation was voluntary, and all participants were informed that they could opt out of any part of the study at any time.

The two teacher participants taught English at the same senior high school, and were given pseudonyms to ensure anonymity. Teacher A was given the pseudonym of “Lisa”, and teacher B was given the pseudonym of “Melinda.” Lisa had been teaching English since 1995. Her English classes are at all senior high-grade levels. Lisa holds a Bachelor of Arts and a Bachelor of Education. She has never heard of the term Universal Design. Melinda had been teaching for 16 years at the same school in Winnipeg. Melinda holds a Bachelor of Arts, Bachelor of Education, and a Masters in Education. She had very limited knowledge of Universal Design.

Lisa’s class was designated the control group (traditional methods) and Melinda’s class was designated the experimental (UD) group. For the study, each class was taught during a 4 week period that accounted for approximately 20 instructional hours, in blocks of 5 hours per week. Each teacher recorded the activities in her classroom during the four weeks of the study. The manner in which they were to be taught, however, was to be quite different (see Tables 1 and 2). Lisa taught the unit using traditional methods. For the purposes of the study, we defined “traditional teaching methods” as whatever Lisa normally did with a class during a novel study. Melinda infused UD aligned principles into planning for and teaching the novel study.

Melinda’s UD Training

Prior to either class commencing the novel study unit, I needed to ensure that Lisa

was using traditional methods throughout the course of the novel study, and that Melinda understood and implemented a unit plan based on the Universal Design construct. I asked Lisa to provide me with an outline of the unit plan prior to commencement, and to keep a daily journal record of classroom activities and assignments.

When training Melinda about Universal Design, I first provided an overview of Universal Design as it applied to physical settings and instruction. Second, I reviewed the principals of Universal Design. Third, Melinda and I reviewed the process of Universal Design. Fourth, I shared several examples of Universal Design units.

Universal Design overview

As a way of providing an overview of Universal Design, I asked Melinda to first complete Updike, Reimer, Romeo, & Young's (2007) "Universal Design in Education" survey in order to learn about the construct of Universal Design, and determine self-perceptions of: (a) the alignment of Melinda's current methods of instruction with the principles of universal design (UD), and (b) areas in the teacher's teaching practices that she believed could be made more compatible with UD. Upon completion of the survey and my interview, I provided Melinda with three 45 minute training sessions that began with me highlighting the construct (The Center for Universal Design, 2007) of Universal Design. These training sessions commenced two weeks prior to the novel study. During this time, we first reviewed and discussed her completed Universal Design survey, and looked for areas of strengths and weaknesses. I then shared a power point presentation with her that highlighted the challenges and benefits of inclusion, and how UD could help overcome these challenges. I explained that it was originally an architectural term, but that educators were attempting to use UD's principles in education, and the process of Universal Design (Burgstahler, 2006).

Universal Design principles

Melinda and I met to review the seven principles of Universal Design (What is Universal Instructional Design, 2002), as a means of reviewing these principals, I interviewed Melinda upon completion of the survey on Universal Design. The purpose of this interview was to obtain Melinda's feedback regarding his or her initial thoughts about Universal Design and her perceptions on how it aligned with her current practices. The interview gave me an idea as to where Melinda was in terms of UD familiarity prior to the novel study. This was a semi-structured interview using the Universal Design survey as a supplement.

Universal Design process

I reviewed the process of UD (Burgstahler, 2008) with Melinda. Together, we reviewed the UD process and how it relates to Melinda's task. For example, we identified the application of what is being designed as a grade 11 English novel study of the book Night. We defined her universe as the grade 11 high school English students. We reviewed the importance of involving her students in the design process of the novel unit, and discussed the importance of offering a variety of activities in her unit. I then asked her the following questions in a semi-structured interview.

1. What type of unit are you designing?
2. Describe the type of students that you are designing the unit for?
3. Will you involve the students in the unit design process? How?
4. Will you adopt inclusive guidelines? Explain.
5. How will you plan for accommodations?
6. What do you feel you need to be appropriately trained in incorporating UD?
7. How are you planning on evaluating outcomes, efficacy, and impact?

