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Assistive Technologies for Computer-Based Assessments

By Mark Hakkinen[1]

Key definitions:

accessibility – the degree to which a product, device, service, or environment is available.

assistive technology – any item, piece of equipment, or system used to increase, maintain, or improve functional capabilities of individuals with disabilities or functional limitations.

haptics – a technology that provides communication feedback via touch.

Acronyms:

AAC: augmentative and alternative communication

CBT: computer-based testing

IMS GLC: IMS Global Learning Consortium

LD: learning disabilities

W3C: World Wide Web Consortium

WCAG: W3C's Web Content Accessibility Guidelines

Introduction

It is ETS's mission to help advance quality and equity in education by providing fair and valid assessment, research, and services for all people worldwide, and that includes people who have disabilities. The work to achieve this mission is facing a number of challenges in a changing world, partially due to rapid technological change and the spread of information technology.

This essay discusses the impact of technology on education and educational assessment, which is even more profound for test takers with disabilities and special needs.

Disability is not a small or marginal phenomenon. The World Health Organization and the World Bank reported in 2011 that 20% of the global population has a disability — that is, about one billion people (World Health Organization & the World Bank, 2011).

In addition, this segment of the population can include persons with any of a broad range of physical, sensory, cognitive, psychiatric, and learning disabilities. While computer technology can impede access to information for people with disabilities, it can also open new opportunities to improved fairness and validity of assessments (Bennett, 1999).

New computer and information technologies have fundamentally changed the landscape in ways that provide unprecedented access to information and educational resources for all students, including those with disabilities. These technologies have also made it easier and less expensive to accommodate specific needs for presenting instructions and test items during an assessment to students with a disability.

Assistive technologies are key to providing access. Today they often come as built-in features in off-the-shelf products such as the iPad®, iPhone®, Apple TV®, and Android™-based phones and tablets. A user with a visual impairment can simply turn on a device's accessibility features to enable programs such as the VoiceOver screen reader or a magnifier. Such applications can be downloaded (for free or at low cost) and installed if the device does not already have that capability preinstalled. For users

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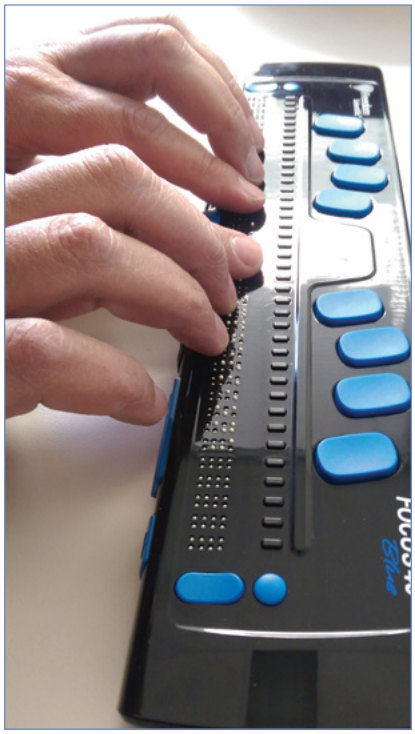

A refreshable braille display, upon which users can read using their fingertips. The braille text is displayed through a long matrix of pins that can be individually raised to form letters and words. Above the display pins on this photo are braille input keys. The braille display can be used in combination with a speech synthesizer, which converts text to speech.

Laws and regulations related to persons with disabilities

ADA: Americans With Disabilities Act (1990)

IDEA: Individuals with Disabilities Education Improvement Act (2004)

RA: Rehabilitation Act (1973)

European Commission Standardization Mandate 376 (2013)

United Nations' Convention on the Rights of Persons With Disabilities (2007)

with a communications impairment, applications are available that can turn the tablet or smartphone into an augmentative and alternative communication (AAC) device. Many newer devices are also able to interoperate with various types of assistive technology hardware, such as wireless refreshable braille displays.

As much as the new technologies present opportunities for learners with and without disabilities, it is crucial that the new computer-based delivery platforms and assistive technologies not alter the construct to be assessed or make the assessment process more complicated for the test taker.

