Supporting young children who are congenitally blind in the use of the

QWERTY keyboard: What does the literature tell us?

Abstract

The focus of this paper is to examine strategies and processes that may play a

role in the development of early keyboarding skills by young children who are

blind and who are novice computer users. Despite the research literature failing

to provide specific research data on the ways in which young children who are

blind learn the concept, lay-out and use of the keyboard, some pertinent

background information is available that helps to shape our understanding of

the area. This includes being able to clearly differentiate between touch typing

and keyboarding. The paper concludes with a call for research into the free

exploration of the keyboard by young children who are congenitally blind,

particularly into salient features on the keyboard as potential reference cues for

haptic spatial coding.

Introduction

Being able to accurately and efficiently use a computer keyboard to facilitate the

use of assistive technology (AT) – as a tool to provide access to information - is

an essential skill for students who are blind and one that is becoming

increasingly more important (American Foundation for the Blind and Perkins

School for the Blind, 2012; Bishop, 2004; Diggs, 2002; Knight, 2013; Presley &

D'Andrea, 2008). Keyboarding and technology are included in the expanded

core curriculum for students who are blind or vision impaired in Australia

(Statewide Vision Resource Centre, 2013) and in the United States of America

(USA) (American Foundation for the Blind and Perkins School for the Blind,

2012).

In a national survey, Kelly (2009) found that the majority of students with

vision impairment in the USA did not have the opportunity to use AT, resulting in

their falling behind their sighted peers. Kelly and Smith (2011) reviewed 45

years of English language research literature on the effectiveness of AT as an

educational intervention for students aged 3 – 21 years of age who are blind or

have vision impairment, with or without additional disabilities. They noted that

there is little evidence-based research on the strategies in the instruction and

use of AT of students who are blind or vision impaired. This type of research is

necessary to be able to assess how effective the applied strategies are in those

students' educational outcomes. This paper aims to clarify current

understanding of the strategies and procedures that children who are

congenitally blind might apply, when given the opportunity to freely explore the

QWERTY computer keyboard as novice computer users. An analysis of these

strategies and processes can inform new instruction methods to teach

keyboarding skills.

(Touch) typing

The QWERTY keyboard takes its name from the six keys in the top row of letters. Although the keyboard is a device mainly developed for information input, it also provides tactile and audio feedback when a key is pressed (Stone, Jarrett, Woodroffe, & Minocha, 2005). The terms (touch) typing and keyboarding appear to be used inconsistently throughout the literature. Many educators mainly see the keyboard as a tool for (touch) typing. Bishop (2004) has described typing both as a communication tool, and as a keyboarding skill for AT use. According to McKinnon and Nolan (1990), keyboarding includes using such function keys as the Control and Alt keys and combinations of these. This skill primary enables the use of such AT as screen reading software. Finally, 'touch typing' is defined as typing accurately while not looking at the keyboard (McKinnon et al., 1990; Presley et al., 2008). This paper considers 'typing' to be a specific use of the keyboard, for text entry, and 'keyboarding' to be a more general definition of the interaction with the keyboard, which can include typing as well as the use of the keyboard as an interface with AT.

Instruction and practice

For a child who is blind, a computer keyboard represents opportunities as well as challenges. Acquiring the skills to use the keyboard accurately and efficiently is a process that can't be learned intuitively by a student who is blind, or without instruction. These skills need to be taught by teachers with proper knowledge and expertise, and the skills need to be practiced and applied. A common

thread through the research literature is that instruction and practice positively impacts on the learning outcomes of children who are blind. This applies to the learning of keyboarding skills (Bishop, 2004; Knight, 2013; Presley et al., 2008), the acquisition of haptic exploration skills and effective exploratory strategies (Berlá & Butterfield, 1977; Theurel, Witt, Claudet, Hatwell, & Gentaz, 2013; Withagen, 2008), accurate recall of spatial layouts (Millar, 1975), understanding tactile representations (Marek, 1997; Marek, 2000a), and conceptual understanding (Marek, 2000b). No published best practice for teaching keyboarding skills to young students who are blind is available. Current teaching methods to introduce these students to the QWERTY keyboard appear to be based on the experience and personal approach by individual educators.