Universal Design examples

Melinda and I reviewed several examples of the Universal Design construct being applied to English Language Arts curriculum. We examined a "web site" that provided a good example of a UD novel study (LaFleche, 2009) for the book, To Kill a Mockingbird (Lee, 1960). There, we reviewed a number of activities, assessment strategies, and assistive technology tools displayed on the website. I showed her how pre-typed chapter summaries, audiotapes, and chapter-by-chapter vocabulary sheets could benefit her students. Melinda stated that she would look at this website and incorporate similar strategies into her unit.

Melinda and I attempted to meet regularly once the novel study began, but it became difficult to meet in person due to my inability to meet during the school day and her busy schedule in the evenings and weekends. We agreed to continue these UD training sessions over the phone and by email, as we mutually agreed that it was the best way to connect. I continued to send her websites about Universal Design that provided teachers with explanations of UD, and models of Universally Designed units and lessons.

"That's good enough!"

Two weeks into the novel study, I sensed that Melinda was growing tired of the tutorials, and so I asked her if she thought that she had enough learning. She emphatically stated, "I think that's good enough!" when I asked her if she had enough training from me, and it would be better to cease with these learning activities. Therefore, Melinda and I stopped with the training, after five sessions of training on Universal Design. I had concerns over whether or not I had provided sufficient training, and concluded that it was best not to force the issue. Cawley, Foley, and Miller (2003) noted that even relatively short amounts of teacher training can influence the lesson development of teachers, and so all further training of UD was ceased.

There were implications for my study because the training stopped. From my own research perspective, I had concerns over whether or not sufficient training had occurred. I worried that I risked the assurance of Melinda strictly adhering to UD principles throughout the remainder of her unit.

From the teacher's professional perspective, however, my inability to control every single aspect in the classroom provided the teacher with some professional "wiggle room." By not being as prescriptive and allowing Melinda some flexibility to choose classroom activities based on her training, perhaps the model became more functional for her. Although I originally intended to insert a more tightly controlled unit plan, Melinda's polite rejection of further training in Universal Design inevitably caused me to reflect on the efficacy of learning theories, and how best they can be incorporated into teachers' practice.

This seems to be a noteworthy area to explore because not every type of theory has to be held to the same standard of infallibility. Although Levy (2010) never specifically referred to Universal Design, he did speak about the differences between event theories and construct theories. Unlike event theories, which Levy (2010) stated could be “verified or proven” (p.11), construct theories provide explanations that are not directly measurable, and can never be proven. Instead, they are “intangible abstractions” (p.11) that should be evaluated for their usefulness, not their correctness. Levy further cautioned that when construct theories are mistaken as fact, there is a tendency to believe they must be “obeyed” and never “violated” (Levy, 2010, p.12). Levy (2010) referred to this error in thinking as the “reification of theory” (p.12). Levy (2010) noted that, “To reify is to invent a concept [or construct], give it a name, and then convince ourselves that such a thing objectively exists in the world” (p.9). Perhaps by allowing Melinda the autonomy to create her own version of Universal Design, Melinda was more willing to “buy in” and test the usefulness of the theory in the manner she sees most applicable to her environment. Melinda seemed to feel more empowered to try and make Universal Design work in her classroom.

Lisa and Melinda were interviewed prior to, midway, and immediately following the novel study. Based on analysis of the teacher interviews and the teachers’ daily teaching logs; it was hoped that further insight could be attained regarding the efficacy of UD teaching practices in a senior high school setting. In particular, I anticipated that the interviews with Lisa and Melinda would generate a wide variety of ideas. I read through these data sources, identified and coded emergent themes and sub-themes, and then assigned interview quotations and teacher log observations to the themes and sub-themes. Finally, I analyzed the emergent themes in order to determine their significance with respect to prior research, implications for practice, and possible future research.

