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Unleashing the Power of Innovation for Assistive Technology

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Unleashing the Power of INNOVATION for Assistive Technology

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NCTI

Now is the time to take the lead and demonstrate powerful INNOVATIONS for individuals with disabilities that create new SOLUTIONS for students, teachers, and service providers.

About the Authors

This brief was written by Tracy Gray, Ph.D., Director; Heidi Silver-Pacuilla, Ph.D., Deputy Director; Cynthia Overton, Ph.D., Senior Research Analyst, and Alise Brann, M.S. Ed., Ed.S., Research Analyst, of the National Center for Technology Innovation.

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About the National Center for Technology Innovation

The National Center for Technology Innovation (NCTI), established in 2001, advances learning opportunities for *all* students, with a special focus on students with disabilities, by fostering technology innovation. NCTI offers technical assistance to facilitate growth and sustainability of learning and assistive technologies. The Center is funded by the Office of Special Education Programs at the U.S. Department of Education and is located at the American Institutes for Research in Washington, DC. The contents of this brief were developed under a grant (PR/Award #H327Z060003) from the U.S. Department of Education. However, these contents do not necessarily represent the policy of the U.S. Department of Education, and you should not assume endorsement by the Federal Government.

NCTI

National Center for Technology Innovation

www.NationalTechCenter.org

1000 Thomas Jefferson St, NW Washington, DC 20007

Phone: (202) 403-5323 | Fax: (202) 403-5001 Email: ncti@air.org

An Issue Brief from the National Center for Technology Innovation

The unprecedented increases in federal funding, coupled with new guidance from the U.S. Department of Education, school district purchasing power, and developments in consumer electronics, present an unparalleled opportunity to unleash the creative power of innovation to meet the needs of all students, particularly those with disabilities.

The American Recovery and Reinvestment Act (ARRA) and new Administration priorities present the field of educational and assistive technology (AT) researchers, developers, and vendors with new and exciting possibilities. The confluence of federal stimulus money and guidance from the U.S. Department of Education, Office of Special Education Programs (OSEP) to school districts to consider investing in "state-of-the-art assistive technology and training" affords the field a rare opportunity to define and shape what state-of-the-art assistive technology can be.

The National Center for Technology Innovation (NCTI), funded by OSEP, serves our stakeholders by providing a better understanding of the Administration's priorities and goals and offering guidance to make wise technology purchases and development decisions. This Issue Brief, Unleashing the Power of Innovation for Assistive Technology, harnesses the thinking of our stakeholders and the literature in the educational and assistive technology field to provide insight for current and future investment, development, and research.

> "Innovation is a new approach that brings mproved results… a product, platform, process, or idea…"
>
> —Smith, 2009

The Policy Landscape

ARRA funds plus the U.S. Department of Education's core reforms are expected to transform and reinvigorate public education throughout the nation. Additional federal initiatives, such as the Serve America Act and the Social Innovation Fund, "give us a rare opportunity to move beyond some of the barriers to innovation in education" (Smith, 2009, p. 7).

ARRA funds from the Department are governed by four broad principles: (a) spend funds quickly to save and create jobs; (b) improve student achievement through school improvement and reform; (c) ensure transparency, reporting, and accountability; and (d) invest one-time ARRA funds thoughtfully to minimize the "funding cliff" (www.ed.gov/policy/gen/leg/recovery/factsheet/idea.html).

These goals resonate with the overall priorities of the Department to advance student achievement through core reforms such as (a) making progress toward rigorous college- and career-ready standards and high-quality assessments that are valid and reliable for all students, including English language learners and students with disabilities; (b) establishing pre–K to college and career data systems that track progress and foster continuous improvement; (c) making improvements in teacher effectiveness and in the equitable distribution of qualified teachers for all students, particularly students who are most in need; and (d) providing intensive support and effective interventions for the lowest-performing schools (see http://www.ed.gov/policy/gen/leg/recovery/implementation.html).

Guidance for spending funds for special education programs available through IDEA Part B and Preschool Grants were made available through OSEP in 2009. A list of suggested uses for the funds is presented in Text Box 1.

Text Box 1: Suggested Uses for IDEA ARRA Funds

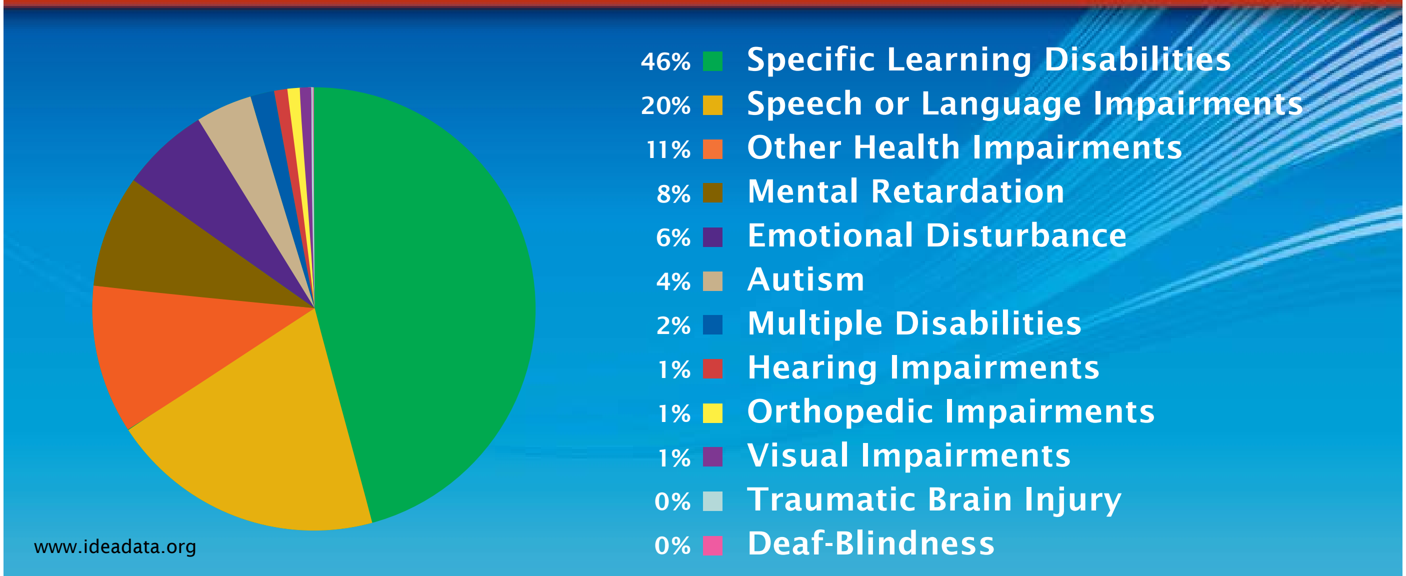
The IDEA ARRA funds constitute a large one-time increment in IDEA, Part B funding that offers states and LEAs a unique opportunity to improve teaching and learning and results for children with disabilities. Generally, funds should be used for short-term investments that have the potential for long-term benefits, rather than for expenditures the LEAs may not be able to sustain once the ARRA funds are expended. Some possible uses of these limited-term IDEA ARRA funds that are allowable under IDEA and aligned with the core reform goals for which states must provide assurances under the State Fiscal Stabilization Fund (SFSF) include:

- Obtain state-of-the-art assistive technology devices and provide training in their use to enhance access to the general curriculum for students with disabilities.
- Develop or expand the capacity to collect and use data to improve teaching and learning.
- Provide intensive district-wide professional development for special education and regular education teachers that focuses on scaling-up, through replication, proven and innovative evidence-based school-wide strategies in reading, math, writing and science, and positive behavioral supports to improve outcomes for students with disabilities.
- Expand the availability and range of inclusive placement options for preschoolers with disabilities by developing the capacity of public and private preschool programs to serve these children.
- Hire transition coordinators to work with employers in the community to develop job placements for youths with disabilities. (www.ed.gov/policy/gen/leg/recovery/factsheet/idea.html)

The Implementation Landscape

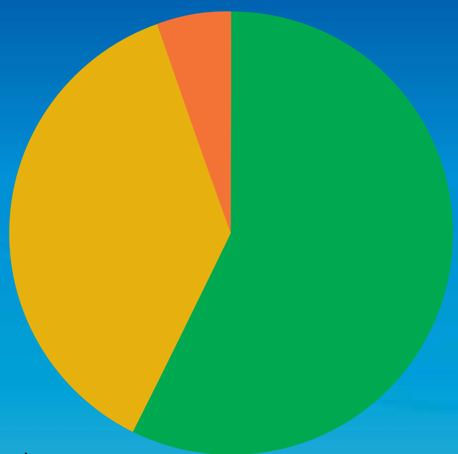
According to the Individuals with Disabilities Educational Improvement Act (IDEA), every student eligible for special education is entitled to have assistive technology "considered" as an accommodation or learning support when his or her Individualized Education Plan (IEP) is written or renewed. In 2006–2007, nearly six million children were receiving special education services in the United States, which represents approximately 7.7% of the total school-age population (see www.ideadata.org). The breakdown of categories of disability is shown in Figure 1. We also know that many of these children with IEPs are spending their school time in mainstreamed general education classrooms. Figure 2 shows that 57% are spending 80% or more of their school day in general education classes, most likely taught by general education teachers.

Figure 1: Disability Categories by Percentage of Total Students Served Under IDEA in 2007



Yet, very little national data are available about how schools and teachers are evaluating children for AT, determining the best tool for the task, providing AT services, or monitoring the implementation. A survey of AT use provided data to describe students using AT by grade level, disability category, sex, ethnicity, and placement in the school (general education class, special education class, alternative school, etc.; Quinn, Berhmann, Mastriopieri, & Chung, 2009). From this sample of 628 students, those with multiple disabilities were reported as using AT most frequently (27.7%), followed by students with learning disabilities (16.7%) and orthopedic impairments (14.6%). Students were more likely to use AT in self-contained special education classrooms (40.4%) and resource rooms (19%) than in general education classrooms (11.5%) or at home (2.3%). These low percentages are echoed in other sources that have tried to document the use of AT for particular impairments. Studies of students with visual impairments estimate that only 40% of students are learning with technology in schools (Kapperman, Sticken, & Heinze, 2002; Kelly, 2008). For students with learning disabilities (Cortiella, 2009), only an estimated 25–35% of students are using technology in instruction and learning.

Figure 2: Percentage of Time Spent in General Education Classes by Students with IEPs



More is known about the barriers to high-quality implementation, such as a lack of teacher training in AT, specific AT devices, and AT implementation to help students succeed with the general curriculum (Bausch, Ault, Emenova, & Behrmann, 2008). In a study of AT services in 14 states (training, technical assistance, fitting/adapting, and coordinating with other service providers and families), researchers found that only 40% of what IEPs listed as services fell within the federal guidelines. This lack of coordinated services with the provision of AT is "alarming because successful implementation of AT devices is not possible without the support of AT services" (Bausch et al., 2008, p. 11).