Drivers of Innovation

Innovations in technology have spurred the development of assistive technologies that have helped make information technology and the World Wide Web accessible to individuals with disabilities. Another key driver behind this technology innovation is the trend toward standardization, which essentially means that something is built or executed in a certain way, adhering to technical or other specifications that have evolved over time or were set deliberately. It is hard to imagine the modern world without standards for measurement, machine parts, tools, electrical current, data traffic, file format, and so on. Without such standards, computer-based information and communication would have been more expensive, harder to access, and harder to learn and keep up with. Some standards have been driven by commercial needs to spur interchange of information resources, developed and monitored by national and international standards organizations, while others have been mandated by national governments. Technical standards are essential to ensuring that end users with disabilities are able to use assistive technologies across different software products, document files, and websites in a reliable and robust manner. In addition to standards from the domain of technology, the field of assessment develops and maintains its own standards. The *Standards for Educational and Psychological Testing* (*Testing Standards* for short) emphasizes "that fairness to all individuals in the intended population of test takers is an overriding, foundational concern" (American Educational Research Association [AERA], American Psychological Association [APA], and National Council for Measurement [NCME], 2014, p. 49). The latest edition of the *Testing Standards* (AERA, APA, & NCME, 2014) adds two relatively recent concepts, accessibility and universal design, which are key components to supporting the needs of a diverse population of test takers, including those with disabilities.

In addition to the *Testing Standards* (AERA, APA, & NCME, 2014), the 2014 edition of the *ETS Standards for Quality and Fairness* (Educational Testing Service [ETS], 2015), which are based on the 2014 edition of the *Testing Standards*, requires ETS, when providing assessments for people with disabilities, to

> *… ensure that ETS will take into account the diversity of the populations served as it designs, develops, and administers products and services. ETS will treat people comparably and fairly regardless of differences in characteristics that are not relevant to the intended use of the product or service.* (ETS, 2015, p. 19)

"As much as the new technologies present opportunities for learners with and without disabilities, it is crucial that the new computer-based delivery platforms and assistive technologies not alter the construct to be assessed or make the assessment process more complicated for the test taker."

and to

> *Provide appropriate accommodations or modifications for people with disabilities.* (ETS, 2015, p. 21)

Standards typically define technical requirements that enable accessibility, but there are also legal requirements that people with disabilities be treated fairly. The United States government has enacted laws, specifically the Americans With Disabilities Act of 1990, as amended (ADA), and the Individuals With Disabilities Education Improvement Act of 2004 (IDEA).

IDEA requires that state- and district-wide assessments be accessible to students with disabilities. The law mandates that all such computer-based testing (CBT) programs develop accessibility features and possibly offer alternate assessments so that students with disabilities can participate.

These laws seek to prevent people with disabilities from being excluded from educational or employment opportunities. The combination of technical standards and laws that incorporate or reference those standards is an emerging trend and specifically define the technical requirements to ensure access. A growing number of states rely on the accessibility standard in Section 508[2] of the Rehabilitation Act of 1973, as amended, which requires that federal agencies make their electronic and information technology accessible to people with disabilities and favor the procurement of technologies that meet specific technical criteria for accessibility. Section 508 specifically addressed technical requirements that computer-based systems can be used by people with disabilities, and this requirement also covers digital assessments. These technical requirements are based on the accessibility standards developed by the World Wide Web Consortium (W3C).[3]

Similar requirements have also begun to appear internationally in the form of accessibility legislation modeled on that of the United States. For example, the European Union's Standardization Mandate 376 (European Commission, 2013) seeks to prevent new Internet and computing technology products and services from introducing accessibility barriers and, like Section 508, emphasizes procurement of products and services that support accessibility. On a global level, the United Nations' Convention on the Rights of Persons With Disabilities (United Nations General Assembly, 2007) is another important starting point when countries consider accessibility legislation, with the convention's specific reference to inclusion of people with disabilities in all aspects of life, including education.

What does this mean for educational assessment? The combination of industry standards and legal requirements as described above, with increased innovation in testing (e.g., simulations, adaptive assessments), present increased challenges for digital delivery of assessments. There already have been several legal challenges to

[2] **http://www.section508.gov/section508-laws**
[3] **http://www.w3.org/TR/WCAG20/**

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testing organizations when students with disabilities were not included in the digital delivery of the assessment, including the Partnership for Assessment of Readiness for College and Career (PARCC; Samuels, 2014). In 2012, the Office of Civil Rights at the U.S. Department of Justice was asked to intervene when a student in Oregon challenged the use of a paper-based braille format that was offered to braille readers when other students were offered a computer-adaptive assessment (Samuels, 2012). This challenge resulted in the development and delivery of the first computer-adaptive assessment administered using refreshable braille, text to speech, and on-demand embossing. And in a broad settlement of a suit on behalf of test takers with disabilities against the Law School Admissions Council, a key provision will allow test takers to use accommodations, including screen-reading software that they have been allowed to use on previous assessments (U.S. Department of Justice, 2014).