Results

First Teacher Interview

During my first interviews with Lisa and Melinda, a wide range of ideas came up for discussion. It appeared that Melinda and Lisa often felt unprepared to handle all of the challenges that students with diverse abilities bring to the classroom. For example, Melinda discussed how teaching four classes per semester limits her ability to provide prompt feedback for her students, saying, “In terms of all the marking, I find that, especially if you’re on your four different English courses in that semester, the marking can’t be done maybe as quickly as it should be.”

Lisa noted the continuous struggle with addressing individual student needs while meeting the demands of the curriculum, saying, “The delivery and pace of the course lessons also requires constant monitoring and reviewing, especially with classes that all have students with a broad range of abilities.”

Although each teacher provided unique insight into her methods of instruction. Melinda and Lisa had much in common. First, they began teaching at approximately the same time (Melinda in 1994, Lisa in 1995), have taught English at all high school levels, and both struck me as caring, committed teachers, who were candid about their strengths and weaknesses. Second, Melinda and Lisa both admitted that inclusion was increasingly difficult to accomplish, especially at the high school level. Third, they were both frustrated at times about the barriers that prohibit successful learning in the classroom.

Midway Interview – An Emerging Shift among the Teachers?

Midway through the novel study unit, Lisa and Melinda were interviewed about their experiences thus far. While both teachers found many challenges within their classrooms, Lisa seemed frustrated by the apathy of many of her students, while Melinda seemed to be excited about how UD was assisting her with the unit. Lisa first reported that the unit was going, "Right along on schedule." She began the unit with the students viewing Schindler's List. Students have had, "Class time every day to read the text and respond to comprehension questions, and yesterday we went over the answers to those…questions."

It was apparent during the midway interview that Lisa was very frustrated with her classroom's attitude and performance. For example, one of Lisa's major sources of frustration centred on her students' apparent lack of motivation in the classroom. For example, she stated, "I find that one of greatest challenges as a teacher is when students do not take any responsibility for their learning. No matter how much time I try to plan class time to give students to do their work, there are still those who mismanage their time and fail to meet even the basic requirements!"

Alternatively, Melinda was much more upbeat when interviewed midway through the novel study. When asked to describe her experiences to this point in incorporating UD-friendly activities, she replied:

> *So far I have found [UD principles] very helpful in engaging all of the students. [My English class] is quite a mixed bag when it comes to abilities and behavior, including 8 International students who are really struggling with the language, and 3 students who came out of our Core Focus program last year (a class for students having behaviour, focus and ability difficulties, as she describes it) so I have found that employing universal design activities has not only allowed the students to be more successful, they are able to focus better and enjoy the part of their reader response logs, and then they will write their test!*

Melinda appeared eager to share how she aligned her teaching of the unit with specific UD principles and provided many concrete examples of how the UD principles (The Center for Universal Design, 2007) assisted her in providing a more inclusive classroom environment. For example, when asked about how she was accessible and fair to all parties, Melinda stated:

> *I have included things like listening to the novel on a recording while they are reading. This has allowed the novel reading to be more accessible to those who are struggling readers since these students (the struggling ones) would typically not bother to pick up the novel at all. Since we read it together in class, they were all following along, and the intonation of the narrator's voice helped with the comprehension of the text. It was great – the room was dead quiet, and all of the students were reading along the entire time! This would never have happened if I had just said,"Ok- we're going to have a reading period today. Everybody try to get to the end of chapter 2 by the end of the class." That would end up in continual chatting and behaviour problems.*

Melinda tried to have students do a variety of activities from, "Group discussions, writing tasks, group writing tasks, and flip chart presentations" in order to give that flexibility for the varied needs of the students. It was obvious to her that "Some students excel at the writing, whereas others would rather just talk about it out loud and express things orally instead." Still, she seemed to appreciate the individual differences, describing them as, "Great, because this is what it's all about, right? As long as they are demonstrating that they can meet the outcomes, who cares how they do it!"

