enthusiasts. In this case, the facilitator was a sighted individual who had first emulated a user with visual impairment and then was able to better communicate instructions meaningfully. Similarly, the role of the facilitator could be initiated by an experienced iPhone user with visual impairment.

References

AppAdvice. (n.d.). *Apps for blind and visually impaired*. Retrieved from http://appadvice.com/applists/show/apps-for-the-visually-impaired

Buckley, K. (2009, October 24). *Accessibility for iPhone, iPad, and iPod Touch: A blind user's review*. Retrieved from http://www.nillabyte.com/entry.php?280-Accessibility-For-iPhone-iPad-And-iPod-touch-A-Blind-User-s-Review

Color identifier. (2012, February 03). Retrieved from http://itunes.apple.com/sg/app/color-identifier/id363346987

Digit-eyes audio scanner and labeler. (2012, April 18). Retrieved from http://itunes.apple.com/us/app/digit-eyes-audio-scanner-labeler/id376424490

Kane, S. K., Bigham, J. P., & Wobbrock, J. O. (2008). Slide rule: Making mobile touch screens accessible to blind people using multi-touch interaction techniques. In: *Proceedings of the 10th International ACM SIGACCESS Conference on Computers and Accessibility,* 73–78.

Kendall, S., Nino, M., & Stewart, S. (2010). Using the iPhone and iPod touch@work. *Computers in Libraries, 30*(2), 14–19.

LookTel money reader. (2011, November 29). Retrieved from http://itunes.apple.com/us/app/looktel-money-reader/id417476558

Mazzochhi, S. (2011, Dec 14). iPhone for visually impaired people [video file]. Video posted to http://www.youtube.com/watch?v=LKB0cWqgB7Y

McConatha, D., Paul, M., & Lynch, M. J. (2008). Mobile learning in higher education: An empirical assessment of a new educational tool. *Turkish Online Journal of Educational Technology, 7*(3), 15–21.

Young, J. R. (2011). Top smartphone apps to improve teaching, research, and your life. *Education Digest, 76*(9), 12–15.

Meng Ee Wong, Ph.D., *assistant professor, National Institute of Education, Nanyan Technological University, Early Childhood and Special Needs Education, 1 Nanyang Walk, Singapore 637616; e-mail: <mengee.wong@nie.edu.sg>.* ***Stacey S. K. Tan, B.Sc.,*** *volunteer, Retinitis Pigmentosa Society Singapore, c/o 11 Third Hospital Avenue, Singapore 168751; e-mail: <stacey_sg@hotmail.com>. Please address all correspondence to Dr. Wong.*

An Alternative Option to Dedicated Braille Notetakers for People with Visual Impairments: Universal Technology for Better Access

Sunggye Hong

Technology provides equal access to information and helps people with visual impairments to complete tasks more independently. A major obstacle to the use of assistive technology for people with visual impairments is the expense associated with purchasing, maintaining, and updating such technology equipment (Microsoft Corporation, 2004). Sapp (2007) suggested that there are three important elements of technology to be considered for people with visual impairments. These are affordability, accessibility, and usability. Although proprietary technology venues developed for people with visual impairments may have fulfilled needs associated with accessibility well, it is the other two critical components for which there is significant room for improvement.

Universal design refers to "the process of creating products (devices, environments, systems, and processes) which are usable by people with the widest possible range of abilities, operating within the widest possible range of situations (environments, conditions, and circumstances)" (Vanderheiden, 1996, p. 1). The concept of universal design may have

potential implications for addressing the issues related to the use of technology devices by people with visual impairments. More specifically, affordability, accessibility, and usability of technology devices can be successfully addressed by adopting universal design.