Like their sighted peers, students who are blind are at some stage taught two-handed touch typing through the traditional method, positioning the fingers on the home row (Bishop, 2004; Knight, 2013; Presley et al., 2008; Stauffer, 2008). On a standard QWERTY keyboard, the home row keys are A-S-D-F, and J-K-L-;. In the Home position, the thumbs of both hands rest on the space bar. However, the space bar is not part of the teaching method. No research data is available on possible processes which could make the learning of typing easier for students who are blind.

A 'touch' situation, without looking at the keyboard, is clearly not a choice, but a necessity for students who are blind. Interestingly, recent studies found

that sight plays a role in the touch typing performance of skilled typists on a QWERTY keyboard. Not only do typists monitor the computer screen for words that show up incorrectly, but they also rely on visual perception of the keyboard to support their performance (Liu, Crump, & Logan, 2010; Snyder, Ashitika, Shimada, Ulrich, & Logan, 2014; Tapp & Logan, 2011). This supports the notion that keyboard instruction of children who are congenitally blind should take a different approach from that of sighted students.

Students who are blind have an extra workload compared to sighted students, because apart from most elements in the Core Curriculum, they also have to undertake subjects of the Expanded Core Curriculum. However, this should never be a reason to exclude them from learning technology at a young age, as has been observed by the author in some instances. Most of the concerns raised by Gale (2001) with regard to braille education of students who are blind, also apply to technology education in Australia. For example, technology education to students who are blind is generally the responsibility of itinerant support teachers. Little support is in place for these teachers to acquire and maintain comprehensive and up-to-date knowledge of and skills in the use of AT. With an already high workload, their interactions with any student are not very frequent, and generally too short to teach a child the necessary technology skills. The regular classroom teacher usually doesn't have sufficient specialised knowledge and understanding of AT to be able to assist the child who is blind in acquiring the necessary skills, nor awareness of the support and encouragement that is required. Short immersion courses, organised by a small

number of specialised vision service centres, may improve students' AT skills, and provide teaching staff and parents with an opportunity for training and to share experiences (Doepel, 2014).

When to introduce keyboarding

Most authors agree that the age at which formal teaching of keyboarding and typing should start is dependent on the individual. An assessment of the individual student's needs and skills is essential. (Bishop, 2004; Knight, 2013; Special Education Technology British Columbia, 1999). This may require a collaborative approach, including an occupational or physical therapist (Presley et al., 2008). The American Foundation for the Blind and Perkins School for the Blind (2012) advise that students who are blind or vision impaired should ideally be introduced to keyboarding skills well before they need to apply these skills at school, and well before their sighted peers. Diggs provides background for this notion:

> Students who are blind or visually impaired must master keyboarding, windows concepts and controls, keyboard equivalents for mouse commands, their assistive technology, and the concepts needed to understand the software to be used prior to accomplishing the same tasks as their sighted peers. (Diggs, 2002, p. 7)

The age at which sighted students in mainstream education are taught touch typing seems to continue to go down. Successful pilot studies with students from year 3 (aged 8-9 years) in Australia (McDougall, 2014) strenghten the intention of the Australian Curriculum, Assessment and Reporting Authority (ACARA) to move the National Assessment Program – Literacy and Numeracy (NAPLAN) online. Although NAPLAN will continue to be paper-based for 2015 (ACARA, n.d.), from the beginning of the school year 2015-2016 in a number of States in the USA the Common Core standards exams will be held online, with the keyboard as input device, by students from second grade (7 years old) (Layton, 2013). These developments have given the call to teach all students in mainstream education touch typing skills from a very young age a huge impetus. As students who are blind ideally need to have keyboarding skills for use with AT before they learn to type, from what age should they be taught to use the keyboard? Based on the experience with the development of other skills, effective preparation, training and instruction may enhance and speed up the learning of keyboarding skills by young children who are blind. Future research is needed to improve understanding of the most effective ways of preparation and instruction.