Novel Study Unit Daily Activities

The novel study continued in both classes for approximately another two weeks after the midway interview. At the conclusion of the novel study, both teachers provided me with summaries of their unit plans. As I reviewed the daily activities of the classrooms, I noticed that Melinda's classes were much more varied in terms of activities. She incorporated movies, television interviews, representative diagrams, small and large group discussions, and deskwork.

Lisa chose to spend a much more significant amount of time devoted to individual deskwork, correcting of questions and answers, and teacher lectures. In short, it appeared that Melinda's class was provided with a much more colourful and eclectic mix of learning opportunities that may appeal to the different types of learners in her classroom. Based on her more dynamic instructional methods, Melinda appeared more talented as a teacher.

Table 1. Lisa's Daily Unit Plan for "Night". Source: author.

Week	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	Gates- MacGinitie Pre-Test Viewed "Schindler's List"	Viewed "Schindler's List"	Concluded "Schindler's List" "Night" book handed out , ch.1 read aloud	Distributed and read intro notes (vocabulary, character list, historical timeline, map) All Chapter questions distributed to students (so can be done in case any kids get sick. Students work individually on questions	Individual work period for students to complete assigned discussion questions.
Week 2	Individual work period for students to complete vocabulary questions, some students ready to begin chapter questions	Individual work period: reading ahead, chapter questions, and/or vocabulary	Individual work period: reading ahead, chapter questions, and/or vocabulary	Individual work period: reading ahead, chapter questions, and/or vocabulary	Many students had still not completed first chapter set of discussion questions, and/or vocabulary, (so had today) to finish their work
Week 3	Reviewed timeline and class hand-out sheets about "Night." Begin correcting vocabulary words	Reviewed and corrected answers for discussion questions for pp. 1-20. Read excerpts from novel as it pertains to questions and allows for class discussion about the text.	Continued to correct answers for discussion question from pp.2143. Discussed the word 'night' as symbol for the novel	Corrected chapter questions for chapters 3-9. Class discussion as we corrected answers for chapter. Questions and allows for class discussion about text. Distributed questions	Set date for test of novel unit study. Students work individually on reader response logs. Reviewed concepts of simile, metaphor, and irony. Wrote vocabulary definitions on chalkboard. Students work on simile and metaphor hand-out sheets. Begin activity sheet for Irony. Review study checklist for novel unit test.
Week 4	Night unit test	Gates Post-test.			

Table 2. Melinda's Daily Unit Plan for "Night". Source: author.

Week	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	Gates- MacGinitie Pre-test	Brainstorm on meaning of holocaust Present and describe holocaust timeline Create bio poem Simile/metaphor review and sheet (for style in the novel)	Gates test	Hitler bio (think, pair share) Read aloud his bio Read Chapter 1	"Survivors of the Holocaust" video
Week 2	Oprah article – interview with Elie Weisel Read Ch.2	On-line pictures of Elie touring concentration camps and real photos of the camps and people at the end of the war Vocabulary used in Night – group search and share with class (chart paper, etc.) Read ch. 3.	Hitler character map Read ch. 4	Irony in Night – explain irony - sheet – do first together, rest in pairs. Listen to ch. 5 on CD ROM *(noticing at this point that some aren't reading the novel, so I made the choice to get the CD so that we could listen and follow along – worked great – everyone on task and following).*	review ch. 1-5 Listen to ch. 6
Week 3	Reflection (2 prompts on overhead) on Night thus far Listen to ch. 7,8,9	Study guide questions ch.6&7 Simile of myself sheet	Study guide questions 8&9	Stereotype – discuss, group sheets on scenarios	Themes – group discussion, sheet
Week 4	Tone and symbol in Night – review meaning of terms, sheets	Characterization – Elie, Elie's father – behavior, appearance, and dialogue	Review Night Vocab (test prep)	Go over test requirements Start Schindler's List movie	Schindler's List conclusion
Week 5	No classes	Schindler's and review for test	Night Test	Gates Post Test	

