Meeting the Needs of All Students:
A Universal Design Approach to Computer-Based Testing

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Over the past two decades, many large-scale testing programs have transitioned to computer-based delivery in order to increase the efficiency of delivering and scoring tests and reporting results. Computer-based testing, if carefully designed and administered, may also have the potential to increase test validity, particularly for students with disabilities and other special needs, by providing a consistent testing environment for all students that accommodates special needs in an equitable manner.

Applying the principles of universal design to the development of computer-based testing systems can remove many of the barriers to the accurate measure of achievement for students with special needs. Nimble Assessment Systems has worked with several state testing programs and schools to access this potential; the result is NimbleTools, a universally designed test-delivery system that embeds several different accessibility and accommodation tools to facilitate testing of students with disabilities and special needs. In this article, we outline some of the shortcomings of current approaches to testing for students with special needs, discuss the benefits of a universal design approach, and explore how the principles of universal design were applied to the design and development of NimbleTools.

Current Approaches to Test Accommodations

Traditionally, paper-based testing programs have attempted to increase test validity for students with special needs by providing test accommodations. Test validity is a measure of the extent to which a test measures a given construct without interference from non-tested constructs (Messick 1989), thus permitting a valid inference about an examinee's achievement, ability, or readiness for a given educational program. Test accommodations alter either the manner in which test items are delivered to a student or the means by which a student responds to test items or both (Driscoll 2007). For students with disabilities and special needs, test accommodations are intended to decrease the influence of construct-irrelevant barriers and thus increase the validity of their test scores (Elliot, Kratochwill, and Schulte 1999; Crawford 2007; Sireci, Li, and Scarpati 2003; Sireci, Scarpati, and Li 2005). By decreasing the influence of non-tested constructs, test accommodations allow students with disabilities and special needs a better opportunity to demonstrate their achievement and participate in assessment programs on a more equitable basis (Driscoll 2007).

Appropriate accommodations vary with the individual student's disability; they may include having written materials read aloud for students with dyslexia or other reading disorders, magnifying materials for students with visual impairments, using tools that isolate (or mask) information on a page for students with information-processing or attention disorders, and using oversized writing materials or a special keyboard for students with fine motor skill difficulties (Abedi et al. 2001; Crawford 2007; Gibson et al. 2003; Sireci, Scarpati, and Li 2005; Tindal et al. 1998). Within the United States, test accommodations are required by two federal laws: the Individuals With Disabilities Education Act of 2004 (IDEA) and the No Child Left Behind Act of 2001 (NCLB).

While all US testing programs make provisions for test accommodations, several shortcomings are common (Exhibit 1). The fundamental problem faced by state testing programs attempting to comply with federal accommodation requirements stems from the need to adapt standard test materials and administration procedures to the unique needs of students. In the fixed medium of paper, accommodations require the development of multiple versions of test materials and the provision of additional test proctors with specialized skills, such as the ability to communicate in American Sign Language or to speak a student's first language. Computer-based testing can overcome these shortcomings by allowing students' needs to be accommodated within the framework of the test; besides reducing cost and logistical barriers, computer-based testing using a system based on the principles of universal design can improve test validity and allow students with special needs to compete on a more-level playing field.

Universal Design

Universal design is a direct response to design flaws in buildings—staircases and escalators, narrow hallways, high sinks—that make it difficult for people with physical disabilities to access buildings or use facilities within those buildings (Hanna 2005). Prior to the passage of the Americans with Disabilities Act of 1990 (ADA), people with physical disabilities often required assistance to access facilities available only via stairs or tight entryways. In other cases, they had to use a separate entrance, such as a loading dock or side door. In the most inaccessible buildings, persons with mobility issues might have to be carried inside.

The phrase universal design, coined by Ron Mace, describes a movement within architecture that aims to design buildings to accommodate the widest range of users, including individuals with disabilities (Rose and Meyer 2000); the movement was spurred by passage of the ADA and the subsequent development of specific standards for compliance. Architects applying the principles of universal design consider multiple needs of potential users during the design stage, avoiding expensive and often awkward retrofitting after construction (Dolan et al. 2005). In 1997, the Center for Universal Design (CUD) formally defined universal design as "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" (CUD 1997, "Universal Design Definition," ¶1).

