Assistive Technology
Outcomes and Benefits

A joint publication of the Assistive Technology Industry Association (ATIA) and the Special Education Assistive Technology (SEAT) Center

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seat center
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Assistive Technology Outcomes and Benefits

Assistive Technology Outcomes and Benefits is a collaborative publication of the Assistive Technology Industry Association (ATIA) and the Special Education Assistive Technology (SEAT) Center at Illinois State University. This publication is provided at no-cost to readers. It is a peer-reviewed, cross-disability, transdisciplinary journal that publishes articles related to the *benefits* and *outcomes* of assistive technology (AT) across the lifespan. The journal's purposes are to (a) foster communication among vendors, AT Specialists, AT Consultants and other professionals that work in the field of AT, family members, and consumers with disabilities; (b) facilitate dialogue regarding effective AT practices; and (c) help practitioners, consumers, and family members advocate for effective AT practices.

Editing policies are based on the **Publication Manual**, the American Psychological Association (5th ed.). Additional Information is provided on the inside back cover. Any signed article is the personal expression of the author; also, any advertisement is the responsibility of the advertiser. Neither necessarily carries the endorsement of ATOB unless specifically approved by the ATIA.

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Editorial Policy

Assistive Technology Outcomes and Benefits is a peer-reviewed, cross-disability, transdisciplinary journal that publishes articles related to the *benefits* and *outcomes* of assistive technology (AT) across the lifespan. The journal's purposes are to (a) foster communication among vendors, AT Specialists, AT Consultants and other professionals that work in the field of AT, family members, and consumers with disabilities; (b) facilitate dialogue regarding effective AT practices; and (c) help practitioners, consumers, and family members advocate for effective AT practices.

Assistive Technology Outcomes and Benefits invites submission of manuscripts of original work for publication consideration. Only original papers that address *outcomes and benefits* related to AT devices and services will be accepted. These may include (a) findings of original scientific research, including group studies and single subject designs; (b) marketing research conducted relevant to specific devices having broad interest across disciplines and disabilities; (c) technical notes regarding AT product development findings; (d) qualitative studies, such as focus group and structured interview findings with consumers and their families regarding AT service delivery and associated outcomes and benefits; and (e) project/program descriptions in which AT outcomes and benefits have been documented.

ATOB will include a broad spectrum of papers on topics specifically dealing with AT outcomes and benefits issues, in (but NOT limited to) the following areas:

- Transitions
- Employment
- Outcomes Research
- Innovative Program Descriptions
- Government Policy
- Research and Development
- Low Incidence Populations

Submission Categories

Articles may be submitted under two categories—*Voices from the Field* and *Voices from the Industry*.

Voices from the Field

Articles submitted under this category should come from professionals who are involved in some aspect of AT service delivery with persons having disabilities, or from family members and/or consumers with disabilities.

Voices from the Industry

Articles submitted under this category should come from professionals involved in developing and marketing specific AT devices and services.

Within each of these two categories, authors have a range of options for the type of manuscript submitted. Regardless of the type of article submitted, primary consideration will be given by the journal to work that has *quantifiable results*.

Types of articles that are appropriate include:

> **Applied/Clinical Research.** This category includes original work presented with careful attention to experimental design, objective data analysis, and reference to the literature.
>
> **Case Studies.** This category includes studies that involve only one or a few subjects or an informal protocol. Publication is justified if the results are potentially significant and have broad appeal to a cross-disciplinary audience.
>
> **Design.** This category includes descriptions of conceptual or physical design of new AT models, techniques, or devices.
>
> **Marketing Research**. This category includes industry-based research related to specific AT devices and/or services.
>
> **Project/Program Description.** This category includes descriptions of grant projects, private foundation activities, institutes, and centers having specific goals and objectives related to AT outcomes and benefits.

In all categories, authors MUST include a section titled *Outcomes and Benefits* containing a discussion related to outcomes and benefits of the AT devices/services addressed in the article.

For specific manuscript preparation guidelines, contributors should refer to the *Guidelines for Authors* at http://atia.org/

Outcomes and Benefits in Assistive Technology Service Delivery

Phil Parette
Editor

David Dikter
Associate Editor

It is with great pleasure that we welcome many new colleagues to the Editorial Review Board of Assistive Technology Outcomes and Benefits (ATOB). Our Call for Reviewers this past Spring, coupled with personal invitations extended from our editorial office to experts in the field, culminated in a four-fold increase in the number of peer reviewers working with the journal. We are also excited about the journal's new website presence at: http://atobjournal.org which went live in September, 2007. Since receiving ISSN designations for previous issues of ATOB, we are now making available hardcopy versions of the current publication and previous volumes on demand from the website. For more information regarding acquisition of hardcopy volumes, please visit http://www.atobjournal.org.