Final Teacher Interviews - Different States of Energy and Emerging Talents

At the end of the novel units, I conducted post-novel study interviews with Melinda and Lisa. The original purpose of these interviews was to compare and contrast methods of instruction between the two teachers. As the interviews progressed, I discovered that Lisa and Melinda wanted to talk more about how they thought the novel study went, whether or not their students were successful, and their perspectives on why success was or was not achieved. After reviewing the transcripts of interviews, Melinda's comments seemed much more positive than Lisa's responses. I think that Melinda believed she was much more successful than Lisa did at the conclusion of her novel study.

> *I thought it worked out really well! I mean, these are things that we should be thinking about all the time, anyway, and I really try to implement this type of planning and thinking in all of my classes, but I have to say that with the novel study, this is really easy to do. The great thing about a novel study is it can be so wide open, you know, so the range of activities and lessons that you can do around it is really big, which allows all of those learners in your class a chance to get at the learning tasks by whichever way works for them!*

Interestingly, both teachers stated that a great deal of effort was necessary on their part to be successful in the classroom. Lisa stated:

> *I cannot be ever complacent with these students as they have many needs and are very demanding. I found their classroom behaviour to be very challenging and their misbehaviour would affect their potential to be successful if and when particular students would be chronically disruptive during class lessons, class discussions, and class work periods.*

Universal Design training did not seem to make Melinda believe that she was immune to expending great amounts of energy in order to teach her grade 11 class. During the third interview, Melinda expressed this reality:

> *It is actually quite a bit of effort to teach this range of students! Some just "get it" every time, some need a bit more nudging, and some need the constant help in grasping any concept. Combine that with kids always coming in late, kids away for whatever reasons, kids acting up, constantly interrupting instruction, phone calls you need to make for late work, missing work, missing kids!.*

Throughout the novel study, both teachers admitted that teaching high school English for students with a wide range of abilities was a very challenging endeavour which required a great deal of energy on their part. The biggest difference, however, seemed to lie with how Lisa and Melinda spent their energy.

Lisa seemed frustrated at the end of the novel study. She stated that even though she has, "Put forth a tremendous amount of energy and effort" into her classroom instruction", she was astounded by, "The students' lack of effort or commitment to learning and taking responsibility for their own learning." It seemed as if Lisa shifted the blame for her classroom's apparent lack of success on her students' unwillingness to take personal responsibility for their learning.

Overall, Melinda's responses indicated that she felt successful teaching her class. Melinda was concerned that teaching English took up a lot of her personal and professional energy, but believed that Universal Design made her a more talented and proficient educator:

> *Nowadays, it takes more effort than it did, even 10 years ago, but if that's what it takes, then that's what it takes. Now (teachers) got a very busy, full plate, when you're constantly thinking, 'OK, how can I get that to them a better way, how am I going to assess this so that they can all have a fair go of it?' I would say…minimum amount of effort? No, not a chance. We see kids coming into grade 9 here with a grade 2 and 3 reading level! So now we mix them up with kids*

> *who are university bound, and we have a challenge on our hands! That's where this universal design thing comes in. It's just a necessity and a reality of life in this job now. Anyone who isn't teaching this way now, is probably only hitting home to 10-15% of their students, because, at least in this school, you just can't "blanket teach" anymore, and still think you're doing a good job. And the way I see it, most of us get into this job, because we like kids and want to help them get to where they need to be for whatever their goal is. It's a caring profession, right? So let's care and do what it takes to make that happen.*

It is possible that Melinda's positive response and willingness to take on the challenges that teaching high school English resulted in part because of a long-standing personal philosophy of education that may differ from Lisa's philosophy. However, Melinda's responses throughout the final interview supported the notion that Universal Design may help teachers increase their talents and abilities to perform their duties in inclusive environments. Melinda's comments supported the idea that the construct of Universal Design, if presented to the teacher and permitted the professional discretion to infuse it into instruction, can help teachers feel empowered to overcome the challenges.