The theory of universal design is encapsulated in seven important design principles that require architects to consider the usefulness, accessibility, flexability, and useability of the buildings they create (Thompson, Johnstone, and Thurlow 2002, 4). The concept has extended beyond the field of architecture to many other arenas, including product design, media, and recreation. Universal design has come to include the concept of allowing users to select from among multiple alternatives for use. Discussing the application of universal design to learning systems, Rose and Meyer (2000) emphasize that "Universal Design does not imply 'one sizes fits all' but rather acknowledges the need for alternatives to suit many different people's needs . . . the essence of [universal design] is flexibility and the inclusion of alternatives to adapt to the myriad variations in learner needs, styles, and preferences" (4). A good example of choice among alternatives is the closed captioning of television programs; the user, whether hearing impaired or not, may access a program with the volume on or off and with captioning on or off.

Universal design for learning (UDL) applies these same design principles to education by considering a variety of potential accessibility and learning needs when developing instructional materials. UDL seeks to address three potential barriers to learning when developing learning materials (Rose 2001). The first barrier relates to recognition networks and the manner in which a student is able to access content. Meeting the recognition needs of all students requires that content be presented in different manners—textually, graphically, or orally—so that students who are better able to access content through different modes are accommodated. The second barrier relates to students' ability to engage with materials; students must be offered multiple avenues to interact with new information or develop new skills including through group or individual activities, via text-based materials, or with manipulatives or other tools. The goal is to provide options that allow students to interact with content in a manner that maximizes their engagement with that content. The third barrier is related to the expression of understanding; overcoming it requires the provision of multiple methods for students to communicate understanding of a given topic or demonstrate acquisition of a given skill. For example, students might demonstrate understanding through written text or oral explanations, by creating a product such as a model of a scientific principle, or by performing demonstrations such as a chemical experiment. Consideration of these three types of barriers should guide developers of tests and testing systems to offer options that enable test takers to access, interact with, and respond to test content in ways that remove the barriers erected by disabilities and special needs (Thompson, Johnstone, and Thurlow 2002).

Applying Universal Design to Computer-Based Testing

Applied to computer-based testing systems, the principles of universal design and UDL require developers to build features into the architecture of a system that allow accommodation tools to be accessed flexibly to meet the needs of each individual user. In a universally designed test-delivery system, all students across a testing program use the same standard interface and have access to high-quality tools and accommodations delivered in a controlled, standardized, and equitable manner.

This approach contrasts sharply with current approaches to computer-based testing and test accommodations that require schools and students to provide accommodations either by using separate software in conjunction with the testing system or by employing a completely different system for students requiring accommodation. These approaches are analogous to asking a person with a physical disability to use a separate entryway to enter a building. Moreover, the use of additional software and separate interfaces for different student groups increases the cost of testing, causes confusion for students and school personnel who must be trained on the different interfaces, and results in a different test experience for a student who is assigned an accommodation even if the student ultimately chooses not to use the accommodation.

Universal Design in NimbleTools

NimbleTools is a direct outgrowth of research on computer-based test accommodations conducted by the New England Compact, a collaborative effort by the state departments of education in New Hampshire, Vermont, Rhode Island, and Maine to enhance state assessment programs (Exhibit 2). As a result of early success with a read-aloud system for mathematics tests in New Hampshire, Nimble Assessment Systems partnered with the New Hampshire Department of Education and Florida's Dyslexia Research Institute to develop a universally designed assessment system that integrates a variety of test accommodation tools. With funding from the National Science Foundation, the NimbleTools alpha version was developed and piloted with approximately 10 teachers and more than 100 students.

The seven principles of universal design and three principles of UDL were applied throughout the design and pilot-test stages. Each of the accessibility tools built into NimbleTools was developed through an iterative, collaborative design process. After developing a prototype of the computer-based, human-voice read-aloud tool sought by the New England Compact, we solicited comments and suggestions from state assessment leaders and experts in the field of disabilities and special needs; this input led to the modification of tools to meet students' needs more effectively and to the development of additional accessibility and interaction tools. When developing specific tools, we worked both with experts who were familiar with the particular need being addressed and with students who had that need. On occasion, multiple versions of a tool were developed to meet a specific need within a class of general needs; for instance, multiple versions of magnification tools were created to accommodate students with moderate and with severe visual impairments. All tools and navigation components were designed so that they could be manipulated using only the Tab and Enter keys, allowing students to take tests using alternate communication devices, such as switch mechanisms or sip-and-puff devices.