Among various assistive technology options for people with visual impairments, braille notetakers have been considered the most significant because of their technological innovation. Braille notetakers allow users who are visually impaired to retrieve e-mails, access web pages, maintain schedules and calendars, emboss braille documents, and perform math and scientific calculations (Farnsworth & Luckner, 2008). With their capability to utilize speech and braille at the same time and to use six-key entry or a traditional QWERTY keyboard, braille notetakers became widely used among people with visual impairments. For example, Edwards and Lewis (1998) reported that almost 25% of teachers in Florida said they used braille notetakers in providing instructions for their students. Various types of techniques in utilizing braille notetakers have been devised. For example, Kapperman and Sticken (2003) reported that braille notetakers could be successfully used to create mathematical equations and could assist students with visual impairments in communicating better with their math teachers. Nemeth code instructions (Amberg, 2001), foreign language translation (Kapperman & Sticken, 2002), and general notetaking and braille translation (Farnsworth & Luckner, 2008) were implemented as significant functions of the braille notetakers.

A DEDICATED BRAILLE NOTETAKING DEVICE

A braille notetaker is a portable device that has built-in refreshable braille display and is designed specifically for people with visual impairments (Samuels, 2008). While having functions similar to mainstream laptop computers and maintaining equivalent connectivity options such as Universal Serial Bus (USB), wireless local area network (LAN), and Bluetooth, it can store electronic documents, translate uncontracted and contracted braille in "real time," and allow access to mainstream technology such as reading Microsoft Word and text documents. In a Delphi study conducted by Smith, Kelley, Maushak, Griffin-Shirley, and Lan (2009) on identifying important competencies of assistive technology, the use of braille notetakers was regarded as a topic with which teachers of students with visual impairments should be acquainted. Furthermore, one participant of the study conducted by Farnsworth and Luckner (2008) indicated that the use of the braille notetaker positively reshaped his school work and communication with others. This statement exemplifies the importance of a braille notetaker for people with visual impairments.

Although braille notetakers provide a variety of functions for people with visual impairments, there are some perceived disadvantages as well. For example, the average cost of a 32-cell, refreshable-display version of braille notetakers ranges from $5,500 to $6,500. A BrailleNote Apex, a notetaker commonly used by people with visual impairments and equipped with 32 braille cells, costs $6,195 (National Federation of the Blind, *Technology Resource List*, n.d.). Since the braille notetakers have been developed for a small population, maintenance and updates can be costly. For example, the manufacturers of many braille notetakers recommend annual service maintenance, the cost of which can be substantial. The standard Portable Document Format (PDF), a file format widely used to distribute digital contents, cannot be accessed by any braille notetaker unless the file is converted to an accessible document format using a computer. Similar limitations exist for accessing applets (small applications or "plug-ins") on a webpage in Java programming language, using Flash contents, and installing external applications that are not available as parts of braille notetakers. As a

result, users must wait until manufacturers implement necessary features on these devices, and these updates are often introduced long after mainstream technology options have been made available to sighted users. Obtaining maintenance and repair services can also be costly and time consuming. The use of braille notetakers is unique to people with visual impairments and thus unnecessary attention can be drawn from the public to users of such technology. This unwanted attention can be an especially critical barrier for those students who are in public school systems.

Since the technology implementation is based upon a proprietary design, users often have to learn an extensive number of commands to operate the tool. For example, in order to use certain braille notetakers, people have to memorize a great many chord commands. To invoke chord commands, users must press a spacebar and braille keys simultaneously. Since different companies utilize different command structures, the learning curve for a new device can be time consuming and can require memorizing many new commands.

New Technology Combinations to Be Considered

With innovative user interfaces and fast-developing hardware capability, recent smartphones, including some tablet devices, embrace many features that had only been available for desktop computers in the past. These smartphones also have many accessible built-in features. Among them, a function that requires closer examination is a feature for a user to connect a refreshable braille display wirelessly. For example, Apple's mobile devices that utilize IOS5, their latest operating system for mobile devices, can be connected to a refreshable braille display. With its screen reader, VoiceOver, users can navigate web pages, compose e-mails, and maintain calendars and other functions available on these devices via voice output, as well as access wirelessly connected refreshable braille display. Since numerous applications developed by users and software developers are added daily, and many of these applications follow general guidelines for accessibility, users who are visually impaired have many more capabilities on smartphones than on their proprietary counterparts. Table 1 compares the major functions of an iPhone 4 and a refreshable braille display with a Braille Sense.

