Performance Enhancement & Health 2 (2013) 101–109

Contents lists available at ScienceDirect

Performance Enhancement & Health

journal homepage: www.elsevier.com/locate/peh

Audio assistive technology and accommodations for students with visual impairments: Potentials and problems for delivering curricula and educational assessments

Michael A. Nees*, Lauren F. Berry

Lafayette College, Easton, PA, United States

ARTICLE INFO

Article history:
Received 19 February 2013
Received in revised form 23 August 2013
Accepted 24 August 2013

Keywords:
Text-to-speech
Auditory graph
Universal design
Sonification
Standardised testing

ABSTRACT

Audio assistive technology and testing accommodations have become an increasingly prevalent and potentially useful means of promoting inclusivity in education. Technologies such as text-to-speech and other forms of audio information representation have helped to make curricula more accessible to people with visual impairments and other disabilities. Auditory accommodations in educational testing have also been implemented in an attempt to ensure equitable access to educational evaluations for people with disabilities. The potential benefits of audio assistive technology and accommodations notwithstanding, barriers remain to the implementation of audio in education for people with disabilities. Concerns with validity in audio tests, technical difficulties in the delivery of audio, and general stigma associated with the use of assistive technology and accommodations present formidable challenges that must be met before the full potential of audio assistive technology can be realised. This review examines current practices, potentials, and problems with the use of audio assistive technology and accommodations in educational settings.

The importance of advancing equality and participation in society for people with disabilities has been recognised by local (see, e.g., Thurlow, 2007), national (Australian Government, 2012; Dove, 2012; U.K. Department for Education, 2012), and international governing bodies (e.g., U.N. General Assembly, 2006). The widespread availability of computers and other devices with high fidelity audio capabilities has opened a multitude of possibilities for improving the delivery of curricula and ensuring fairness in educational assessment for people with visual impairments and other disabilities. Audio has become increasingly pervasive in many computing technologies (Edworthy, 1998; Flowers, 2005; Hereford & Winn, 1994; Kramer et al., 1999), though sound was examined as an information display as early as the 1950s (Frysinger, 2005). One important factor motivating the implementation of auditory displays in systems has been the desire to use assistive technology (AT) to meet the needs of populations of people with disabilities—especially people with visual impairments. When educational experiences become accessible with sound, collateral benefits may accrue for sighted learners. Further, sound may be an important tool for universal design (Nees & Walker, 2009)—an inclusive design approach that emphasises accessibility for all people, including those with disabilities (Connell et al., 1997). The use of sound for presenting educational materials may also accommodate disparate learning styles or simply make learning more fun. As such, audio has begun to make curricula accessible for learners for whom traditional textbooks and visual materials are inadequate. Further, audio has played an important role towards ensuring people with disabilities are given fair opportunities to express their educational achievements and aptitudes in both classroom and high-stakes testing scenarios.

A recent study (Marder, 2006) suggested that the majority of students with visual impairments (especially those without comorbid developmental disabilities) are educated in general classrooms with their sighted peers and often participate in mainstream activities—including group work, writing assignments, and exams—with their classmates. Not surprisingly, most of these students accessed the educational curriculum with the help of some form of AT. Technology seems to afford access with some degree of success; Marder reported that almost half of the students with visual impairments and no concurrent developmental disabilities earned grades of "mostly As and Bs" in their classes. Human aids that read written information aloud to the learner (i.e., *oral readers*) were not commonly reported for students with low vision—a degree of intact visual capabilities. Only about a quarter of students who were blind used a human reader to access educational materials. Instead, nearly one-third of students who had low vision and about two-thirds of students who were blind reported accessing the

* Corresponding author at: Lafayette College, Department of Psychology, Oechsle Hall, 350 Hamilton Street, Easton, PA 18042, United States. Fax: +1 610 330 5349.
E-mail addresses: nees.michael@gmail.com, neesm@lafayette.edu (M.A. Nees).

2211-2669/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.peh.2013.08.016

educational curriculum with AT that used auditory presentation, including audiobooks and computer software.

Research (e.g., Sloutsky & Napolitano, 2003) has suggested that audition may be dominant over vision in young children in some circumstances; thus, audio may present unique learning opportunities for children (Droumeva, Antle, & Wakkary, 2007). The potential benefits of audio AT in educational settings extend across the entire age spectrum to students in higher education and even informal lifelong learning activities. Despite the tremendous potential for audio AT to promote participation and collaboration in educational settings with diverse learners, many outstanding issues remain with respect to the best practice use of audio AT. In this review, we weigh the potential benefits and difficulties of audio AT in educational settings. Our discussion is divided into three major sections: (1) audio AT for delivering educational curricula; (2) audio accommodations in educational testing; and (3) problems with audio AT and accommodations. Although our review is most immediately informed by policies and practices in the United States, the majority of the information presented has relevance in the United Kingdom (U.K. Department for Education, 2012), the European Union (Arsenjeva, 2009), Australia (Australian Government, 2012), and even in the Global South (Davison et al., 2012; Walker, Bruce, Nees, & Mwaniki, 2011).