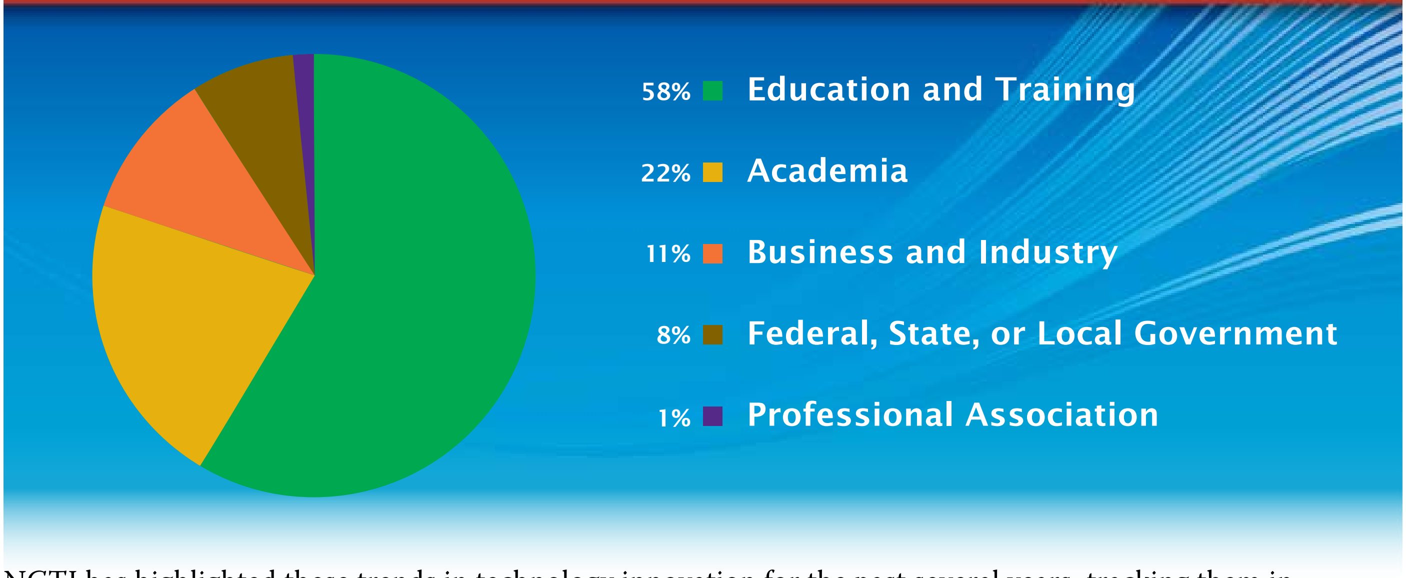
Disaggregating the impact of AT from other elements of teaching and learning on achievement has proved to be exceedingly difficult. Even the most concerted efforts fall prey to the complexity of incomplete and missing data, incomplete implementation efforts, inability to track students over time across districts, and uneven achievement measures (Edyburn, 2009).

Defining Elements of State-of-the-Art Assistive Technology

What does state-of-the-art mean in the field of AT? To answer that question in light of the new policy landscape and implementation realities, NCTI contacted stakeholders in the educational and assistive technology field to gather their perspectives. More than 65 people provided input, representing education and training; academia; business and industry; federal, state, and local governments; and professional education or AT associations. See Figure 3.

Five themes emerged from this input, a literature review, and trends tracking of consumer and educational technology. These themes define state-of-the-art AT: Convergence; Customizability and Universal Design for Learning (UDL); Research- or Evidence-Based; Portability to Promote Independence; and Interoperability (see Figure 4). Underlying these themes was a technology design imperative: the devices and systems should be simple—simple to learn, to use, to integrate, and to support.

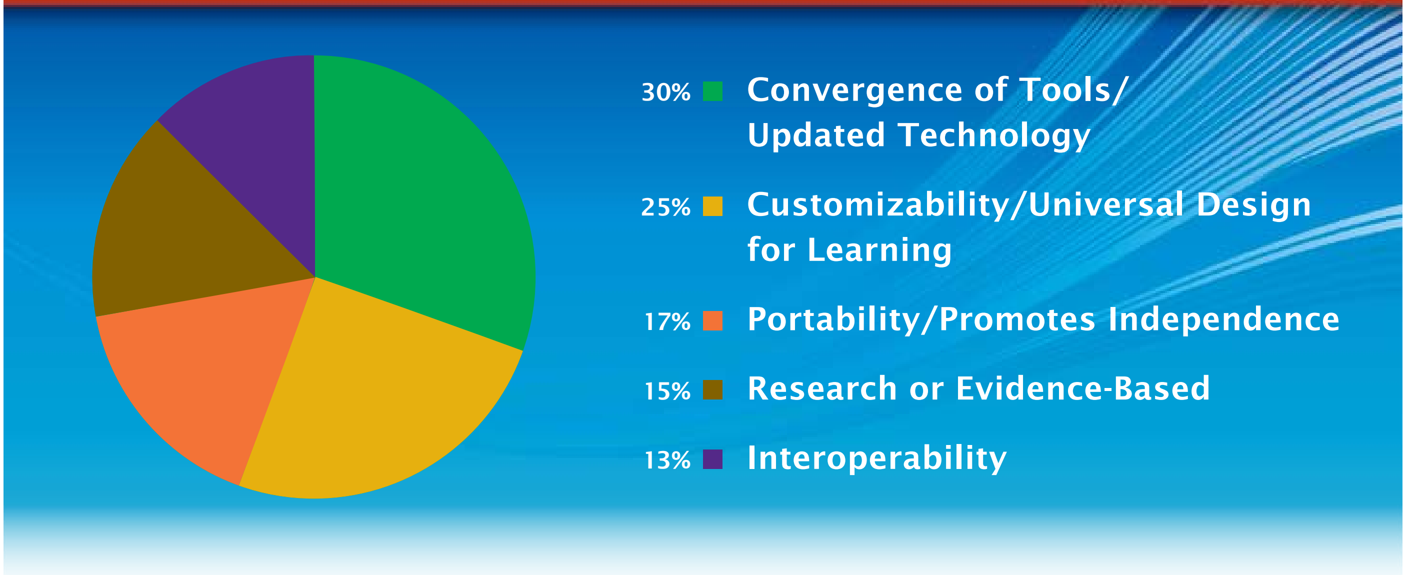
Figure 3: Respondent Demographics



NCTI has highlighted these trends in technology innovation for the past several years, tracking them in both consumer electronics development and educational and assistive technology. Now, it seems, these trends are becoming valued and the expected standards by the thought leaders in the field. Applications originally designed for people with disabilities are increasingly recognized as presenting solutions for the wider consumer market (Jana, 2009).