Advantages of the combination of a refreshable braille display with a smartphone include low cost, seamless interaction with sighted people, easy maintenance and support, fast implementation of new functions, and universal access to applications and web pages. While smartphones require monthly data plans (thus direct comparison of costs cannot be made), other devices such as iPads or iPods do not require a monthly subscription charge. A refreshable braille display from Perkins (40-braille cell version) costs $2,495 (Perkins Products, n.d). An iPad equipped with 16GB of storage costs $499. When combined, an iPad along with a refreshable braille display costs roughly half that of a similarly equipped braille notetaker. Second, and more important, the option of utilizing mainstream technology demonstrates superb integration with the external environment. Accessing different file types and synchronizing e-mail and calendar are limited or difficult to implement on braille notetakers. The built-in universal access for these smartphones makes it much easier for users to exchange data and ideas with other people. Third, although a refreshable braille display should be cleaned and maintained like a braille notetaker, support and service options for smartphones such as iPhones are much more flexible and often take less time. Finally, a smartphone allows various external applications to run on its environment, making implementing and expanding additional functions more flexible.

Table 1
Comparison between a Braille Sense and an iPhone 4 connected with a refreshable braille display.

Function		Braille Sense	iPhone 4
Connectivity	Bluetooth	Yes	Yes
	Wireless LAN	Yes (802.11G)	Yes (802.11N)
	Wired LAN	Yes (10/100 Ethernet)	No
	USB	Yes	No
	External VGA	Yes	No
	Parallel port	No	No
	Serial port	No	No
E-mail	POP3 Ssupport	Yes	Yes
	IMAP support	No	Yes
	Exchange support	No	Yes
	Basic e-mail function	Yes	Yes
	Multiple e-mail accounts	Yes	Yes
Internet	Basic navigation	Yes	Yes
	Flash support	No	No
	Java Applet support	No	Yes (limited)
	Bookmark support	Yes	Yes
	Multiple tabs	No	Yes
Software	Calendar	Yes	Yes
	Calculator	Yes	Yes
	Messengers and social network services	No	Yes (with external applications)
	Voice recorder	Yes	Yes
	Address manager	Yes	Yes
	Media player	Yes	Yes
	Clock	Yes	Yes
	Installing external applications	No	Yes
	Modify default menu layout	No	Yes
Storage	External memory card support	Yes	No
	Installed storage	8GB	16/32GB
Synchronization	Wireless sync	No	Yes
	USB sync	Yes (limited to Windows only)	Yes
	Sync application	Window active sync	iTunes
	Data sync	Contact and schedule	Contact, schedule, music, video, bookmarks, and other files
Braille document	Display braille contents	Yes	Yes
	Input braille contents	Yes	No
	Braille translation	Yes	No
	Handling common braille file extension	Yes	No
Word processing	Supports basic feature	Yes	Yes
	Supports advanced feature	Yes	Yes (with add-on)
	Supports major file extension	Yes (limited)	Yes
	Print	Yes (wired)	Yes (wireless)
	Emboss	Yes	No
GPS	Built-in compass and map	No	Yes
	GPS function	Yes (optional)	Yes (optional)
	Voice guidance	Yes	Yes
	Braille guidance	Yes	Yes (limited)
	Adapted for visually impaired users	Yes	Yes (limited)

(cont.)

Table 1
(cont.)

Function		Braille Sense	iPhone-4
Access to media	Video	No	Yes
	Music	Yes	Yes
	Voice memo	Yes	Yes
	Pictures	No	Yes
	DAISY	Yes	Yes (with external applications)

Note: Compared equipment and configurations are as follows: Braille Sense, iPhone 4.

