Disability in a digital world: Do assistive technologies still matter?

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Introduction

I commenced my first job with disabled people in 1983. I was an Institutional Aide in a residence for adults with severe cognitive impairments. In the institution, there was a woman in her thirties who could not voluntarily move any part of her body, other than her face and neck. It was assumed that she was profoundly cognitively impaired. She received minimal educational and/or intellectual stimulation. Just before I was hired, she had been fitted with a head-pointer device that enabled her to eat independently by pointing at the desired food, after which a mechanized spoon would scoop and feed. She could also communicate using picture and eventually alphabetic symbols. Using this communication, she was assessed. She tested at the intelligence of a 12-year-old. I continue to have two thoughts. First, I wonder what her IQ would have been if schooling and intellectual engagement had been provided. Second, I wonder how often she must have wanted to scream and swear at the people baby-talking to her.

The head-pointer device introduced above is an assistive technology. It made a remarkable difference to the functioning of this woman for two reasons. First, the technology gave her the capacity to function in ways that she could not accomplish prior to having access to the device. Second, the functional ability to communicate afforded by the assistive technology raised the awareness of her capacities to those around her, and that acknowledgement catalysed changes to the environment, or in other words, the way she was treated.

The technological changes have been incremental since I held that job in 1983. A few years later, in another disability-related career as a Job Placement Officer, I remember that the secretary refused to see any value-added by using a computer. She pushed it to the back of her desk, continuing to use her typewriter. We all gathered in the manager's office to observe the wonders of his new fax machine. Communication was via telephone and my work answering machine was full to overflowing, with the tapes needing to be frequently replaced because they would get worn out from being recorded over. In graduate school in the 1990s, my statistics professor introduced our class to email and told us to celebrate because the widespread application of email was going to revolutionize communication. We didn't get it. The most impactful technological change within my graduate studies (in comparison to the time of my undergraduate studies) was electronic databases of journal articles. This was certainly more time efficient than flipping through printed volumes that resembled telephone books and contained call numbers that must be matched to those on the library shelves.

Compare this to the technology I use in my job today. I wanted to update my knowledge base on assistive technology in order to write this chapter. I clicked on my

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university library's webpage and decided to use the new Summons tool that synthesises data from all of the subscribed electronic databases. I entered the search term *assistive technology* and specified only retrieval of peer-reviewed journal articles post 2005. I could have read hundreds. Sometimes I write drafts of this chapter using my laptop and sometimes on my iPad. Right now I have two monitors going, one with this document and the other, on which, I am keeping up on my email. New emails appear at approximately three-minute intervals. I do not recall the last time my phone rang. I always have my Blackberry in my pocket, and a moment ago, I paused to read a text message. Tonight as I drift off to sleep, I will read a novel on my Kindle, and if my eyes are too tired, I will allow the electronic voice to read it to me.

What about persons with disabling conditions? Have all of the technological advancements made a difference? How accessible are the technologies and devices I use, such as email, iPads, Blackberries and Kindles to the disabled? I no longer have contact with the woman described in the first paragraph, but she may still be alive today. Does she still use a head pointer device, or something much more sophisticated? What about a child born today with the same functional limitations as the woman described above? Would this child require assistive technologies or are mainstream technologies advanced to the degree that they are ubiquitous and solutions for all? Does anyone still require assistive technologies or has the digital age meant equitable experience for everyone?

This chapter will address the questions posed in the paragraph above. However, prior to reaching this point in the presentation, background context is necessary. This chapter will define assistive technology (AT) and provide current examples of AT. The definition of AT will be contextualised through the theory of disability studies and the implications for AT considered. Given this context, the chapter will then address the relationship between *mainstream* and *assistive* technologies. Two main questions will be posed and considered. First, do technological advancements make AT obsolete? Second, can ATs also benefit persons without disabling conditions? The principles of universal design for learning and the electronic curb-cut analogy will be presented. The chapter will also address AT now and into the future, with a review of the AT research and practical strategies and recommendations for teachers. A glossary at the end of the chapter will serve as quick reference to definitions of relevant terms. This chapter also includes an itemised list of the highest impact URLs that inform our thinking and approach to AT.

Definition of assistive technology

The AT articles almost exclusively use the definition taken from the USA Individuals with Disabilities Education Act (IDEA), Title IA602 from 2004. Notably, this definition has not been altered from when it first appeared in USA legislation in 1998 (Alper & Raharinirina, 2006).

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> The term 'assistive technology device' means any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of a child with a disability.

Because this definition was authored in the context of grade-school education, the definition specifies that the users are children. Yet, adults with disabling conditions also use AT. Cook, Polgar and Hussey (2008) included the same core elements as the IDEA definition, but broadened the user population. These authors defined AT as "a broad range of devices, services, strategies, and practices that are conceived and applied to ameliorate the problems faced by individuals who have disabilities" (p. 5). In both definitions, AT includes stand-alone devices such as Braille readers, software such as speech recognition programs, and built-in accessibility software such as electronic voice.

There are two purposes of AT (Jeffs, Behrmann & Bannan-Ritland, 2006). First, AT can tip the scales by supplementing the students' strengths and thereby minimising the impact of his/her limitations. Alper and Raharinirina (2006) described this purpose as a "cognitive prosthesis" (p. 48). Second, AT provides another way of engaging with the curriculum so that the student is not disadvantaged. For example, a student with Cerebral Palsy may use word recognition software so that his composition gifts become more important than his lack of fine-motor coordination. He might also use an adapted mouse that is not as sensitive to muscle spasms.

Some technology may not be designed from the outset for people with disabling conditions, but becomes AT when used to meet the needs of a disabled user. King-Sears and Evmenova (2007) explained, "The same piece of equipment may simultaneously be assistive technology for one student with disabilities and instructional technology for other students" (p. 6). Cook, Polgar and Hussey (2008) explained that technology does not remain compartmentalized or fixed in terms of definitional characteristics. The authors elaborated, "...yesterday's high tech is tomorrow's low tech, custom devices become commercial if more than a few people need them, and appliances often enable the use of tools" (p. 9). The key question determining whether a technology counts as an *assistive* technology is whether the intention is to meet the needs of a person with a disabling condition.