Each of these themes is explored in more detail, with examples of potential growth areas that will advance technology innovation for all students. The last section on training examines best practice for supporting teachers and caregivers as they integrate AT into the education and independent lives of children with disabilities.

Figure 4: State-of-the-Art Devices



Definitions

Convergence: transformation of various systems or devices into a single platform or device

Customizability and Universal Design for Learning (UDL): designed to be configured to meet the unique needs of individuals

Research- or Evidence-Based: supported by evidence of effectiveness for students with disabilities

Portability and Promotion of Independence: AT that offers flexibility to be used in various settings and moves with the user

Interoperability: the ability of two or more systems to exchange information

Convergence

Technological convergence is defined as the transformation of various technological systems to a single platform to perform multiple tasks. In addition to filling the need for "on the go" technology, the convenience offered through technology made available on converged platforms enhances students' educational and social experiences. Several respondents pointed to handheld communicative devices to illustrate how state-of-the-art AT is taking shape through converged platforms. For example, one respondent described state-of-the-art AT as *"the newest versions of software, communication devices with computer access, iPhones and general technology that can be used as a compensatory device."* Similarly, another identified *"small and multi-functional"* devices, both characteristics of converged technologies.

Many of these devices, such as a smart phone, bring together technologies that were once available only on separate platforms, thus making them a viable option to support students with disabilities. Smart phones of all types are an excellent example of converged technologies with the potential to enhance the teaching and learning experience, although the ongoing debate about the appropriateness of cellular devices in schools makes it difficult for some educators to realize their potential value in the classroom.

In addition to serving as a means of communication, smart phones have the capability to run multiple applications that support and accompany students throughout day-to-day activities. For example, deaf students in Taiwan are engaging in an after-school learning program with the assistance of smart phones and the General Packet Radio Service (GPRS) network. With such technology, students and teachers are able to interact to an extent that was previously not possible (Chung & Yi-Ching, 2007). The iPhone, which has proliferated in the United States despite its expense, offers applications such as iSigns, which can facilitate communication between deaf students and general education teachers and others who do not sign. Students and teachers who need to learn American Sign Language can use the iSign program. This "app" (short for software application) contains an animated phrase book of 800 signs with gestures modeled with a 3D character. The Quiz mode enables users to evaluate themselves on all or select signs.

Further, students with hearing and speech impairments can communicate with their hearing peers and teachers by using the Google Android phone and an app called Speaking Pad. Users of these technologies enter data into their cell phone and then make information available through speech output.

Apps for the iPhone are not limited to students with hearing disabilities. Picture Scheduler, a commercially available app, can be used by students with autism and other disabilities to create and organize personal tasks. Students with developmental challenges can use iPrompts, also commercially available, which provides visual prompting tools to help users transition between activities, understand upcoming events, make choices, and focus on tasks.

The story of the Speaking Pad illustrates a trend in innovation recently featured by NCTI*: Going global is as easy as publishing to the Internet. Since the app was posted, it has been downloaded over half a million times.

*Learning and Assistive Technology: Thriving in a Global Marketplace (Gray, Silver-Pacuila, & Overton, 2009)

For students with visual impairments, screen magnifiers are available, enabling users to capture text and images with a built-in camera and then enlarge items that appear on the phone's screen. Screen reading applications such as Mobile Share make documents downloaded on mobile phones accessible with www.Bookshare.org, an online library of digital books underwritten by the U.S. Department of Education for students with qualifying print disabilities, and on iPhones with the Kindle app. The Kindle app allows users to access their Kindle books with text-to-speech without the actual Kindle device.

Students with visual impairments once had to rely on bulky devices to access global positioning software. With the iPhone's built-in global positioning system, speech can be accessed by users with visual impairments by adding a cover or case with a tactile alphabet keyboard. Global positioning devices are also available for download on other cell phones. Both options offer the flexibility of accessing GPS navigational help anytime and anywhere without the burden of a clunky device.

Just a few years ago, each communication device, scheduler, prompt, and navigation system required its own device; converged platforms afford students with disabilities, their teachers, and their parents the convenience of powerful solutions. At the same time, applications designed for people with disabilities are crossing over into the mainstream, blurring the distinctions between AT and consumer technologies. Text-to-speech is an integral part of in-vehicle GPS units and cell phones; screen magnifiers help consumers cope with shrinking screen sizes; and captions on TV and Internet video are being used to reinforce language learning and to provide viewing solutions for noisy environments. Applications originally designed for people with disabilities are increasingly recognized as presenting solutions for the wider consumer market (Jana, 2009).

Customizability and UDL

Customizable technology is designed so that it can be configured in different ways to meet the needs of individual users. Customizability has become a common feature in educational software to increase access to technology as well as to increase the ability to benefit from it. When considering technology for instruction, applying the principles of Universal Design for Learning (UDL) can be an effective way to customize the instruction to meet the needs of a diverse group of learners (see Text Box 2). In the words of a respondent, state of the art is:

> *"any hardware or software that supports the diverse learning styles and needs of students within classrooms."*

Gaming has saturated the youth culture; 97% of students reported playing regularly and 50% reported having played "yesterday" (Lenhart, Arafeh, Smith, & Macgill, 2008). Games of all sorts are increasingly being used in instruction to engage students and to teach them such vital skills as teamwork, decision making, and digital literacy (Chandler, 2009; Van Horn, 2007). Although game developers have not traditionally focused on accessibility and customizability, there is a growing movement to ensure that developers keep these features in mind as they design games.

The Serious Games Initiative has led the effort to draw attention to the educational, social, and health benefits of digital games since its inception in 2002 with sponsorship from the Woodrow Wilson International Center for Scholars. The Initiative produced a taxonomy of games along multiple dimensions, including audience segment, purposes, and type of game (immersive, virtual reality, multiplayer, etc.; http://www.seriousgames.org/presentations/serious-games-taxonomy-2008_web.pdf). The taxonomy can help purchasers, developers, and policymakers understand the market space as well as the potential reach of games for education and training. In 2005, the Federation of American Scientists convened a National Summit on Educational Games that focused on the importance of digital games for learning. In 2009, the National Academy of Sciences hosted a National Research Council, Board on Science Education, workshop to focus on the future of learning science for computer games, simulations, and education.