1. Audio AT for delivering educational curricula

Educational materials can be delivered in a host of presentation formats, including traditional textbooks and, increasingly, electronic books (e-books). Content may vary widely across courses and disciplines, but the fundamental components of most learning materials are weighted heavily towards text—words on the page or screen. Learning materials often also include figures, graphs, and diagrams in addition to text. Still other learning activities are experiential and involve hand-on activities or observations of exhibits. Our discussion of audio AT for delivering educational curricula has been organised around these components of educational materials and experiences, and we believe our review should generalise widely across many subjects and disciplines of study that use text, diagrams and graphs, and/or experiential activities to teach their respective curricula.

1.1. Audio AT for text

Perhaps the most common audio AT is synthetic speech (Massof, 2003). Reading and written communication are prevalent learning activities, and the verbalisation of orthographic information offers a flexible and adaptable means of non-visual communication. Synthetic speech is most often delivered via text-to-speech (TTS) engines, whereby the digital text from e-books, web pages, word processing software, e-mails, etc., is translated to an audible, speech-like signal. TTS sounds are different from natural human speech in that they are produced via computer algorithms, which introduce the potential for TTS to sound robotic and to produce idiosyncratic or errant utterances for some text. A wealth of research has examined the viability of synthetic speech as compared to pre-recorded natural human speech. In general, studies have shown that synthetic speech is more difficult to understand than natural speech, though practice does improve synthetic speech comprehension (Delogu, Conte, & Sementina, 1998; Reynolds, Isaacs-Duvall, & Haddox, 2002). The potential downsides of synthetic speech are balanced by the increased efficiency gained by allowing the user control over the rate of presentation with TTS, and a study suggested that time-compressed artificial speech may be easier to perceive and preferred over natural fast-talking (Janse, 2004). Research (Asakawa, Takagi, Ino, & Ifukube, 2003) has shown that practiced TTS users find presentation rates of up to 500 words per minute to be intelligible for some types of material. Even inexperienced users were able to recall content at TTS rates presented around one-and-a-half times faster than default system settings. From a design perspective, TTS is desirable over pre-recorded audio files of actual human speech, because the full catalogue of potential utterances need not be anticipated and recorded a priori. Further, TTS algorithms have continued and will continue to improve; some current algorithms are almost indistinguishable from natural speech (Schroder, 2009).

TTS has been implemented with considerable success in screen readers—software packages that interface with a computer or mobile operating system to translate text, menus, and commands in the interface into audio. Screen reader users provide input using the computer keyboard, so the use of screen readers is heavily dependent upon keyboard shortcut keys (Kurniawan, Sutcliffe, & Blenkhorn, 2003). For example, pressing the "tab" key prompts the software to read aloud the text of available buttons in a dialogue box (e.g., "cancel" or "continue"), and pressing the "enter" key would select the active button (for a detailed account of screen reader functions, see Asakawa & Leporini, 2009). One estimate suggested that up to 3.5% of internet users access content via a screen reader, and difficulties with estimating the true prevalence of usage could mean that this is an underestimate (Practical eCommerce Staff, 2010). A recent survey suggested that almost all screen reader users have a disability, and the majority feel proficient with the technology and use it with desktop, laptop, and mobile computing devices (WebAIM, 2012). The survey also suggested that most respondents were audio-only users (i.e., they did not use the screen reader in conjunction with Braille or modified visual output).

TTS also has been implemented widely in increasingly popular e-books delivered via e-reader platforms. One of the potential advantages of electronic texts is their ability to provide flexible modes of output (including audio) and supplemental learning information to the reader (Anderson-Inman & Horney, 2007). Further, a recent survey (Bryant, Seok, Ok, & Pedrotty Bryant, 2012) suggested that audio books were the single most-used learning technology for people with intellectual and developmental disabilities. Even most of a general sample of college students who used e-books or e-readers found at least some value in the audio functions of such devices (Foasberg, 2011). E-books and related technologies open abundant opportunities for making educational materials accessible (Cavanaugh, 2002), and increasingly, applications developed for common devices such as smartphones and tablet computers also have usefulness as AT (Douglas, Wojcik, & Thompson, 2012).

When software applications and web content are designed to be accessible to screen readers (see, e.g., Asakawa & Leporini, 2009; Mankoff, Fait, & Tran, 2005), people with visual impairment or other disabilities can access the text content of a wealth of educational materials via audio. E-Books, web pages, and educational software can be studied in collaboration by students with and without visual impairments. Previous modes of alternative presentation such as braille were limited in availability, but digital educational materials are arguably more accessible to people with disabilities now than at any other time in human history (for a review, see Grammenos, Savidis, Georgalis, Bourdenas, & Stephanidis, 2009). Research also has shown that screen readers and TTS audio can benefit students with learning disabilities (see Anderson-Inman & Horney, 2007; Izzo, Yurick, & McArrell, 2009).

Although the direct translation of written language to speech may make the contents of many disciplines (e.g., language arts, social sciences) accessible, students in science, technology, engineering, and math (STEM) courses often encounter special cases of text (e.g., equations) that do not translate as readily to spoken audio (for a review, see Pontelli, Karshmer, & Gupta, 2009). In response, systems for translating equations and other