> ...if the products selected require you to consider your disability issues first, then they are assistive technology – even if they are widely available, mundane, mass-market products. If you did not have a disability, you would not have to think about these product features when you make your choices. When your disability is defining or narrowing your product choices and options, you are buying assistive technology, whether you are calling it that and whether it was designed to be AT. First, wheelchair riders shop for the cars in their price range that can accommodate the wheelchair (i.e., "Can I get in, get my chair in, and operate the controls?"). Then they

> select from that small pool of consumer features they like, such as performance and gas mileage – not the other way around. (Litvak & Enders, 2001, p.717)

These authors asserted that *assistive* technology can be identified and distinguished from other technologies in that the application is to ameliorate disability-related barriers and challenges. The message in the continued quotation above is that AT is also readily identifiable by the availability, selection, quality and aesthetics of the options. Many of the authors agree that AT is necessary, but not sufficient. Seelman (2001) stated this perception clearly. "The assistive technology marketplace is fragmented, small, and weak" (p.670). Whereas there are notable exceptions, other clues as to whether a technology is *mainstream* or *assistive* are represented in the table below.

Mainstream Technology	Assistive Technology
Aesthetically Pleasing	Unattractive
Sleek and streamlined	Oversized and clunky
Affordable	Expensive
Readily and immediately obtainable	Must be custom-ordered from few places

Not only are the design features of AT critiqued in the literature, but so too are other implementation issues. Alper and Raharinirina (2006) presented six barriers to successful AT implementation. First, despite the availability of AT, elements of the curriculum and pedagogy remain inaccessible to students with disabling conditions. Second, an economic divide remains, in that some students cannot have AT because it is expensive and there are limited opportunities for external funding. Third, teachers and other professionals have inadequate training in AT implementation to pass on to prospective users. Fourth, there are numerous occasions in which AT is provided and then not supported on an ongoing, sustainable basis. Fifth, there is gate-keeping in AT provision and many prospective users fall-between-the-cracks, not meeting eligibility criteria. Finally, there are issues of abandonment, or in other words, AT use is discontinued, often because matching of AT and users did not adequately take all contextual factors, such as social inclusion, into consideration.

Examples of AT

Applying the context of her paper to multiple types of disabling conditions, Sze (2008-2009) provided a two-page table of examples of AT and the learning tasks that each enabled. For example, for reading, she listed: electronic reading machine, portable reading pens, portable hand-held dictionaries, and Braille translation software. For writing, she provided examples of: word cueing and prediction programs; speech synthesis software; speech recognition software, and; spelling, grammar, and style checkers. For mathematics she provided examples of: instructional software, and talking calculators.

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Other authors focussed on a particular type of disabling condition and/or on a specified curricular area or pedagogy. Parette, Crowley and Wojcik (2007) wrote about AT for children with emotional and behavioural disorders (EBD). They provided a full-page table of goals, applicable AT and accompanying URLs. Specific to children with EBD, these authors shared examples of AT that allow children to monitor and regulate their own behaviour. Examples of AT included: visual/auditory prompting, cueing devices, and self-graphing devices. The authors were enthusiastic about the benefits of AT for the supported children.

Jutai, Strong and Russell-Minda (2009) analysed literature about assistive technology for persons with low vision. They provided the following examples of AT: handheld magnifiers, electronic vision-enhancement systems, and motility-related devices, such as long canes and night-vision systems.

Writing specifically in the curricular domain of mathematics, Sayeski (2009) used the example of virtual manipulatives. The author explained that they "...look similar to their three-dimensional counterparts and can be controlled and moved by the user in the virtual computer environment" (p. 47). The author included tables of URLs and screen shots of virtual manipulatives, and was impressed with the educational outcomes resulting from use of AT.

Simmons and Carpenter (2010) wrote about the use of AT for spelling. They explained that AT for spelling affords children the opportunity to focus on other elements of composition. "When the act of spelling becomes demanding, students minimize their use of other writing processes, such as outlining or revising, because these processes require a considerable amount of cognitive energy" (p. 6). The authors included a one and half page table of spelling AT, including web-assisted applications such as *Spelling City* and *Spelling Time*.

Theory of disability studies

In the paragraphs above, the term *assistive technology* was defined and examples were given. Because the key defining characteristic of AT is that it is disability-intended, the term *disability* also needs to be defined and discussed. The reader will have noticed that in the sentence above, and frequently throughout this chapter, the phrase, *people with disabling conditions* is used instead of the phrase, *people with disabilities*. When the term *the disabled* is used, it is also intentional; this phrase acknowledges that barriers are present, but does not imply that these barriers are inherent to the person. Edyburn (2010) wrote that a major paradigm shift is "challenging educators to think of their curriculum as disabled, rather than students" (p. 34). Whereas someone can be disabled, they cannot *have* a disability, in that the disability is not a primary characteristic of the person. This is more than semantics and it is important to the way in which assistive and mainstream technologies are

chosen and supported. Disability is a product of the environment. Stumbo, Martin & Hedrick (2009) explained,

> Disability, then, is not just a physical or inherent attribute, but a result of interactions between people and their physical and social environments, including a complicated mix of social, cultural, political, climatic, topographic, architectural, and technological components. (p. 100)

A person is not disabled unless the affordances of their surroundings do not allow the person to optimally function. For example, someone in a wheelchair is not disabled if there is a ramp and he/she is therefore able to enter an elevated building. On the other hand, a blind person is disabled if he/she is unable to engage with the mathematics lecture because he/she cannot read the equations that the instructor wrote on the whiteboard.

The reader will further notice that sometimes the language puts the disability first, as in *blind person*, and sometimes the language is intentionally worded as person-first, as in *persons with cognitive impairments*. The first example of *the blind* mimics the language used by organisations such as the American National Federation of the Blind (NFB). Self-advocacy groups should be the respected authority on the way in which language is used to reflect members' realities. The NFB assert, they are regular people who happen to be blind (Kinash, 2006). Collective action is heightened when people embrace their identities as blind people, just as women banded together to secure their rights (Shapiro, 1993). On the other hand, society has tended to stereotype all people with cognitive impairments, referred to more commonly as *the mentally handicapped* or *the mentally retarded*. The *People First* movement has been important for people with cognitive impairments to combat stigma (Kinash, 2007). Person first language (as in a student with Down Syndrome) reminds the speaker and the listener that Down Syndrome is only one, and not the primary, descriptor of the child. The key of language use is to be aware of implied stigma and avoid stereotyping.