Further challenges and opportunities are expected as the demand, based both on specific state requirements and technology adoption, grows for technology-enhanced assessments delivered to the students' own computing devices, especially tablets. With growing availability of assistive technology solutions on mainstream technology platforms, including tablets, students with disabilities who use those technologies daily are primed to expect that digital assessments will be compatible with the tools they are already using. As noted, recent legal decisions appear to support that view.

The move toward more complex and interactive test items delivered on a range of different platforms (ranging from traditional desktop PCs and Chromebooks™ to tablets such as the iPad) will present significant challenges to assessment developers as they address accessibility issues. An additional challenge is that more test takers will be English language learners with disabilities, combining the need to incorporate accommodations specific to language learners with the need to do so in an accessible manner.

There has been important progress in ensuring that CBT can accommodate the needs of all test takers, but much work remains to be done. As legal requirements are bringing the issue of accessibility and accommodations to the forefront, more research is needed on design of accessible assessments, and in particular the integration of mainstream assistive technologies and accessibility standards in CBT. To successfully align accessible CBT with standards and legal requirements, it is first necessary to understand the population of test takers with disabilities and their specific needs. Especially in the context of technical accessibility standards, the needs of test takers with disabilities can go beyond what has been codified in standards originally developed for accessibility of the World Wide Web.

Test takers with disabilities: Who are they and what do they need? Approximately 13% of the United States population ages 3 to 21 have been identified as having a disability (Snyder & Dillow, 2013). The functional limitation may be physical, sensory, cognitive, or a combination, and can be permanent or temporary.

"It is important to consider a broad range of disabilities right from the beginning in the research and design of computer-based and technology-enhanced assessments."

Table 1. Children 3–21 Years Old Served Under Individuals With Disabilities Act, Part B, 2010–2011

Disability	Percentage of all enrolled disabled students
Autism	6.5
Deaf-blindness	< 1.0
Developmental delay	5.9
Emotional disturbance	6.1
Hearing impairments	1.2
Intellectual disability	7.0
Multiple disabilities	2.0
Orthopedic impairments	1.0
Other health impairments	11.1
Specific learning disabilities	36.7
Speech or language impairments	21.7
Traumatic brain injury	0.4
Visual impairments	0.4

Note: Data from *Digest of Education Statistics, 2012* (NCES 2014-015; Table 48), by T. D. Snyder and S. A. Dillow, 2013, Washington DC: National Center for Education Statistics.

However, disability statistics (see Table 1) tell only part of the story, as it is easy to focus on one type of disability, while a student may have multiple disabilities. There can also be individual differences in terms of the severity or extent of the functional limitation a student experiences. For example, autism can describe a range of functional limitations that exist along the autism spectrum; visual impairments can include blindness, partial vision, and low vision.

What are assessment accommodations? The traditional way of addressing specific needs of a student with a disability has been to provide an assessment accommodation, which is defined as "a change in the materials or procedures used for testing that does not change the construct that a test is intended to measure" (Lazarus, Thurlow, Lail, & Christensen, 2009) (Thurlow & Larson, 2011, Definitions section, para. 1).

A review (Thurlow & Larson, 2011) of testing accommodations provided to students with disabilities on state accountability assessments identified 72 types of testing accommodations listed in state policies. The range of accommodations requested highlights the diversity of disabilities. At present, though, there is little information about which accommodations are used most often in K–12 and higher education in the United States and globally.

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Assessment accommodations are essential to supporting the needs of students with disabilities, but the prevalence of a disability varies, and some accommodations may be requested less frequently than others simply based on how many students with a particular disability take a specific assessment. It is important to consider a broad range of disabilities right from the beginning in the research and design of computer-based and technology-enhanced assessments.

On ETS admissions and licensure assessments, the most commonly granted accommodations are extended time, separate room, audio (i.e., screen reader or human reader), large print, screen magnification, calculator (or talking calculator), scribe or keyboard entry aide, additional supervised break time, and sign language interpreted instructions for deaf or hard of hearing test takers.

It can be challenging to identify and implement the best accommodations for all test takers with special needs. However, there exists a solid foundation for incorporating accessibility in computer-based systems, and it is important to apply current knowledge when creating computer-based assessments while at the same time directing research efforts to areas where important unanswered questions remain.