New accessibility features were not simply layered onto the existing system. Instead, in accordance with the principles of universal design, the system was redesigned and rebuilt with each addition so that each tool was incorporated into the fundamental structure of the system. Redeveloping the underlying architecture of the system ensured that each tool interacted with all other tools. This allowed multiple accommodations to be provided simultaneously; for instance, read-aloud could be paired with magnification, high contrast, and extended time. Ground-up redesign also ensured that each tool functioned in the same way in any operating system environment, ensuring standardized, equitable access to all accommodations.

The result was a system that helped students perform well on tests and feel comfortable about their performance. The usability studies for the alpha version revealed that:

- Students who used the NimbleTools read-aloud tool spent more time listening and relistening to text than students taking the test with a human reader.
- Nearly three-quarters (70%) of students who used the NimbleTools alpha version stated that they would prefer to use NimbleTools for future tests.
- The vast majority of students felt that they performed better using NimbleTools than when they received accommodations for a paper-based test.
- Students performed significantly better on a mathematics test when using the alpha version of NimbleTools accessibility and accommodation tools than when using a traditional, nonaccommodated computer-based test (effect size=.48) (Hoffmann 2007).

In its current, fully operational form, NimbleTools includes a full range of accessibility and accommodation features, including:

Read-aloud of text with student's choice of human or digital reader (Exhibit 3); Accessibility by Intellikeys keyboard and writers (Exhibit 4);

- Accessibility by Braille display and writers;
- Tab/Enter navigation, allowing keyboard or switch access;
- Presentation of signed text in American Sign Language or Signed English (Exhibit 5);
- Magnification of text and images for students with moderate visual impairments (Exhibit 6);
- Magnification of text and images for students with low vision (Exhibit 7);
- Masking of test items, answers, or both (Exhibit 8);
- Auditory calming (Exhibit 9);
- Reverse contrast with selection of contrast color (Exhibit 10);
- Color overlays with selection of overlay color (Exhibit 11);
- Reading assistant with color overlay and magnification options (Exhibit 12);
- Read-back of open-ended responses;
- Alternate language text and read-aloud (Exhibit 13);
- Talking calculator; and
- Extended time.

In Fall 2008, many of the tools built into the updated interface were examined in a study that focused on students in grades 6 and 9 (Russell et al. 2008). Two groups of students in each grade level participated in the study. The first group included students who were eligible for one or more test accommodations, including read-aloud of text, magnification of test items, auditory calming, and alternate color contrasts. The second group included students who were not eligible for any test accommodations. Both groups of students took two tests using NimbleTools. For the first test, students were not provided access to any of the NimbleTools accessibility tools. For the second test, students were allowed to use NimbleTools accessibility tools; students with disabilities and special needs were allowed to use tools assigned by their teachers while students without special needs were given access to any tool of their choosing. This study found that the use of the accessibility tools had a positive effect on the performance of students who were eligible for test accommodations but a negative effect on the performance of students who were not eligible for test accommodations.

The study also found that the vast majority of students reported that the universally designed test-delivery interface was easy to use. Students were also asked about each of the tools that they used while performing the second test; the vast majority of students reported that the tools were both easy and helpful to use during the test. Finally, after using NimbleTools, 85% of all students who participated in the study indicated that they wanted to use the interface to take tests in the future.

Conclusion

For developers of computer-based testing and learning systems, the development of NimbleTools provides a concrete example of the value of considering accessibility features during the early stages of design. For educational leaders, the positive effect that the use of NimbleTools has had on the attitudes and performance of students with special needs demonstrates the value of considering accessibility features when selecting assessment and learning systems. While NimbleTools represents a unique example of a universally designed test-delivery system, the application of universal design principles to the development of other educational systems promises to improve access and achievement for students with special needs.

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