These and other national meetings of experts signal the increasing focus on the value of these games to education at all levels, for example,

- preschool literacy games offered by known content providers such as Sesame Street Workshop;
- social skills practice games for children on the autism disorder spectrum;
- a middle school civics education game developed with Former Supreme Court Justice Sandra Day O'Connor; and
- epistemic games for career exploration and transition planning (Shaffer & NCTI, 2007).

There also exists an increasing body of research into the educational value of digital games, including online video games, which have not been specifically designed for education (e.g., Gee, 2007). Organizations such as the John D. and Catherine T. MacArthur Foundation and the Joan Ganz Cooney Center are advocating the consideration of the educational value of all these types of games. Despite lingering controversy over the content of some destructive or socially negative games, this research indicates that in addition to learning content, players are developing 21st century skills such as organizational, problem-solving, and multitasking abilities (Ito et al., 2008). Games also provide opportunities for improved self-confidence and social growth through online interaction. Until recently, online games have been primarily web-based games accessed through a personal computer. However, the newest game consoles (e.g., Xbox 360, Wii, PlayStation 3) include the option of multiplayer games through Internet connections, bringing interactive online games to these game consoles, which are often located in family space rather than on individual desktop computers.

Text Box 2: Universal Design for Learning (UDL)

UDL provides a blueprint for creating flexible goals, methods, materials, and assessments that accommodate learner differences. The term "universal" does not imply a single optimal solution for everyone. Instead, it is meant to underscore the need for multiple, customizable approaches to meet the needs of diverse learners. A UDL curriculum offers the following:

- **Multiple means of representation to give learners various ways of acquiring information and knowledge;**
- **Multiple means of action and expression to provide learners with alternatives for demonstrating what they know; and**
- **Multiple means of engagement to tap into learners' interests, challenge learners appropriately, and motivate them to learn (see more at www.cast.org).**

As games have become increasingly complex over the years, potential players and developers who have disabilities have been hindered from participating. Organizations that focus on games for these players, such as Universally Accessible Games, the Serious Games Initiative, and the International Game Developers Association (IDGA) Game Accessibility Special Interest Group, have supported designing games with customizable features that make them universally accessible. These features include captioning of dialogue, text-to-speech for onscreen text dialogue and instructions, the ability to magnify areas of the screen, the ability to use an adapted controller in place of the standard one, and customizable colors for colorblindness.

In keeping with the principles of UDL are recommendations for offering variations in the degree of difficulty and additional supports such as guides and features that highlight important points or reward effective strategies. An example of guidelines for accessible games can be found at www.medialt.no/rapport/entertainment_guidelines/. To help developers understand the importance of game accessibility, Universally Accessible Games has created Game Over, a totally inaccessible game that highlights the importance of accessibility features (www.ics.forth.gr/hci/ua-games/game-over/). Although these features are recommended as supports for players with disabilities, all players can benefit from the customizability they provide and can contribute to the social interaction and group problem solving that research has shown occur through playing these games.

Providing customizable features in multiplayer games and any educational software to support a diverse group of users ensures that more users can benefit and contribute.

Research or Evidence-Based

Given the importance of interoperability and convergence when it comes to AT devices, many AT researchers have begun to shift away from device-focused or even disability-focused research toward an examination of specific features and broader audiences. With the swift change in technologies and tools, it is unlikely that an AT device or system today will perform in the same way as a similar one will perform five years from now. As NCTI shared in Moving Toward Solutions (2005), researchers are recognizing that with rapidly shifting technology, state-of-the-art research should focus on features, usage, and the population rather than individual products. As features beneficial to users with and without disabilities become commonplace on everyday electronics, AT researchers have found that to stay current, they need to recognize that state-of-the-art research and evidence may come from other disciplines or from consumer testing and demand.

Even without formal studies or marketing research, AT specialists and developers can still determine utility, interest, and efficacy simply through reading reviews, determining the number of downloads, and talking or chatting online with users. Consumer devices are unlikely to thrive if they are cumbersome, difficult to use, or prohibitively expensive. State-of-the-art AT research must draw evidence from both traditional and nontraditional sources and uses to inform practice (Gray, Silver-Pacuilla, & Saucer, 2008; Overton, Volkman, Silver-Pacuilla, & Gray, 2008).

Augmentative and Alternative Communication (AAC) devices provide a good example of what the future of AT may look like in terms of research and advances in knowledge. The term refers to any means of communication that replaces or augments verbal communication. AAC devices may be used aided or unaided and range from the extremely low-tech (pointing to an image on a printout of items) to more high-tech devices (communication software loaded onto a smart phone). Given that the ability to communicate is so central to relationships, work, and human interaction, communication devices have received a great deal of attention. In recent years, advances in consumer technology have led to new possibilities for communication, opening up new research in the area of AAC.

One challenge historically to state-of-the-art AT research is that assistive devices have not always kept up with consumer electronics in terms of options available (e.g., wireless access, Bluetooth). For example, although we now have cell phones that are essentially pocket-sized computers, many AAC devices still have not "derived benefit from the concept of 'convergence'; that is, providing access to multiple communication functions and electronic tools in a single device" (DeRuyter, McNaughton, Caves, & Bryen, 2007, p. 259). As developments in consumer technology have led to AAC devices that are smaller, faster, and lighter, the challenge is to ensure that they provide the same kind of access to multimedia, web, and interactivity offered by a fairly basic cell phone (Caves, Shane, & DeRuyter, 2002; DeRuyter et al., 2007).

Easy and reliable access to mainstream technology is not just a matter of convenience for users with disabilities. In an era when almost everyone is capable of multiple modes of communication, when people can access information and social networks with a push of a button on a computer in their pocket, lacking this kind of access leads to "digital exclusion" (DeRuyter et al., 2007).