Conclusion

Based on this case study and the themes that were generated, a number of other studies could be conducted and prove insightful. For example, research is needed on teachers coping with the diversity of academic skill levels in senior high school, with particular emphasis on English Language Arts. More studies are required to examine teacher stress, workload, and job satisfaction and frustration. Further research into reducing teacher stress load through UD would be interesting. Further, it would be interesting to conduct a case study where a teacher taught a novel study unit once using traditional methods, and then taught it again after being trained in Universal Design.

It might also be helpful to conduct a study similar to this one, but using a qualitative design with some quantitative data collected within it. This approach may ensure richer and more trustworthy qualitative data. In addition, rather than looking specifically at academic outcomes as success indicators, it might be valuable to conduct a study of UD looking for other outcomes such as engagement between students and their teachers, engagement between students and their peers, and/or changes in the self-concepts of the students. It might also be useful to conduct a long-term, whole school study on the efficacy of UD. A study comparing and contrasting a newer, more universally designed high school with an older school with retrofitted technology may be intriguing. Finally, it may be beneficial to conduct further studies that explore the evolutionary nature of the development of UD in education.

Although being a Manitoba high school English teacher these days can be a challenging profession, my study supports the idea that the Universal Design construct may provide a useful theoretical framework for teachers to creatively and independently develop practical ways to promote and improve student literacy in their classrooms. By enhancing their talents, teachers trained in UD may spend less time and energy blaming the less successful students in their classrooms, and spend more time and energy universally designing their instructional practices to meet the needs of all students.

Melinda's largely positive responses concerning the challenges of teaching this high school novel study, her willingness to implement strategies related to UD, and her more diverse and imaginative lesson planning provided the evidence required to support such a claim, or at least to warrant further research in this area. Melinda's overall responses and more eclectic novel unit plan seemed to support McGuire, Scott, & Shaw's (2006) assertion that Universal Design principles and processes may help teachers provide access to the general education curriculum to students with a wide range of diversity characteristics. The manner in which the UD construct is shared with teachers is also crucial. It seemed as though brief bursts of agreed upon training, combined with the allowance of teacher autonomy to creatively incorporate it into their instruction, is a promising model to explore. In short, the construct theory of Universal Design combined with some independence given to the teacher may help high school English teachers creatively open the book for more of their students.

References

[1] Adelson, R. (2004, October). Universal design: Opening every door. Inside MS, 22(4), 30-34. Retrieved September 16, 2008, from CINAHL database.

[2] Bowe, F. (2000). Universal design in education: Teaching non-traditional students. Westport, CT: Greenwood Publishing Group.

[3] Burgstahler, S. (2008). Universal design in education: Process, principles and applications. Retrieved Nov. 18/08 from http://www.washington.edu/doit/Brochures/Programs/ud.html

[4] Burgstahler, S. (2007). Above from universal design in education: Principles and applications. Retrieved Oct 29/07 from http://www.washington.edu/doit/Brochures/Academics/ud_edu.html

[5] Burgstahler, S. (2006). Equal access: Universal design of student services. Retrieved November 2, 2007 from http://www.calstate.edu/accessibility/downloads/Equal_Access_Student_Services. pdf

[6] Campbell, M, & Kmiecik, M. (2004). The greatest literacy challenges facing contemporary high school teachers: Implications for secondary teacher preparation. Reading Horizons, 45(1), 2-25.

[7] Cawley, J., Foley, T., & Miller, J. (2003). Science and students with mild disabilities. Intervention in School & Clinic, 38(3), 160-171.

[8] Curry, C. (2003). Universal design: Accessibility for all learners. Educational Leadership, October, 55-60.

[9] Darzentas, J. & Miesenberger, K. (2005). Design for all in information technology: A universal concern". In Anderson, K.V., Debenham, J., & Wagner, R. (Eds.). (2005). Lecture Notes in Computer Science (pp.406-420). Berlin: Springer.