What are the implications for assistive technology? First and foremost, it is important to recognise that all people have the right to an equitable educational experience. The right to be able to enter the room, engage with student peers, read the textbook, hear what the teacher presents, observe, manipulate and experiment, and demonstrate learning through assessment is applicable for each and every student no matter what type and degree of diversity is involved. The teacher and every other member of the educational team have an obligation to ensure that each and every student is not disabled by pedagogy. If the learner requires assistive technology in order to participate, then this is a right rather than a privilege.

It is also important to recognise that persons with disabling conditions regularly face stigma, discrimination, prejudice and oppression. The way in which supports are provided should reduce rather than heighten these realities. For example, if there are AT options that

will raise a child's *cool-factor* amongst his or her peers, this should be used, rather than another option that will make difference and disadvantage salient. For example, if the latest iPad meets the student's accessibility needs, then the learner should use this rather than a big, clunky, institutional-looking device that does not look like something any other child would want. Technologies should be chosen that engage the student in the classroom community over those that segregate and isolate the learner in a cubicle down the hall.

While a social justice approach to AT cannot be overstated, it is important to recognize that often the most effective solutions are simple, efficient and non-disruptive. Many disabled self-advocates will assert that they are not looking to be coddled or for an excuse not to work hard. Nor are they looking for expensive, grandiose technologies. One of the participants in Kinash's (2006) research on blind online learners explained,

> Blind people in general do not want to have their needs met to the exclusion of people with vision because we're a very small percentage of the population. What we want (and maybe I shouldn't speak for all people, but what I think blind people and other people with disabilities want) is to be able to access the same educational material as anyone else would be able to access. And if there's a need for a neat visual thing, then that's okay. But there needs to be an alternate link available, an alternate description that describes what happened or what is going on in the class, or an alternate assignment, or audio presentation that includes the visual but describes what's going on interactively. I guess if multimedia is used it can be very powerful, and even for a blind person, as long as it doesn't exclude the person. As long as there is some way of including the person in the experience. (p. 86,7)

This explanation clarifies that there are components of new technologies that escalate, rather than ameliorate inaccessibility. Specifically, while technological advances have enabled the proliferation of multimedia such as images and video online, these features are largely inaccessible to blind people, just as audio is inaccessible to the deaf and hard of hearing. The sighted and the hearing should not be denied multimedia enhancements, but care must be taken so that such features are compatible with ATs that enable access (Lee & Templeton, 2008).

Relationship between mainstream and assistive technologies

As stated above, technology is not a static entity. New designs, merging platforms, and user-discovered applications blur the distinctions between definitional categories of technology. Specifically in the context of AT, technologies designed in a special education context were designed to catalyse the education of students with disabling conditions. Educational policy shifts toward inclusive education resulted in prioritization of technologies that enable access to the general curriculum. Emerging technologies bring new educational possibilities. Edyburn (2010) wrote, "The reason why UDL [defined below] is possible today

as opposed to the 1950s or 1970s is that digital technology provides a high degree of flexibility" (p. 38). Negroponte (1995) wrote about this change as the move from atoms to bits. Printed books, for example, are made of atoms. They are only available in print format. They cannot be searched and do not enable internet hyperlinks. Enhanced electronic books, on the other hand, are composed of bits. Readers can click on hyperlinks in the *Table of Contents* and move directly to the sections they want to read. They can click on key terms and read a definition. They can search and sometimes bookmark and make and remove highlights. For readers with a disabling condition, format in bits rather than atoms means that ATs such as screen readers and optical character recognition are functional, thereby making the book accessible. Readers can also pull the book in the desired format, such as electronic audio, or enlarged font. When the book is in print, the text is only available in the font and size selected by the printer. All of these changes blur the distinction between what counts as *mainstream* and what counts as *assistive* technologies.

Do technological advancements make AT obsolete?

The primary means of inquiring into the question of whether technological developments have erased the need for assistive technologies is to observe whether persons with disabling conditions continue to use these specialized technologies. It is intuitive that a significant proportion of persons with disabling conditions would cease using assistive technologies if accessible mainstream solutions were ubiquitous and effective.

The answer to the question of whether persons with disabling conditions continue to use assistive technologies despite advancements in mainstream technologies is *yes*. Stumbo, Martin & Hendrick (2009) reported that rather than decreasing, use of assistive technologies by persons with disabling conditions has substantially increased, and the authors predict that the upward trend will continue. Sze (2008-2009) agreed, elaborating that the increasing prevalence of inclusive education has resulted in more pronounced use and further development of AT. These authors strongly advocate for the continuance of AT. Stumbo, Martin & Hendrick wrote,

> The challenge to society is recognizing that AT is of primary significance in affording Americans [sic] with disabilities the highest degree of independence possible, in attaining higher education degrees, successful careers, and fruitful lives. (p. 108)

Johnstone, Thurlow, Altman, Timmons and Kato (2009) concluded their research by writing, "use of assistive technology in the process of reading cannot be ignored" (p. 74). The literature reviewed in preparation for writing the chapter you are currently reading consistently asserts that accessible mainstream technologies are necessary, but that they are not sufficient. Persons with disabling conditions will continue to require well-designed and affordable specialized technologies.

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Observing whether persons with disabling conditions continue to use ATs is one way of addressing the question of whether new technologies have made ATs unnecessary. However, this approach to the question is inconclusive, in that perhaps the reason that ATs continue to be used is that there is economical hegemony around a whole marketplace of sales and maintenance of these technologies, and teachers and students continue to use ATs because they are status quo.