Research that provides information on which features are most effective for which populations, under which conditions, and for which tasks is still in the early stages, particularly for new technologies. This is true for nearly all disabilities and devices. Initial research in the area of AAC devices has shown some interesting findings in terms of features and specific users. For example, AAC systems with static visual-graphic systems may be more effective for users with autism, whereas other users may benefit more from speech-generating devices (Nunes, 2008; Wilkinson & Henning, 2007). The advent of new technologies and multimodal communication abilities in both mainstream commercial communication devices and AAC devices has led to further confirmation of research that multimodal approaches (voice output devices, gesture, sign, facial expressions, picture symbols, computer-based technologies) are most effective in meeting a wide variety of communication needs in a variety of environments (Wilkinson & Henning, 2007). These findings, in turn, encourage AT vendors and researchers to create more-targeted devices and to develop technologies that incorporate a wide variety of features that are customizable to provide tailored user profiles to best serve the needs of a diverse AT using population (Blackstone, Williams, & Joyce, 2002).

The lessons learned from cutting-edge research in the AAC field have implications for further research and development in the field of AT more broadly. When devices are designed with respect to the specific needs of a variety of AAC users and their close contacts, they are less likely to be abandoned (Blackstone et al., 2002). As consumer electronics add more features for user control, many options once found solely on a dedicated AT device (such as communication boards) are easily added to more readily available (and possibly less expensive) mainstream devices.

The importance of drawing on knowledge from multiple arenas is echoed in a comment from a respondent about evidence-based state-of-the-art AT:

> *"State-of-the-art implements the most recent knowledge of a particular device genre, and that includes traditional research-generated knowledge, but also consumer driven knowledge (i.e., what we learn about state-of-the-art cell phones is not necessarily from research, it is from consumer demands)."*

New directions for AAC research include:

- **Exploring potential uses of RFID technology in AAC;**
- **Investigating innovative AAC designs for children and their effect on communication and language development;**
- **Identifying specific design features of AAC devices that improve ease of use for adults with acquired communication impairments (e.g., traumatic brain injury, stroke); and**
- **Utilizing digital technologies to allow AAC users to dynamically capture and display relevant content on their device (e.g., images, objects, sounds).**

Source: AAC Rehabilitation Engineering Research Center, http://aac-rerc.psu.edu/

Portability to Promote Independence

IDEA 2004 requires schools to educate students with disabilities in the least restrictive environment, and the trend toward serving students in general classrooms shows that this is happening (see Figure 2). Portable technologies are helping redefine the mandate of least restrictive environment and boosting student independence. With portable technologies, students who had been anchored in designated special education and resource rooms may now be mainstreamed and included in the general classroom. The flexibility to move freely among core classes, electives, and extracurricular activities with technology means greater access to the general curriculum. As one respondent stated,

> *"Technology which moves all people forward helping them to interact and communicate with others and to have self-determination is state-of-art in AT devices."*

Portable AT is appearing more frequently on new laptop computers. Many laptops come standard with a host of accessibility features, including text-to-speech, highly customizable interfaces, and voice recognition. Most are capable of running almost any AT or mainstream software required for class. They also enable students to engage in digital games, which can be an exciting recreational experience and an engaging educational opportunity for students who learn differently. Laptop computers are becoming more affordable and have a longer battery life than older models.

With price tags starting at about $200, Netbooks are a more-economical option to laptops for many users. Although these tiny versions of laptops are limited by their storage space and lack of a CD drive, other valuable features make them a viable option. They weigh only about 2.5 pounds, compared to the 6 pounds or more of a standard laptop. This small size makes it easy for a student to slip one of these devices into a protective cover, put it in her backpack, and be on her way. AT products are increasingly offered in a modified format to complement Netbooks as they become more popular. It does not hurt their popularity that they look "cool," which reduces the social stigma commonly associated with any device designated specifically for students with disabilities.

One step further is a promising movement toward high-quality, fully portable, open source AT. Under this model, students can carry AT software on their jump drive and use it whenever appropriate. This is ideal in computer-rich settings where the hardware is easily available but requires support to ensure accessibility. This is also a viable option for students beyond the classroom. They can take their jump drives with AT software home, to a friend's house, or to the public library. This approach offers a level of freedom and flexibility that was unimaginable just a short time ago.

One study (Izzo, Yurick, & McArrel, 2009) explored the impact of CLiCk, Speak on high school students with disabilities in an online transition curriculum that focused on information literacy. CliCk, Speak can be downloaded onto a jump drive and is described as "the only free, professional-grade screen magnifier that works across remote desktop software such as Terminal Services/VNC" (Izzo et al., 2007). Results indicate that students' unit quiz and reading comprehension performance increased with the use of this support. Additional benefits are cited by Steve Jacob, president of the IDEAL Group, Inc., which developed CLiCk, Speak and a host of other portable AT. Solutions such as this have the potential to:

- Reduce the cost significantly of providing AT software to students;
- Enable students attending any school or university to use their AT on practically any PC;
- Reduce incompatibility issues;
- Eliminate vandalism and innocent corruption of PC-based AT software because portable AT applications are not installed; and
- Eliminate the problem of too few AT software-equipped computers in schools, colleges, libraries, community centers, places of employment, etc.

Innovation in portable devices is evolving to the point that they can provide flexibility for students with disabilities to learn and experience schooling and community independence in powerful new ways. The potential for transition- and working-age youth and adults with disabilities is only beginning to be explored.

Interoperability

Interoperability means many things in terms of AT in school, home, and community settings. It can refer to the technical definition of "the ability of two or more systems or components to exchange information and to use the information that has been exchanged" (Institute of Electrical and Electronics Engineers, 1990). It has the common definition of a device that can be used on multiple platforms, such as a Windows operating system (OS) and a Mac OS. It can also refer more broadly to the design of a system or a device that shares information, such as a software program that sends reports to a school's integrated data management system. The inability of devices to be used in multiple settings, or the lack of interoperability, is cited as a major barrier to sustained AT use (Bausch et al., 2008).