Preparing for keyboarding

A number of essential prerequisite skills for the development of efficient keyboarding skills have been identified in the research literature (Bishop, 2004; Knight, 2013; Presley et al., 2008; Special Education Technology British Columbia, 1999), for example cognitive development, hand size and dexterity.

Knight (2013) and Presley et al. (2008) propose that prior to students who are blind learning correct typing, they first need to explore the keys, and acquire pre-keyboarding skills. Bishop (2004), however, cautions that 'playing' with a computer keyboard can lead to the development of bad locating habits. Her comments were given in a reference to what in literature on mainstream touch typing courses is generally called 'hunt-and-peck strategies', which, it is claimed, are difficult to undo later on. There are no empirical data available on whether or not children who are blind can in fact develop hunt-and-peck strategies, generally understood to involve looking at the keys to seek out one key at a time, with one finger of each hand. In the opinion of the author, a playful introduction to the keyboard is essential for very young children who are blind. Sighted children learn from watching others, or by trial and error. However, the opportunities for incidental learning by children who are blind are few and far between. Free exploration and learning pre-keyboarding skills from a very young age can be an important foundation on which formal keyboarding and typing skills can be built when required. As Knight (2013) points out:

> Children are regularly engaged with technology, even before they commence formal education. Children who are blind or have significant vision impairment require an environment that nurtures positive and meaningful technology experiences. (Knight, 2013, p. 2)

Withagen (2014) found that children who are congenitally blind show superior performance to sighted children, in short term and long term verbal

memory tasks. She suggests that children who are blind are being trained in serial memory skills more than their sighted peers. Children who are blind always have to memorise verbal input, which is inherently sequential, as well as practice the sequential tactile processing of braille. Lockhart and Zeitz (2012) found that any music experience, not limited to playing the piano, positively affected computer keyboarding skills in students aged 9-11 years who were given a four week keyboarding instruction program. They explained this by suggesting that both skills benefit from the instruction of fine motor skills. Finally, Theurel et al. (2013) examined the effect of textures in tactile pictures on recognition accuracy by children who are early-blind. They found that early experience with tactile images and with braille supports the development of effective and efficient haptic exploratory procedures. Thus, it appears that experience with certain skills can affect the acquisition of other skills that may involve similar processes.

Anecdotal evidence from educators and therapists suggests that children who have learnt to read braille, learn keyboarding easier and faster, using both hands when exploring the keys. Prebraille - to support the future development of formal braille reading skills - has been described extensively in the literature. Prebraille skills are physical and sensory. These are different from emergent literacy skills, which are cognitive (Perkins Scout, n.d.). Prekeyboarding can similarly be defined as supporting the future learning of formal keyboarding and typing skills. Both prebraille and prekeyboarding help a child to get ready for formal instruction. Various resources list toys, everyday activities and hands-on

experiences with which parents can support prebraille and Early tactile learning in very young children who are blind (Cleveland & Sewell, 2009; Hall, 2005; Reed-Brown & Palmer, n.d.; Sewell & Strickling, 2004). This type of resources does not appear to be available for prekeyboarding. However, examples of prebraille skills, such as identifying various sizes and shapes of objects, understanding of part-to-whole relationships of objects, fine motor skills and dexterity, finger isolation, labelling and understanding of concepts such as up/down, left/right and previous/next, appear to be essential for prekeyboarding as well. Similar to prebraille, with the possible involvement and encouragement of the child's parents, prekeyboarding as an early, playful familiarisation with the keyboard may help to create a valuable foundation for future formal keyboarding education.

Supporting the acquisition of keyboarding skills

The literature provides no specific research data on what processes and strategies are involved in young children who are blind's learning of the concept, lay-out and use of the keyboard. Divergent opinions exist on the way locating and identifying the keys can be supported. Like Bishop (2004), Presley et al. (2013) state that tactual motor patterns of the hands reaching out to the keys need to be established in the brain through practice. Locator dots on specific keys can provide basic orientation cues to the keyboard (Knight, 2013; Presley et al., 2008). These are similar to a 2003 invention which places tactile 'bumps' on the letters F and J to help sighted typists know where exactly to place the fingers for better speed and accuracy of typing (Modified keys on a keyboard,