Another means of addressing the question as to whether assistive technologies continue to be necessary is to ask the experts. Some authors are beginning to publish papers specifically addressing this question. For example, Emiliani (2006) wrote a journal article titled, *Assistive technology versus mainstream technology: The research perspective.* Litvak and Enders (2001) wrote a chapter in which they specifically posed the question, "will technology replace assistance." In both of these examples, the authors asserted that there will always be a need for specialized supports for persons with disabling conditions, including assistive technologies. For example, Litvak and Enders (2001) wrote,

> The idea of substituting one type of support for another may be seductive, but the one-size-fits-all approach this implies is not compatible with consumer responsiveness and control over one's life. It fails to acknowledge the wide range of variation among people with disabilities, due to resources and choices as well as size and shape. (p. 719)

These authors are asserting that needs and solutions should not be over-simplified. Edyburn (2010) wrote, "when designers assume that everyone is like them (e.g., tall, short, average weight, able to read at grade level), the product they create will meet the needs of a narrow range of users" (p. 36). Accessible and equitable education is complex, and therefore, the means of achieving effective pedagogies must be individualized and multi-faceted.

Emerging technologies are both a solution and a problem for persons with disabling conditions (Emiliani, 2006). A person with a disabling condition has communication, sensory, mobility and/or intellectual challenges. For example, a person who has recovered from throat cancer and has had his larynx removed cannot vocalize in the regular way. A blind person cannot see to read printed text. A quadriplegic cannot walk or use her arms. Impaired learning is a common characteristic of Down Syndrome. Technological innovation means that the person with a removed larynx can speak using a voice box. However, speech recognition software cannot accurately detect his words, and he cannot use this innovation. The invention of refreshable Braille displays means that the blind person can read. However, advances in visual media (images and video) mean that most website are inaccessible to the blind (Kinash & Paszuk, 2007). Now quadriplegics can eat independently using a head pointer device, but they cannot text their friends. A high school student with Down Syndrome can use spell-check to proofread her work, but cannot escape the proliferation of visual images that send the message that her physical beauty is not the type that society

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values (Kinash, 2006). Each of these examples illustrates how technological innovation ameliorates problems for persons with disabling conditions, and at one and the same time raises mainstream technological potential creating and/or making new problems salient. A metaphor is a chef with a child. Just as the chef lowers the cookies so that they are in reach of the child, the chef takes something new and delicious out of the oven and places it up high. Edyburn (2010) wrote about the example of the Kindle.

> Consider the recent fiasco with the Amazon Kindle, where designers failed to recognize that blind readers would want to use a hand-held reading device and that they would need voiced navigational menus – a design decision that was reversed in December 2009 after six months of complaints and disability advocacy. (p. 36)

The rapidly evolving nature of technology means that the accessibility gap is widened faster than it is bridged for persons with disabling conditions.

The authorities on whether ATs remain necessary even with the advent of sophisticated technologies are people with disabling conditions. Kinash (2006) queried this relationship between mainstream and assistive technologies with the people she interviewed for her research on blind online learners. One of the participants, for example, stated that she liked the idea of more of the instructor's recorded voice on online course sites. However, she explained that she would still require her screen reader AT to find her way to the auditory tracks on the course site. This led Kinash to introduce the following analogy,

> An analogy regarding accessible buildings might serve to clarify. The inside of the room might be completely accessible to someone in a wheelchair. The room is constructed on a single level, and all shelves are mounted at a level that someone in a wheelchair could access the contents. Unless, however, the doorway is built wide enough to let the wheelchair pass, the person cannot enter the accessible room. (p. 136)

Other people Kinash interviewed explained that they *required* the AT for accessibility, and that they also *preferred* the high-end specialized design with features that would be left off for a mainstream consumer base. For example, the specialized screen reading technology used by most of the blind research participants enabled access to diverse types of documents that mainstream screen reading technology did not, and finer calibration of voices and speed of playback. The bottom line was that even though there are now built-in tools and free and inexpensive mainstream software for functions such as translating written text into voice and for recognising voice and capturing in print, many persons with disabling conditions do not feel that the *mainstream* replace the *assistive* technologies.

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Can ATs also benefit persons without disabling conditions?

Most readers have likely heard the phrase that *necessity is the mother of invention*. Disabled people can be considered to experience more instances of *necessity* in that they have more accessibility needs that might be resolved by technologies. As such, O'Connor (2000) described technology users with disabling conditions as *early adopters.* People with disabling conditions might be considered to have led the way for other technology users. A blind friend showed me her talking GPS nearly a decade before I purchased a GPS of my own. Jacobs' (2004) analysis of technologies supports this view. Jacobs traced the origins of many technologies used by people on a regular basis, such as telephones, email and flatbed scanners. All of these technologies were initially designed to meet the needs of (a) person(s) with disabling conditions. The technology moved out of the realm of AT when it was discovered that the applications would benefit the mainstream population.

Universal design for learning

Universal design for learning (UDL) is a pedagogy that has "captured the imagination" of educators within special, inclusive and mainstream education (Edyburn, 2010, p. 34). The most basic definition is implementation of the proposition that "good design for people with disabilities benefits everyone" (Edyburn, p. 34). The most common model of education is framed by teacher implementation of grade-specified curriculum and pedagogy created by a team of experts (Jardine, Clifford & Friesen, 2003). There is an implicit one-size-fits-all assumption that every learner will more or less learn in accordance with this educational plan. Proponents of UDL disagree. They believe that the defining characteristic of contemporary classrooms from preschool through to post-graduate school is diversity. Learners are individuals, and as such, need a rigorous, intentionally planned, flexible curriculum and pedagogy.

The concept of UDL is an extension of the architectural concept of Universal Design (UD). The North Carolina State University's (NCSU) Disability Studies website credits the definition of UD to Ron Mace. NCSU's Center for Universal Design opened in 1989 and used the following as its definition of UD. "Universal design is 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." The most common example in the literature is of flexible countertops. Universally designed countertops can be easily lowered by the user in a wheelchair and raised for use by a tall person.

NCSU established seven principles of UD. The first principle is equitable use, in that the design should afford access and functionality to accommodate as much user-diversity as possible. Second, features should be designed so that they are flexible rather than fixed and static, so that they meet the unique needs of the user. Third, it is important that the design is simple and intuitive to use. The feature is only as effective as the users' awareness that the capability exists and the user's capacity to make it happen. This relates to the fourth

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principle, which is that the usage information is perceptible. If there are cues as to how to specialize, these identifiers must be easily perceived. Fifth, there must be tolerance for error. Yesterday, in trying to load my daughter's photos from her Android smart-phone to her laptop, I inadvertently erased all of her contacts. This is not high tolerance for error. The design must also mean low physical effort (sixth principle). Returning to the flexible countertops, the operating lever should not require extensive physical force. The final principle is size and space for approach. The innovation should not take-up much more room than the original non-UD design.