As noted earlier, students with disabilities of all types are spending more time in general education settings and away from resource room placements (see Figure 2), making the trend toward interoperability more urgent. For technology to be part of the learning solution, it must be readily available to students and teachers as part of the instructional environment. One respondent wrote,

> *"It should work well on school networks, be easy to understand and use, easy to program, be compatible with other software and well enough known that the average tech person at a school can trouble shoot with it."*

As the technology industry moves to software as a service (SAAS) and cloud computing, the potential grows for software applications that are not installed on a particular machine but rather are accessed through the Internet from any machine. As ubiquitous Internet access becomes a reality in schools, this trend may empower users of specific software licenses to use that software on whatever machine they are near, thus eliminating the need for resource rooms or specialized AT labs. This movement is advancing in parallel with that of putting licensed software on jump drives for ease of access, as cited above under Portability.

Interoperability also implies that programs can share and compile data. Two innovations are contributing to this development. Programs that customize profiles and collect student data for individualization of instruction collect a wealth of performance data and are growing in popularity because of their ability to assist teachers in managing and monitoring differentiation efforts. Simultaneously, districts and states are moving toward assigning unique student identifiers to construct robust data systems that link local data with district or state data. These trends create the reality that student performance data collected from an educational or assistive device or software program could contribute to the larger dataset of the student's performance and progress toward IEP goals, eliminating the need for teachers to transfer and analyze that information. This ability could contribute to the evidence base of AT outcomes and benefits.

An example of this kind of connection can be seen in TeachTown, a software program for autism services that provides clinical services on and off the computer and coordinates data and communication among parents, teachers, and clinicians. Sharing data facilitates communication, boosts the effectiveness of the clinical intervention, and eliminates the need for teachers or clinicians to transfer data manually into the school's IEP records.

Interoperability may bring the field closer to realizing "AT 2.0" as Marshall Raskind describes, a time when AT is delivered as a service to the user without the dependence on a particular set of corresponding operating systems, applications, or even a particular setting. (See the video of Raskind's presentation at the 2008 NCTI Technology Innovators Conference at www.NationalTechCenter.org.) Related to Customizability, this potential of interoperability makes possible learner profiles that can be created, saved, and used as needed across multiple machines and applications.

Simplicity

From all sectors, stakeholders qualified their responses to "What is State-of-the-Art AT?" with a plea to make devices, applications, and systems "simple." NCTI hears this plea from parents and caregivers as well. Too often, the sophistication of the features or interface of new devices precludes easy use by direct consumers or their parents, teachers, and friends. Although this design principle may exert pressure on the others listed here, such as portability and convergence, we consider it imperative to the design of AT. With more students being served in general education classrooms of up to 30 students, devices and systems need to offer as little complexity and facilitate as much independence for the user as possible. Two respondents provided strong statements on this theme:

> *"The simplest tool that overcomes the barrier is the tool which should be considered state-of-the-art."*
>
> *"Make it simple, but not one bit too simple."*

State-of-the-Art Assistive Technology Training

Decades of research in the fields of adult learning, professional development, technical assistance, knowledge development, and implementation science have identified best practices in technology training and integration. Successful technology training is planned and intentional, continual, tailored to meet individual teacher needs, and grounded in evidence-based practice (Billig, Sherry, & Havelock, 2005; CEO Forum, 2000; Desimone, Porter, Garet, Yoon, & Birman, 2002; Guskey, 2000; Hamilton et al., 2002; Royer, 2002; Sudsawad, 2007).

Although most schools have access to computers and wireless technology, teachers often do not use technology—assistive or mainstream tools—to their full capacity (CEO Forum, 2000; CITEd, 2009; Price, Cates, & Bodzin, 2002). Insufficient training and professional development is one reason for failures of technology integration. All too frequently, technology tools are purchased and then neglected because teachers do not have access to high-quality training and learning opportunities. Simply demonstrating an AT device is not enough to help teachers make full use of technology with their students; training is most effective when it helps teachers identify how the technology can mesh with their curriculum, content area, and student learning goals (CEO Forum, 2000; Elmore, 1996; Glazer, Hannafin, & Song, 2005). Particularly with high-tech tools and AT devices that require intensive training, teachers need hands-on, concrete examples of how to integrate technology with their teaching to best meet the needs of diverse learners (Glazer et al., 2005). One respondent commented:

> *"State of the art training must go beyond the initial exposure to the device to include guided practice, mentoring, coaching and ongoing opportunity to problem solve, refine skills, and develop advanced skills with devices and software."*

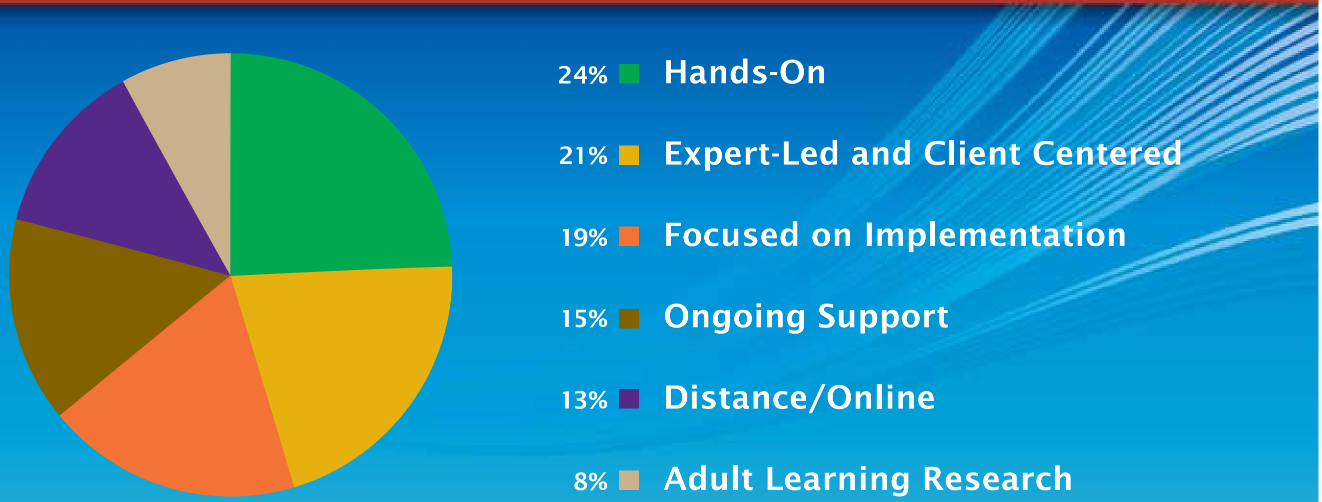
With expert-led, targeted training that addresses technical knowledge, lesson planning, and actual classroom use, teachers are more likely to feel confident enough with the tool to make it an integral part of their teaching (Elmore, 1996; Ertmer, 2005; Glazer et al., 2005).