Accommodations that target specific disabilities may require complex and overly specialized functions resulting in CBT platforms where functionality, appearance, and quality vary from vendor to vendor. Such built-in accommodations may also differ from the assistive technology tools that a student uses on a daily basis, whether in the classroom or at home. A growing number of students prefer to use their own assistive technologies, such as screen readers or magnifiers, instead of equivalent features built into a CBT platform.

One way to approach this problem is to create computer-based assessment platforms that support both student-preferred assistive technologies and built-in accommodations, but this can be technically daunting. Given the wide range of assistive technologies in use, the developers of CBT are faced with concerns ranging from ensuring test security to verifying compatibility with specific versions of tools. Allaying these concerns will require collaboration across the assessment, standards, and assistive technology communities.

Further, deciding which accommodation features to build in to a CBT platform and which should be handled by a compatible assistive technology is critical, as the decision can impact software complexity, implementation costs, and test-taker experience, particularly if there are differences between mainstream assistive technologies students may already be familiar with and similar functions implemented directly in the CBT. The greatest technical challenge is in providing accommodations for students with sensory disabilities, specifically those with visual impairments. Because of the complexity of the software behind assistive technologies such as screen readers, a strong case can be made that developers of CBT should focus on supporting those technologies rather than creating them. Such an approach can leverage the assistive technology skills of the student when it comes time to taking an assessment.

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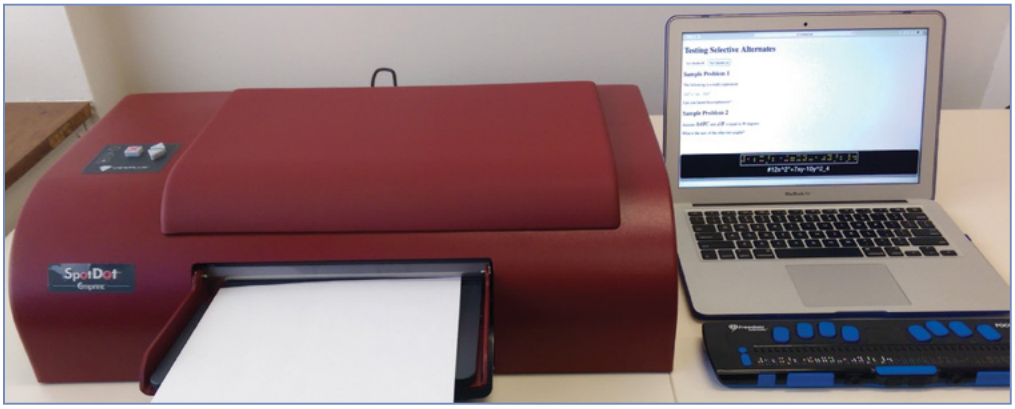
The next section explores how students with sensory disabilities use technology to access both learning materials and assessments.

Trends in technology use by students with sensory disabilities. Students with disabilities have access to a growing ecosystem of technology products and software that support learning. Students in the subgroup that have *sensory* disabilities can access learning materials and assessments through assistive technologies — that is, objects, pieces of equipment, or systems that are used to increase, maintain, or improve these students' functional capabilities. *Visually* impaired students can use common assistive technologies such as screen readers — software tools that translate textual information displayed on the computer or tablet screen into an alternative format such as computer-synthesized text-to-speech (TTS) or a refreshable braille display. Screen readers such as VoiceOver for Apple® products and JAWS for Windows® PCs enable visually impaired users to access information nonvisually. For students with speech impairments, AAC technology provides hardware and software interfaces that enable a student to generate speech. And for students with physical limitations who cannot use a computer mouse or keyboard, switch interfaces enable software applications to be controlled via external hardware such as sip-puff tubes (a form of on/off switch) or large, easy-to-activate buttons.

Assistive technologies have historically been expensive and required special training. They have often only been able to *reduce* a functional limitation and not eliminate it. Assistive technologies may allow a person to perform a task, but not always as efficiently as a person who does not have a disability.

However, the choices available for students with disabilities have never been greater, thanks to the wide and inexpensive availability of computer-based products that feature accessibility and assistive technologies. Many smartphones and tablets support TTS and refreshable braille. Hence, many students with disabilities expect technologies used in the classroom for learning and assessment to be compatible and work just as well as their own computers, tablets, and phones.