n.d.). Hersh and Johnson (2008) promote the use of braille labels on the keys to provide tactual feedback about which keys are pressed when touch typing, however Presley et al. (2008) caution that such labels can become counter-productive and should only be used in the early learning stages. Stauffer (2008) utilises braille labels on the keyboard for students who are blind and have additional disabilities. In her whole-language approach to literacy, students learn to read un-contracted braille through learning how to type. Diggs (2002) proposes a concept-based approach to teaching students who are blind about different elements of technology use, similar to hands-on teaching of real objects and elements in the child's environment. The Early Learning Access Technology Framework for children who are blind or have significant vision impairment (Knight, 2013) provides educators and parents with a valuable step-by-step method to develop 'keyboard awareness' in children from two to six years of age. Games and activities are listed that may train the use of particular keys and support a broad understanding of the structure of the keyboard. The use of tactile markers on keys is suggested, but there is no mention of other reference cues or orientation strategies that may support the efficient locating and memorisation of the keys. It appears that various approaches exist on this subject. Although support and instruction should always be tailored to the needs of the individual child, future research may assist in determining elements of best practice which may benefit all children who are blind in their early learning of keyboarding skills.

Haptic exploratory procedures

Active touch, involving conscious movement, was first described by Katz (1925) and is investigated as distinct to passive touch in Gibson's seminal work (1962, cited in Heller & Gentaz, 2014). Haptic perception includes the two subsystems of the cutaneous sense and kinesthesis or proprioception (Pagliano, 2012; Sanders, 2008) and is a perceptual system involving exploratory or scanning procedures and movements (Lederman & Klatzky, 1987; Millar, 2008). Nevertheless possibilities exist to identify objects by a 'haptic glance', that is, a short contact with an object (Klatzky & Lederman, 1995). "Active touch can aim to obtain haptic 'apprehension': assessing object properties and understanding how they combine to produce the whole, as opposed to "recognition", i.e., 'categorization'". (Lederman et al., 1987, p. 344). Students who are blind must learn from part-to-whole, as they only experience discrete parts of an object, and as a result they have to memorise sequential input of small pieces of tactual information, and then piece the parts together, based on that information (American Foundation for the Blind and Perkins School for the Blind, 2012; Withagen, 2014). This process can require considerable time and effort (Jansson, 2008). Children who are blind and who are novice computer users can only build a complete understanding of the lay-out and structure of a keyboard one key at a time.

In their seminal work on haptic object recognition, Lederman et al. (1987) describe the sequential intake of information through purposive haptic "exploratory procedures or EPs, which are dictated by the object properties that

the haptic system chooses to process, both perceptually and cognitively"
(Lederman et al., 1987, p. 365). The six EPs they described and investigated
are: "lateral motion", "pressure", "static contact", "unsupported holding",
"enclosure" and "contour following". They suggest that when an unfamiliar
object is examined for the first time, the "enclosure" EP is best qualified to get a
quick haptic glance, which could then be used to guide subsequent exploration.
If something really stands out during this first exploration, this salient feature
would then be further explored with the EP that is best specialised to achieve
this. Klatzky, Lederman, and Reed (1987) investigated the circumstances under
which four of the before mentioned EPs were used, and how haptic with and
without visual exploration compared with each other in these tasks. Specific
tasks and instructions regarding the exploration of object's dimensions and
properties showed to influence the outcome.

Kalagher and Jones (2011) studied haptic exploratory procedures in 3-5
year old sighted children, and found that they used the same hand movement
patterns in matching tasks, as those used by adults. Withagen (2014) described
the tactual functioning and EPs used by blind and sighted children through the
Tactual Profile, an assessment tool designed to evaluate the tactile skills of
children from 0 – 16 years who are blind and have no additional impairments,
with regard to tactile sensory functioning, tactile motor functioning, and tactile
perceptual functioning. Withagen, Vervloed, Janssen, Knoors and Verhoeven
(2009) used the Tactual Profile instrument to study the EPs in haptic tasks of 48
children from the Netherlands, demonstrating that they master approximately 94%

of tactual tasks they meet in everyday live, which enables them to execute the tasks they meet in mainstream education. At 5 and 6 years of age there may be a transition point in the control of tactual skills; children of this age-level only mastered on average 85% of tactual skills. Future research may be able to establish whether or not findings from these studies into haptic exploratory procedures can inform the learning of keyboarding skills.