The alert reader will have drawn many analogies from architectural UD to the context of education and so too did the principals of the NCSU Center for Universal Design. The NCSU Disability Studies web-pages explain that,

> An outgrowth of the UD model, Universal Design for Learning (UDL) uses UD principles, to design courses "to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design."

The proliferation of UDL as a facet of pedagogy is credited throughout the literature to the Center for Applied Special Technology (CAST). The principal members of CAST have published three books on the topic of UDL (Rose & Meyer, 2002; Rose, Meyer & Hitchcock, 2005; Rose & Meyer, 2006). Each of these books was set in the context of kindergarten through twelfth grade education. Burgstahler and Cory (2008) published a book applying UDL to higher education.

Across these books, three principles define the core tenets of UDL. The first is multiple means of representation. This means that the educator builds planned redundancy into instruction. The educator's lessons, lectures and/or tutorials use a combination of text, image, metaphor, audio, video, demonstration and hands-on experimentation to convey educational messages. The second principle is multiple means of engagement. This principle acknowledges that learners are motivated in different ways. Some students attend only to reach graduation, or to obtain a ticket to a job. Others are authentic lifelong learners and are stimulated by ideas and reflection. Some students prefer individual study, while others thrive in group-work. UDL advocates pre-planned, yet flexible combinations of these various approaches and means of engaging student motivation. The third principle is multiple means of demonstration. Rather than tightly defined, fixed assessment tasks, UDL means allowing students the degrees of freedom to determine how to best provide evidence of their learning. Some students will write an essay and others will create a podcast or video.

Opitz (2002) provided examples demonstrating how accessible design benefits everyone. In each case, she juxtaposes a solution for a person with a disabling condition with a mainstream pedagogical advantage.

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> Images can be effective in providing alternative examples or explanations of content. ... Sounds can also be used, but captions or alternative text benefit the deaf and those with hearing by providing a written script to follow and to refer back to at a later date. Easy-to-read content benefits all learners by "chunking" the information into blocks of important information that can be easily read and understood by any audience. (p. 12)

The essential element of UDL is that it is pre-planned. UDL is designed into curriculum and pedagogy from the outset, rather than retrofitted or adapted on-the-spot.

Edyburn's (2010) overall evaluation of UDL in education is that there seems to be value-added in its implementation. However, there is a paucity of well-designed empirical literature providing evidence that UDL is making a difference in education. He also assessed that the UD principles outlined above have incomplete application to learning, leaving educators guessing in regard to best practices in UDL implementation. As title of his journal article, Edyburn posed the question, "Would you recognize universal design for learning if you saw it?" By this question, Edyburn did not mean that UDL may be authentically present in our curriculum and pedagogy and that we are not identifying it and labelling it as such. He meant the opposite, in that he fears that there are numerous instances in which educators and researchers claim to be teaching through UDL, when upon closer investigation, the principles are not upheld.

As such, Edyburn (2010) articulated ten propositions for the effective implementation of UDL. The first proposition is that "universal design in education is fundamentally different from universal design in the built environment" (p. 36). Constructing learning through creating shared understandings scaffolded on prior student experiences is vastly different from constructing buildings in keeping with blueprints. The second proposition is that "UDL is fundamentally about proactively valuing diversity" (p. 36). Curriculum and pedagogy are complex and must be carefully considered. There are no quick fixes when teaching to a group of diverse learners. In relation to this proposition, Edyburn wrote, "UDL is more than simply integrating the latest technology tools into the curriculum" (p. 36). While emerging technologies enable capacity for multiple means of representation, engagement and demonstration, inclusion of multimedia does not guarantee learning. Poorly designed technological insertion can be distraction rather than pedagogy. Edyburn's third proposition is a defining characteristic of UDL. He wrote, "UDL is ultimately about design" (p. 37). He distinguished between design and technology.

> Design is fundamentally about problem solving. Instructional design is about the efficacy of learning. Central to all of these constructs is evidence of intentionality and how problems can be resolved through innovative design. Technology is simply the delivery system. (p. 37)

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In other words, the educator must be proactive in identifying the problems that diverse students might experience in learning the lesson or lecture, and design the input, process and output such that the experience is accessible and equitable for all.

At this point in the presentation of Edyburn's (2010) propositions, the reader might be thinking that perhaps UDL is just a catch-phrase for good teaching. Edyburn disagrees, and his fourth proposition is in fact that, "universal design for learning is not just good teaching" (p. 38). Edyburn elaborated,

> UDL represents a 21st-century intervention that seeks to use emerging insights gained from research in diverse fields such as brain imaging, learning sciences, instructional design, and technology. Good teaching has never been able to address the full range of diversity found in a classroom. (p. 38)

In other words, educators might have experienced success with typical students through applying pedagogical principles of giving immediate and specific feedback and periodically confirming understanding. However, mature learners with families and careers, students with emotional and behavioural disorders, and people with sensory impairments need more from the educator and the education in order to learn. This proposition leads seamlessly into the fifth, which is that "universal design for learning does not occur naturally" (p. 38). UDL must be intentional, researched and rigorous. The sixth proposition is that "technology is essential for implementing UDL" (p. 38). Inclusion of technology is necessary because the capacities of electronic media enable accessibility, but not sufficient, in that the technology must be carefully infused in the context of rigorous pedagogical principles and understanding of diversity. The seventh proposition is that UDL is not assistive technology. As described above, the defining element of AT is that it is intended for persons with disabling conditions. UDL, on the other hand, is design for all, including students with and without disabling conditions. The eighth proposition is that "it is necessary to measure the primary and secondary impact of UDL" (p. 39). There is a rich and important relationship between research and practice. Both are necessary to inform the other. To date, UDL has been minimally researched, and educators are therefore under-informed as to evidence-based implementation. The ninth proposition is that "claims of UDL must be evaluated on the basis of enhanced student performance" (p. 39). Hand-in-hand with the eighth proposition, Edyburn is calling for rigorous empirical research on UDL that establishes whether this educational design is making a difference to student learning, and of which students specifically. The tenth and final proposition is that "UDL is much more complex than we originally thought" (p. 40). This proposition needs no further elaboration, beyond that articulated in the propositions that preceded it.