A workstation that can enable a person with a visual impairment to type, read and "print" braille text. To the left is an embossing printer, which embosses raised dots onto paper to form braille text, as well as raised dot tactile graphics. In front of the laptop is a refreshable braille display.

"Standards-based software and hardware have the important benefit of driving down the cost of the technology development and acquisition, and this is especially true with assistive technologies."

The Need for Technical Accessibility Standards in Assessment

The potential benefit of technology is obvious, but that potential is wasted if different technologies cannot work together. Puffert (2000) described a classic story of standardization from the early 1800s. At that time railroads in the United States used nine different gauges (width) of track, leading to incompatibility between rail systems and the free movement of passengers and cargo. When tracks were standardized to a single gauge beginning in 1860, rail traffic grew, enabling economic expansion and opportunity. The effectiveness that technology can bring to accessibility requires that software and devices can reliably and seamlessly work together to the benefit of the user. Standards-based software and hardware have the important benefit of driving down the cost of the technology development and acquisition, and this is especially true with assistive technologies. Standards can also lower the necessary investment in learning how to operate new hardware or software applications. The user benefits from consistent and robust standards for components such as (a) the computer's operating system and user interface to web pages containing assessment items; (b) web browsers used to deliver a web page, such as Apple's Safari® or Google's Chrome™ browser; and (c) assistive technologies with screen readers and refreshable braille displays. Standards allow multiple vendors and technologies to work together, but there are many standards and they, too, need to interoperate (i.e., be able to work seamlessly together to achieve a common goal). When standards with a similar goal take different approaches to reaching that goal, the seamless, reliable ability to exchange information in an interoperable manner becomes difficult, increasing costs to convert information into a common format and resulting in inconsistent experiences for the users of systems based on each standard. Seeking to harmonize multiple accessibility standards has become a critical concern in the assessment community. In assessment, two technical standards have emerged that are both crucial to delivering digital assessments to test takers with disabilities:

- World Wide Web Consortium Web Content Accessibility Guidelines (World Wide Web Consortium, 2008)[4]
- IMS Global Learning Consortium standards (IMS GLC)[5]

Need for Empirical Research to Support Computer-Based Testing Standards and Guidelines

Accessibility is becoming the norm for computer-based systems, whether it relates to an assessment, web-based practice material, or an item-authoring tool. Guidelines and requirements, such as Section 508 and the Web content accessibility guidelines (WCAG) (World Wide Web Consortium, 2008) provide system designers and developers with valuable baseline guidance on accessible design, but they are not specific to the context of CBT. This is particularly crucial in an assessment context. Design guidelines for accessibility recommend adapting content to better meet the needs of the user, which could require providing descriptions of complex images for persons with visual

[4] **http://www.w3.org/TR/WCAG20/**
[5] **http://www.imsglobal.org/background.html**

"The challenge for researchers is that new technologies emerge rapidly, gain rapid adoption, and can have significant impact for accessibility. Understanding the tools that test takers use in their daily lives will be key for researchers focused on the development of accessible CBT."

impairments and alterations of visual layout for persons with low vision. However, a textual description of an image could invalidate an item for students with visual impairments if it reveals the answer when describing its salient features or spatial relationships. Alternate media such as embossed paper tactiles may be appropriate alternatives from the assessment perspective and are already in use (Greenberg, 2012). Emerging technologies offer further options for the future, including haptic effects on a tablet (Hakkinen, Rice, Liimatainen, & Supalo, 2013) or 3D-printed objects (Siu, 2014), but these approaches will need to be verified by evidence that supports their appropriateness in assessments. The challenge for researchers is that new technologies emerge rapidly, gain rapid adoption, and can have significant impact for accessibility. Understanding the tools that test takers use in their daily lives will be key for researchers focused on the development of accessible CBT.

Conclusion

Ensuring accessibility of computer-based assessments is vital to serving the needs of test takers with disabilities. While the goal is often set by legal requirements to provide access to education for students with disabilities, research is essential to achieving that goal in a way that meets the students' needs in a valid, fair, and reliable manner. The key to doing this is a multipart effort. The focus must be on understanding the requirements of test takers with disabilities and the assistive technologies they use both in and out of the classroom. Knowing what works, especially in a period of rapid technological change, is essential in creating computer-based assessments. Developing and using technical standards and guidelines across the learning and assessment environment plays an essential role, as does harmonizing the critical requirements of assessment and accessibility. While there is still a long way to go, research and standards are showing the way forward for achieving computer-based assessments that can serve the needs of all test takers.

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