Spatial coding and reference cues

To form an understanding and mental representation of the spatial lay-out of a keyboard, children who are blind need to use spatial coding, based on haptic exploration. Landau (1991), in an experiment with three children who were congenitally blind, investigated their construction of spatial relationships among object parts. She concludes:

> Visual experience is not necessary for the early development of the capacity to explore objects or layouts, the capacity to assemble haptic and kinesthetic information about objects into a unified representation, or the capacity to transform these representations in ways important to human spatial cognition. (Landau, 1991, p. 176)

Reference cues play a crucial role in spatial coding of people who are blind (Millar, 2008). The tendency for children who are congenitally blind, is to use self-referent and movement coding strategies (Millar, 2008; Ungar, Blades, & Spencer, 1996). In her experiments with braille reading and processing of

tactile maps, Millar (2008) demonstrated that spatial coding is a result of touch and movement, and that under pure haptic conditions it is possible to use external cues as reference anchors to code object locations in small, tabletop space, so not necessarily depending on egocentric referencing alone. In one of her experiments, braille readers explored with both hands the rectangular outlines formed by the raised layout of the brailled text, using that as an external spatial frame in combination with their body-centred reference. Millar (2008) notes that redundancy of reference cues is important, and 'a salient feature within a shape can act as a reference cue relative to other features or to the total configuration' (Millar, 2008, p. 43). Personal observations by the author and anecdotal evidence suggest that although the space bar is not formally identified in the literature as a reference cue which can assist in locating other keys on the keyboard, individual educators do teach children this concept.

Liu (2009) proposes that there is a correlation between navigation by way of a computer keyboard and concepts of Orientation and Mobility training in indoor and outdoor spaces. For example position, planning, and the use of landmarks and routes. Liu et al. (2010) successfully applied findings from spatial memory studies into reference cues in large-scale space, to the small-space environment of a computer keyboard. They propose that "the rows and columns of the keyboard form the reference frame in which the spatial layout of the keys is encoded, with the up–down axis of the keyboard aligned with the front–back axis of the typist" (Liu et al., 2010, p. 475).

Children who are blind use different modalities of representation in spatial memory from sighted children (Millar, 1975). In a game-like experiment involving children who were congenitally or very early blind, and sighted children between approximately 6-12 years of age, she demonstrated that children who are blind use sequential information from touch and movements in spatial memory, as opposed to the visual imagery of sighted children. Verbal labelling and repeated familiarization improved the accuracy of recall of spatial layouts. Younger children required specific instruction and encouragement to use this strategy. If the keyboard is seen as a landscape or a spatial layout, instructing and training children to use verbal labelling, as well as extensive familiarisation with the keyboard may improve their early keyboarding skills.

Conclusion

With a lack of evidence-based research on the use of the QWERTY keyboard by young students who are blind, instruction and training of keyboarding skills is mostly based on experience and the personal approach by individual educators. This applies to whether or not the child should be allowed to playfully explore a keyboard before formal instruction starts, exactly when this formal keyboarding instruction should begin and the best way to support children in locating keys on the keyboard. Some of the research that has been conducted in other areas of interest can contribute to an increased understanding of keyboard access. In particular, the literature on prebraille suggests a possible role for parents in the development of prekeyboarding skills. Exploratory procedures which have been described for haptic object recognition may also play a role in the exploration

and understanding of the lay-out of the keyboard. Reference cues, verbal labelling and comprehensive familiarisation promise to be relevant to support the acquisition of early keyboarding skills. In order to optimise educational outcomes and ensure equal opportunities for students who are blind, there is a call for evidence-based research into early computer use through the QWERTY keyboard by young children who are congenitally blind, in particular into salient features on the keyboard as potential reference cues for haptic spatial coding.

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