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Electronic curb-cut analogy

The concept of UDL becomes clear to many through the electronic curb-cut analogy. Curb-cuts are the portion of the sidewalk that are cut-away and/or sloping so that they rest flush with the road. They were designed for people in wheelchairs to enable access from the road to the sidewalk and vice versa. There are not a lot of people in wheelchairs regularly using each and every curb-cut. However, each curb-cut is regularly used. Curb-cuts outside grocery stores are regularly used by shoppers pushing carts. Other curb-cuts come in handy for parents pushing strollers, inline skaters and cyclists. The curb-cut demonstrates the definitional proposition of UDL in that there are some designs that were implemented for persons with a specific disabling condition that have benefits for many diverse types of people. A similar example that Edyburn (2010) cites is that of the zero-entry pool.

> ...one of the promises of UDL is that by focusing on the special needs of students with disabilities we can design solutions that positively impact other students. This principle can be illustrated by the example of the zero-entry swimming pool. The original design problem focused on how to enable people in wheelchairs to enter a pool. Clearly, the needs of the primary audience have been effectively met through this design. If the design innovation only helps a disability group, the intervention is simply an assistive technology. When the secondary impact of the zero-entry pool is examined, we observe that the majority of the users of the shallow end of the pool are parents with young children, teenagers, and senior citizens. (p. 39)

Technology adds the component of *electronic* to the metaphoric curb-cut. As described above, digital technologies are flexible. This element means that they can meet the needs of many, even when designed to specifically address the needs of disabled users. For example, a primary school teacher had a split-grade class. She started wearing an FM system for a hearing-impaired student. The system not only amplified her voice for the hearing-impaired student, but for the entire class through speakers at the back of the class. The next year, the hearing impaired student moved on to grade four in another class and the teacher stopped using the FM system. The new grade three students who had the teacher the previous year complained that they could not hear the teacher as well as they could last year. The teacher started using the FM system again and has used it ever since.

AT now and into the future

Review of the AT research

A few AT researchers have taken it upon themselves to do an analysis of the state of knowledge of AT as reflected in the published literature. Each of these analyses confirms Edyburn's (2010, 2009, 2006) persistent call for a rigorous research program in AT and UDL. Alper and Raharinirina (2006) searched for empirical experimental cross-disability research with AT as the independent variable and skill acquisition as the dependent variable. They

further confined their search to articles published between 1988 and 2003. The analysts located 60 articles. Analysis of the articles revealed that the majority addressed cognitive and/or learning skills (53% studied participants with learning disabilities and 35% persons with cognitive impairments). The category of lowest study incidence was sensory impairment, with visual impairment, for example, at only 4%. The most popular experimental design was a group comparison method (47%). The majority of studies did not address the themes of family involvement in AT (78% did not) nor ongoing AT support (68% did not). Overall, the researchers concluded that the body of research establishes AT as an important domain of supports in the education of students with disabling conditions. However, Alper and Raharinirina believe that AT research requires development in design and content.

One year after the Alper and Raharinirina (2006) study, Okolo and Bouck (2007) conducted an analysis of peer-reviewed journal articles about cross-disability AT that were published between 2000 and 2006. The authors located 122 papers that met their criteria. Notably, the authors only included empirical literature in that the papers specified that "the author(s) asked a research question and collected data, in some form, to answer that question" (p. 21). Okolo and Bouck's analysis indicated that there is extensive room for growth in research on AT. Consistent with what Kinash and Crichton also discovered in 2007 in looking at the research at the intersection of disability and technology, there were few empirical studies with a rigorous design. Okolo and Bouck discovered that "implementation studies were primarily descriptive" and that 39% of the research designs "offered qualitative information about the use and impact of AT" (p. 27). The published papers are also not maximising the impact factor in that "60% were published in just two [journals]" (p. 27). The research does not appear to have kept up with the emerging trends in technologies. The authors reported "no studies of emerging technologies such as gaming or portable, mobile technologies" (p. 28). Research is also limited in the type of participants chosen for studies. Nearly one-third of research participants across studies had high-incidence disabling conditions such as learning disability and attention deficit disorder, and there were very few studies of people with physical disabilities and sensory impairments such as blindness. Notably, Alper and Raharinirina's and Okolo and Bouck's analyses support one another's conclusions.

Moving from a broad-based review of the AT literature, it is therefore intriguing to next move to an analysis with tighter boundaries, and in an area in which Alper and Raharinirina's (2006) and Okolo and Bouck's (2007) analyses indicated that there was a paucity of empirical literature. Kelly and Smith (2011) analysed research literature published between 1965 and 2009 about AT used by persons with visual impairment. Whereas Alper and Raharinirina's search derived 60 articles and Okolo and Bouck's search derived 122 papers about all types of disability, Kelly and Smith's search derived 256 about visual impairment alone. However, Alper and Raharinirina's search criteria specified 15 years of

publication dates and Okolo and Bouck's criteria specified 6, whereas Kelly and Smith's included 44 years. Perhaps even more important, as is revealed in the outcomes, Alper and Raharinirina and Okolo and Bouck were much more rigorous about what counted as research. Kelly and Smith summarised their results in writing, "a large percentage of the literature consists of anecdotal evidence" (p. 79). The descriptive statistics Kelly and Smith reported are convincing. Forty-eight percent of the articles "discussed theories, beliefs, or practices without a research design or method" (p. 77). Even more telling, only one percent of the articles "presented sufficient data to determine the effectiveness of an intervention with appropriate participants, intervention, control group, and comparison group" (p. 77).