[10] Downing, J., & Peckham-Hardin, K. (2007, Spring2007). Inclusive education: What makes it a good education for students with moderate to

severe disabilities? Research & Practice for Persons with Severe Disabilities, 32(1), 16-30.

[11] Lafleche, M. (2009). Universal design for learning. Retrieved October 15, 2009 from http://tkamforall.pbworks.com/Universal-Design-for-Learning.

[12] Lee, H. (1960). To kill a mockingbird. Philadelphia, PA: Lippincott.

[13] Levy, D. (2010). Tools of critical thinking: Metathoughts for psychology (2nd ed). Long Grove, IL: Waveland Press Inc.

[14] Manitoba Education, Citizenship and Youth (2006). Appropriate Education Programming in Manitoba: Standards for Student Services. Winnipeg, MB: Author.

[15] Manitoba Teacher's Society (2009). MTS task force on teacher workload: Final report. Retrieved from http://www.mbteach.org/library/archives/issues/workload/workload_report.pdf

[16] Mastropieri, M., & Scruggs, T.E. (2001). Promoting inclusion in secondary classrooms. Learning Disability Quarterly, 24(4), 265-274.

[17] McGuire, J.M., Scott, S., & Shaw, S. (2006). Universal design and its applications in educational environments. Remedial and Special Education, 27(3), 166-175.

[18] Ostroff, E. (2001). Preparing and Recruiting Designers for an Inclusive Society. Plenary Address, Inclusion By Design. Montreal, Canada June 2, 2001.

[19] Reimer, K. (2010) Universal Design in Education: The Missing Link? University of Manitoba: MSPACE Thesis.

[20] Riva, N. (2016). 'A lot of kids' needs are not being met': Lots of labels, lack of resources for students with special needs. CBC News. Retrieved April 10, 2017 from http://www.cbc.ca/news/canada/special-ed-iep-support.

[21] Roland, K.A. (2008). Educating for inclusion: Community building through mentorship and citizenship. The Journal of Educational Thought, 42(1), 53-67.

[22] Rose, D., & Meyer, A., (2000). Universal design for learning: Associate editor column. Journal of Special Education Technology, 15,(1).

[23] Senior 3 English Language Arts: Manitoba Curriculum Framework of Outcomes (1999). Manitoba Education and Training. Winnipeg.

[24] Stainback, W.C., & Stainback, S.B. (Eds.). (1996). Controversial Issues Confronting Special Education - Divergent Perspectives (2nd Edition). Boston: Allyn & Bacon.

[25] The Center of Universal Design (2007). Retrieved October 29, 2007 from http://www.design.ncsu.edu/cud/about_ud/udprinciplestext.htm

[26] Tilleczek, K., & Ferguson, B. (2007). Transitions and pathways from elementary to secondary schools: A Review of selected literature. Ontario Ministry of Education.

[27] Udvari-Solner, A., Villa, R. & Thousand, J. (2005). Access to the general education curriculum for all: The universal design process. In R. Villa & J. Thousand (Eds.) Creating an Inclusive School (2nd ed., pp. 134-156). Alexandria, VA: ASCD.

[28] Universal Design (2007). Retrieved November 3, 2007 from http://www.accessiblesociety.org/topics/universaldesign/

[29] Updike, M., Reimer, K., Romeo, L., & Young, L. (2007). Universal Design in Education Survey (Field Test Version). Unpublished course assignment, University of Manitoba. Winnipeg, Manitoba, Canada.

[30] Villa, R., & Thousand, J. (2003). Making inclusive education work. Educational Leadership, 61, (October), 19-23.

[31] What is Universal Instructional Design? (2002) Retrieved October 30, 2007 from http://www.tss.uoguelph.ca/projects/uid/uidintro.html Wiesel, E. (1982). Night. New York. Hill and Wang.

[32] Woolfolk, A.E. (1998). Educational Psychology (7th ed.). Needham Heights, MA. Allyn & Bacon.

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