Research shows that passive dissemination of information is the least effective way of changing teaching practice (CEO Forum, 2000; Elmore, 1996; Guskey, 2000; Sudsawad, 2007). A more multifaceted and interactive approach to technology training is likely to be successful, particularly if teachers have ongoing support and on-site assistance (Abbott, Greenwood, Buzhard, & Tapia, 2006; Pizzo, 1993; Sudsawad, 2007). Providing support and information in a variety of formats—online forums, tutorial videos, and face-to-face interactions—is also important for increasing teacher comfort with a new tool. A blended approach of both online learning and a face-to-face component appears to be most successful (Sudsawad, 2007; U.S. Dept. of Education, 2009).

Seeking out distance or online training can help schools access an expert knowledge base and disseminate information easily and inexpensively (Abbott et al., 2006). Many AT devices are highly specialized, and it may be difficult for smaller schools to find an AT expert locally; online tutorials and support forums may help bridge the divide for teachers learning a new tool and give teachers access to learning anytime and anywhere that is convenient for them (U.S. Dept. of Education, 2009).

Stakeholders echoed these findings when asked to define state-of-the-art training for AT devices. The six key themes, shown in Figure 5, that emerged support the research in underscoring the importance of technology training that is hands-on, expert-led, and client-centered; focused on implementation; ongoing; available through distance and online learning opportunities; and based on adult learning research and strategies.

Figure 5: State-of-the-Art Training



Savvy technology developers and vendors have moved ahead of this training need; many now offer comprehensive professional development that goes well beyond tech support as part of their tool purchase packages. With expert-led on-site trainings, ongoing support, and materials that help teachers integrate tools into their curriculum, these vendors offer state-of-the-art service. An example of this kind of wraparound service is the professional development on writing strategies that accompanies the SOLO, a comprehensive literacy support product by Don Johnston, Inc., which offers the product embedded in the service. See more about the research behind this effort at www.NationalTechCenter.org/index.php/2006/04/26/project-solo-leads-to-unexpected-discoveries/.

Implications

How can innovation be nurtured and harnessed in AT development and implementation to take hold and make a difference in the lives of students with disabilities? How can the field ensure that educational and assistive technology is seen as a critical part of the achievement solution for all students? Given the reality that the vast majority of students with disabilities are being served in the general education classroom for most of their day, AT vendors and service delivery personnel need to be a part of the general education consumer market as well.

To realize its full potential, the AT field must:

- Include innovative uses and interfaces built on the efficiencies and customizability options of mainstream consumer products.
- Develop devices and systems that can interoperate with existing and future technologies in the school, home, and pockets of consumers to reduce redundancy and improve data-tracking effectiveness.
- Insist that more students with disabilities have access to and are learning with AT that will promote their achievement and independence.
- Be guided by related research that informs and is informed by disability research so that products and training reflect the latest knowledge from science, education, and consumer patterns. The evidence base needs to expand to reflect real-world implementation challenges and solutions, with AT training and services delivered collaboratively to general education teachers.
- Seize the opportunity to create new applications with wide cross-over appeal and reach, breaking down the barriers between educational and assistive technologies and between students with and without disabilities.

Now is the time to take the lead and demonstrate powerful INNOVATIONS for individuals with disabilities that create new SOLUTIONS for students, teachers, and service providers.

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***David Baquis,** Accessibility Specialist, U.S. Access Board

***Cathy Bodine,** Assistant Professor, Section Head and Director of Assistive Technology Partners, Department of Physical Medicine and Rehabilitation, University of Colorado Health Sciences Center

***Diana Foster Carl,** special projects coordinator for the AIM Consortium at CAST; formerly Director of Special Education Services at Region 4 Education Service Center, Houston, Texas

***Milton Chen,** Executive Director, The George Lucas Educational Foundation

***David Dikter,** Executive Director, Assistive Technology Industry Association

Jane Hauser, Project Director, U.S. Department of Education, Office of Special Education Programs

Steve Jacobs, President, IDEAL Group, Inc.

***Matthew Kaplowitz,** President, Bridge Multimedia

***Gaylen Kapperman,** Professor and Coordinator, Programs in Vision, College of Education, Northern Illinois University

Elizabeth (Boo) Murray, Senior Research Scientist and Instructional Designer, CAST

***Michael Russell,** Associate Professor and Director, Technology and Assessment Study Collaborative, Lynch School of Education, Boston College

***Rob Sinclair,** Director, Accessible Technology Group, Microsoft Corporation

***Deborah D. Smith,** Professor and Co-Director, IRIS (IDEA and Research for Inclusive Settings) Center for Faculty Enhancement, Claremont Graduate College

Liz Wainger, President, Wainger Communications

***Yong Zhao,** Distinguished Professor and Director, Center of Technology and Teaching, College of Education, Michigan State University

Ruth Ziolkowski, President, Don Johnston, Inc.

***National Center for Technology Innovation Advisory Board Member**

NCTI

National Center for Technology Innovation
www.NationalTechCenter.org
1000 Thomas Jefferson St, NW Washington, DC 20007
Phone: (202) 403-5323 | Fax: (202) 403-5001 Email: ncti@air.org

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