The words in the conclusion of Kelly and Smith's (2011) paper express the interpretation of all reviewed literature analyses. "For students ... to be able to receive high-quality assistive technology that will enhance their educational success, more concrete research on the effectiveness of assistive technology needs to be conducted" (p. 81). This statement was confirmed through Jutain, Strong and Russell-Minda's (2009) analysis of 108 studies, again restricting the literature to studies of participants with low vision. Notably, there are calls for research into specific AT questions within the literature and for authors who pose applied research design. For example, Edyburn (2006) proposed and described an example of a *Time Series Concurrent Differential* model. Edyburn explained that "...a student will use the technology tools in alternate weeks (i.e, one week with technology, one week without technology)" (p. 74). There are measures of performance at the end of each change of experimental condition. What is clear is that there is a need for further empirical AT research in order to establish an evidence-based approach to best practices and assure that supports are enhancing learning.

Three meta-analyses of the AT research literature were presented above. One was published in 2011, another in 2007 and the third in 2006. The authors listed categories and provided some examples of AT tools, strategies and approaches used in the literature. They did not compare these AT solutions to previous approaches and thereby did not assess changes over time. What struck me, frankly, was that I was not struck. I was underwhelmed by the AT presented through the research analyses. I saw few changes since nearly three decades ago, when I was first introduced to AT. My search revealed minimal assurance of learning research in relation to emerging technologies. For example, the title of Pulman's (2007) article is "Can a handheld gaming device be used as an effective assistive technology tool?" His article is about posing that question and proposing research to answer the question. In other words, there is no, or at least unconvincing, evidence in the literature that AT has changed, developed and evolved over time. Perhaps this is a case of – *if it ain't broke, don't fix it*. Perhaps, AT as initially designed was conceived in such a robust way that evolution is unnecessary. I remain sceptical that this is an accurate explanation. I also feel that there is insufficient evidence to assess whether we now have optimal AT solutions. As all three of the teams of research analysts asserted, the perceptions of families and teachers

were underrepresented in the AT research. Also notably missing, was the voice of the AT users.

A factor that was not addressed by the research analysts was whether the authors of the articles have disabling conditions. This is not to say that only authors with disabling conditions have a right to publish research about assistive technology, but if none of the authors have a disabling condition, then the accumulated knowledge is worrisome. For example, it would have been helpful to the discussion above regarding whether AT remains necessary to have been able to review literature on disabled people's perceptions. However, this voice was not available in the literature. As described in Kinash (2006), there is important research application to the disability studies slogan, 'nothing about us without us.' Specifically in the context of assistive technology, Seelman (2001) presented the position of disabled activists that "...disabled people had been shut out of the process of research and development of products to meet their needs" (p.278). One of the deleterious outcomes of research that is conducted by stakeholders who have not lived the researched experience is that imaginations are limited by what is known. In other words, rather than creating a-new, the designers merely modify what exists. Seelman wrote that advocates "...argued for designs specifically for the disabled rather than remade able-bodied equipment."

Another problem of non-involvement of intimately involved stakeholders is that inappropriate resource allocation decisions are likely. A prime example is the auditory pedestrian crossing signal. To the sighted citizen, this modification seems like a valid idea and an altruistic use of taxpayer's money. However, many blind advocates feel that meaningful consultation with the intended users would have resulted in more appropriate allocation of the money. For example, many blind advocates would argue that more effective accessibility amelioration would have been to resource accessible digital textbooks; Kinash's (2006) research indicated that the majority of blind students receive accessible textbooks half-way through the semester rather than at the beginning like the sighted students. So why would blind people not want beeping cross-walk signals? Harkey et.al., (2007) identified eight reasons. Their study indicated numerous problems that their blind research participants experienced with auditory pedestrian signals. Blind people are taught through orientation and mobility instruction to listen to the traffic and its directionality (these cues are necessary because not *all* pedestrian crossings will ever be auditory). The main problem of the pedestrian crossing modification is that the beeping cross-walk signals tend to be louder than the natural cues and distract and impair the message. The bottom line can be summarized in Shapiro's (1993) opening sentence, "Nondisabled Americans [substitute people] do not understand disabled ones" (p.3). It is thereby dangerous and counter-productive that it is assumed that nondisabled people can prioritize problems and design solutions for disabled people.

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Practical recommendations and strategies for teachers

A common theme across many of the current articles on assistive technology is that the key ingredient to supporting the education of students with disabling conditions is acceptance that AT is necessary. Once teachers have accepted that AT is an important component of teaching diverse students, the next component is AT professional development. Okolo and Bouck's (2007) review of the AT literature revealed "...ample documentation that lack of teacher education, professional development ... are major barriers to more effective use of technology" (p. 27). Smith, Kelley, Maushak, Griffin-Shirley and Lan's (2009) literature review and research indicated that most teachers feel that they do not have enough knowledge and are therefore underprepared to support students' AT needs. These researchers conducted a Delphi study, deriving 111 required AT competencies for teachers of students with visual impairments. Many of these competencies also applied to teachers of students with other types of disabling conditions.

Teachers must take the time to get to know each individual student's specific needs and then choose and support the student in effectively using the most appropriate assistive technologies. Sze (2008-2009) organized teacher support of AT into stages. The teacher must first get to know the student, then get to know what AT is available and which software and devices best meet which needs. The next phase is to make an effective match between the student and the AT. Jeffs, Behrmann and Bannan-Ritland's (2006) research also emphasized the importance of the match between the child's needs and the capacities of the particular AT device or software. The final step is to navigate the process of uptake and training to best promote success, both in terms of using the AT to its best advantage and ensuring that use promotes social inclusion.

Some of the features that researchers describe as most essential when choosing appropriate assistive technologies, is that they are affordable and reliable, and that they are able to be maintained for as long as needed. Alper and Raharinirina (2006) listed six success criteria for effective AT implementation. First, family are invited and involved, clearly stating their AT goals. Second, there is clear and specific alignment between the student's own goals and the capacities of the considered AT. Third, the student, family, teacher, and other educational professionals work as a team in AT implementation. Fourth, there is a communication plan throughout all phases of AT. Fifth, there is ongoing support, in that AT is repaired, upgraded and replaced when necessary. Finally, any problems are identified and rectified as soon as possible.

Conclusion

This chapter has considered education in the context of technology and student diversity. Assistive technology was defined and described as a support for students with disabling conditions. Contemporary research on assistive technology was reviewed,

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resulting in a call for enhancement to tools, strategies, approaches and implementation systems, as well as for rigorous assurance of learning research. Principles and propositions for universal design for learning were considered as an approach that is oriented in meeting the learning needs of students with disabling conditions, but provides solutions for many diverse learners.