Additional Considerations

While numerous advantages are identified, the new option may not be for all people with visual impairments: some might derive greater productivity from dedicated braille notetakers. The smartphone/refreshable braille display combination does not have a braille translator. Thus, handling braille files is not as intuitive when compared to a braille notetaker. Second, although the majority of functions can be displayed in braille on a smartphone via its wirelessly connected braille display, there are some functions that must utilize voice output. For example, incorrectly labeled icons on some applications may not be displayed via braille display. Third, since applications are developed by many different companies and individuals, they differ in the way they are set up, and this requires problem-solving skills from users. This can be a huge obstacle for those people who have additional disabilities and who have difficulty generalizing and solving problems. Fourth, in dealing with technical issues, one may have to contact various vendors to identify problems and/or obtain repair services. This can be very inconvenient and time consuming, especially if various versions of software and different types of hardware devices are used in an agency or a school setting. Fourth, as the option is new, support groups for users who are visually impaired may be lacking. Although there are electronic listserves and user-developed demonstrations for the use of smartphones, supporting and instructional curricula materials are not as abundant as for a braille notetaker. It is also very important to note that typing on the new combination may not be as intuitive. Though there are some braille display devices equipped with a six-key keyboard that allows users to type directly to a smartphone wirelessly, those display devices without such a function may necessitate users to type directly into a smartphone or a tablet. Alternatively, an external QWERTY-type keyboard can be added, but this option increases the number of devices to be carried.

From posting a photograph on Facebook or identifying colors and money denominations, to reading bar codes for product usage and user reviews, the combination of a smartphone or a tablet and a refreshable braille display can function as an alternative to a dedicated braille notetaker. More important, this new option can provide many more functions and expand possibilities for people with visual impairments. While specific functions designed for users with visual impairments such as Nemeth code support, braille embossing, and native access to multiple-language braille are not readily available, a smartphone with a refreshable braille display can provide other functions by utilizing external applications that have not been available for a braille notetaker. Teachers of students with visual impairments, orientation and mobility specialists, rehabilitation counselors, and assistive technology specialists should carefully review the combination as an alternative to a braille notetaker and, if appropriate, provide

recommendations and instructions for students and clients with visual impairments.

References

Amberg, E. (2001). BrailleNote. *T.H.E. Journal*, *28*(10), 54–56.

Edwards, B. J., & Lewis, S. (1998). The use of technology in programs for students with visual impairments in Florida. *Journal of Visual Impairment & Blindness, 92*(5), 302–312.

Farnsworth, C. R., & Luckner, J. L. (2008). The impact of assistive technology on curriculum accommodation for a braille-reading student. *RE:view*, *39*(4), 171–187.

Kapperman, G., & Sticken, J. (2002). A software tutorial for learning the Nemeth code of braille mathematics. *Journal of Visual Impairment & Blindness*, *96*(12), 855–857.

Kapperman, G., & Sticken, J. (2003). Using the Braille Lite to produce mathematical expressions in print. *Journal of Visual Impairment & Blindness*, *97*(11), 710–713.

Microsoft Corporation. (2004). *Accessible technology in computing—Examining awareness, use, and future potential.* Redmond, WA: Author. Retrieved from http://www.microsoft.com/enable/research/phase2.aspx

National Federation of the Blind (NFB). (n.d.). *Technology resource list*. Baltimore, MD: Author. Retrieved from http://www.nfb.org/technology-resource-list

Perkins Products. (n.d.). *Adaptive technology: Blindness/low vision products: Braille displays.* Watertown, MA: Author. Retrieved from https://secure2.convio.net/psb/site/Ecommerce?FOLDER=1120&store_id=1101

Samuels, C. A. (2008). Braille makes a comeback. *Education Week*, *27*(43), 27–29.

Sapp, W. (2007). MySchoolDayOnline: Applying universal design principles to the development of a fully accessible online scheduling tool for students with visual impairments. *Journal of Visual Impairment & Blindness*, *101*(5), 301–307.

Smith, D. W., Kelley, P., Maushak, N. J., Griffin-Shirley, N., & Lan, W. Y. (2009). Assistive technology competencies for teachers of students with visual impairments. *Journal of Visual Impairment & Blindness, 103*(8), 457–469.

Vanderheiden, G. (1996). *Universal design . . . What it is and what it isn't.* Madison, WI: University of Wisconsin-Madison, Trace Research and Development Center.

Sunggye Hong, Ph.D., *assistant professor, coordinator, Program in Visual Impairments, Department of Special Education, San Francisco State University, 1600 Holloway Avenue, San Francisco, CA 94132; e-mail: <hong72@sfsu.edu>.*