In the introduction, a number of questions were posed. The answers have been addressed throughout the chapter and are summarized here.

What about persons with disabling conditions? Have all of the technological advancements made a difference?

Review of the research and descriptions of AT implementation reveal that the pace of development of *assistive* technology has not matched that of *mainstream* technology. The level of sophistication reached in *mainstream* technology has not been reached in the field of *assistive* technology.

How accessible are the technologies and devices I use, such as email, iPads, Blackberries and Kindles to the disabled?

Features of most of the technologies I use on a regular basis are not accessible to many groups of disabled people. The exception is email, which can be used with or without a mouse and can be auditory or text-based. Blind users continue to use the AT of screen-reading technology rather than built-in accessibility settings. The woman described in the introduction who can only move her neck and face would not be able to use the touch screen of the iPad or the tiny keyboard of the Blackberry and Kindle. While blind users could listen to content on the iPad, Blackberry and Kindle, they could not navigationally get to the auditory content without assistance from a sighted person.

If the woman described in the introduction who can only use her neck and face is alive today, is it likely that she still uses a head-pointer device for independent eating and communication? What about a child born today with the same functional limitations as the woman described above?

I cannot answer this definitively. Despite the breadth and depth of AT articles used to inform this chapter, there is no indication that the technology has changed from what the described woman used in the 1980s. Perhaps this technology meets needs and there is no need for advanced technologies.

Do children born today with functional limitations require assistive technologies or are mainstream technologies advanced to the degree that they are ubiquitous and solutions for all? Does anyone still require assistive technologies or has the digital age meant equitable experience for everyone?

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The review of the literature used to inform this chapter indicates that persons with disabling conditions continue to require assistive technologies. Notably, need for AT is on the incline rather than decline. Emerging mainstream technologies have introduced more accessibility problems than those they have solved. Emerging technologies require AT innovations or adaptation to existing AT in order to facilitate access. The key, and given priority as the final sentence of this chapter (prior to the glossary and URLs), is that advancement in the field of AT should be conducted in collaboration with ,and through the leadership of, persons with disabling conditions.

Glossary of terms relevant to AT

Accessibility – "simply put, accessibility means providing access – making products and services available to, and usable by, everyone. Accessibility is about removing barriers." (Moulton, Huyler, Hertz & Levenson, 2002, p. 25).
"describes an environment where access is equitably provided to everyone at the same time" (Edyburn, 2010, p. 35).

Accommodations – "Inaccessible environments and materials are modified and made available. Typically, accommodations are provided upon request [initiated by the person with the disabling condition and/or his/her family]" (Edyburn, 2010, p. 35).

Adaptive Technology – often used interchangeably with the term assistive technology. The latter term is preferred in the literature. When distinguished between adaptive technology refers to modifications to mainstream technologies for persons with disabling conditions and assistive technologies to original devices used to enable functionality for persons with disabling conditions.

Advocacy – "efforts raise awareness of inequity and highlight the need for system change to respond to the needs of individuals with disabilities" (Edyburn, 2010, p. 34,5).

Assistive Technology (AT) - "a broad range of devices, services, strategies, and practices that are conceived and applied to ameliorate the problems faced by individuals who have disabilities" (Cook, Polgar & Hussey, 2008, p. 5).

Assistive Technology Device(ATD) – "any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of a child with a disability" (USA, IDEA 2004 Legislation, Title IA602).

Competitive Enablement – "allows consumers to make informed choices by evaluating various types of devices specific to their needs and activities, and lessens the chance that they will abandon the devices they have chosen later" (Jutai, Strong & Russell-Minda, 2009, p. 220).

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Computerized adapted test – "designed to respond to a test taker's ability by providing subsequent test questions that are based on the test taker's individual performance, thereby levelling and individualizing the difficulty of each item" (Kamei-Hannan, 2008, p. 261).

Mainstream Technology – a tool or device, usually digital, designed for use by a majority population, and therefore not specifically designed for those with disabling conditions.

Universal Design (UD) **–** "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." This definition is by Ron Mace and available on the North Carolina State University's Disability Studies webpage at http://www.ncsu.edu/dso/general/universal-design.html

Universal design for learning (UDL) **–** "An outgrowth of the UD model, Universal Design for Learning (UDL) uses UD principles, to design courses "to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design." This definition is available on the North Carolina State University's Disability Studies webpage at http://www.ncsu.edu/dso/general/universal-design.html

URLs high-impact to AT

Accessible technology for persons with disabling conditions

DO-IT (University of Washington – Disabilities, Opportunities, Internetworking and Technology)
http://www.washington.edu/doit/

EASI (Rochester Institute of Technology – Equal Access to Software and Information)
http://people.rit.edu/easi/

Assistive technology definition

IDEA 2004 (USA Individuals with Disabilities Education Act, Title IA602)
http://idea.ed.gov

Assistive technology in K-12 education

SET-BC (Special Education Technology British Columbia)
http://www.setbc.org/

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Conferences

CSUN (International technology & persons with disabilities conference)
http://csunconference.org/index.cfm?EID=80000300

ATIA (Assistive Technologies Industry Association)
http://www.atia.org/i4a/pages/index.cfm?pageid=1

Electronic curb-cuts

CAS (Center for an Accessible Society), Steve Jacobs
http://www.accessiblesociety.org/topics/technology/eleccurbcut.htm

Online accessibility

WAI (Web Accessibility Initiative)
http://www.w3.org/WAI/

Practical implementation strategy for UDL

Edyburn (2009) Tic-Tac-Toe Instructional Planning
http://www.uwm.edu/~edyburn/tictactoe.html

Tools and devices

FANDI (Free and Inexpensive Adaptive Technology Database)
http://www.adaptech.org/en/downloads/fandi

Assistive and Adaptive Technology Resources
(Fee for PDF)
http://aasl.metapress.com/content/nn03812g17271640/

Universal design for learning

CAST (Center for Applied Special Technology)
http://www.cast.org

NCSU-DSO (North Carolina State University, Disability Studies Office)
http://www.ncsu.edu/dso/general/universal-design.html

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