In this issue of ATOB, our lead article is the first of a series of topical articles that address national issues identified at an AT Outcomes Summit conducted in December, 2005, in Chicago (see http://www.nationaltechcenter.org/index.php/2005/12/15/at-outcomes-summit-2005/; Parette, Peterson-Karlan, Smith, Gray, & Silver-Pacuilla, 2006). At this professional meeting, numerous concerns regarding large scale assessments were articulated, leading to an invitation for a team of experts to prepare a synthesis of the research on this topic. Martha Thurlow, Gerald Tindal, Richard Powers, Preston Lewis, Cara Cahalan Laitusis, and Joan Breslin-Larson, present in their article, "Research on AT Outcomes and Large Scale Assessments," a discussion of the role that AT plays in state testing accommodations. The authors describe examples of how AT is used in Kentucky, Minnesota, and Oregon, and highlight current and emerging research activities in this area.

In the second article, "The Effectiveness of Using a Pocket PC as a Video Modeling and Feedback Device for Individuals with Developmental Disabilities in Vocational Settings," Toni Van Laarhoven, Traci Van Laarhoven-Myers, and Leslie M. Zurita describe a multiple probe design examining the effectiveness of using a pocket PC to teach vocational tasks to two adolescents with mild and moderate cognitive impairments. The data presented indicate that introduction of the video-based procedures was associated with significant increases in performance.

In the third article titled, "Providing Curriculum Access to Young Children: Online Workshops for Educators," Linda Robinson, Carol Schneider, and Patricia Hutinger describe the effectiveness of online workshops developed by the Early Childhood Technology Integrated Instructional System (EC-TIIS) at Western Illinois University. Findings presented by the authors indicate that the online workshops are effective in increasing knowledge, skills, and attitudes of education professionals and families.

Particular emphasis is placed on changes in classroom practices made by education professionals after participation in on-line professional development, as well as faculty member outcomes regarding changes made in the university curriculum.

In the fourth article, "Visual Features That Convey Meaning in Graphic Symbols: A Comparison of PCS and Artists' Depictions," by Rupal Patel, Katherine Schooley, and Jessica Wilner, a research and development perspective is presented that may guide future work in the industry when creating augmentative and alternative communication (AAC) symbol sets. In this study, concepts depicted in Picture Communication Symbols (PCS) were examined in terms of a varying visual features and principles, coupled with artists' renditions of the concepts. Findings of the study presented suggest that a diverse set of visual features may be useful for analyzing how meaning is conveyed in existing AAC symbol sets and for developing novel symbols.

In the fifth article, "Universal Design for Learning: Critical Need Areas for People with Learning Disabilities," Wendy Strobel, Sajay Arthanat, Stephen Bauer, and Jennifer Flagg discuss primary market research designed to identify critical technology needs within the context of Universal Design for Learning (UDL) for people with learning disabilities. The study examines the educational technology industry from various expert perspectives and provides a better understanding of its current state, unmet needs, and future course of action for the adoption of UDL in classroom settings nationally.

In the sixth article, "Enhancing Access to Situational Vocabulary by Leveraging Geographic Context," by Rupal Patel and Rajiv Radhakrishnan, a description is provided of work that focuses on access to situational vocabulary through the use of geographic context to predict vocabulary. The authors report a process for collecting samples of spoken language and 'mining' location-specific vocabulary clusters within these samples, with descriptions of how context-driven vocabulary organization and prediction can be integrated into an iconic communication system, thereby potentially increasing a user's access to situationally appropriate vocabulary.

In the seventh article, "Achieving Systemic Change with Universal Design for Learning and Digital Content," Karen E. Ender, Barbara J. Kinney, William M. Penrod, and Debra K. Bauder describe a partnership between the Kentucky Department of Education (KDE) and University of Louisville to develop a statewide initiative addressing the implementation of UDL. The discussion includes descriptions of a statewide accountability testing (CATS), digitized text system, and UDL model schools that were created during the implementation phase. Outcomes reported included overall positive systemic changes for the majority of the model schools included in the project.

Finally, in the eighth article titled, "Evidence-Based Practice and the Consideration of Assistive Technology," George R. Peterson-Karlan and Howard P. Parette provide both a legislative and policy background for evidence-based practice (EBP). Issues related to AT research and the AT consideration process are explored. Of particular interest to researchers and developers of AT *and* practitioners who use findings of AT effectiveness are guidelines for both the development of research-based evidence of AT effectiveness, and guidelines for EBP as part of decision-making guidelines for AT consideration.

References

Parette, H. P., Peterson-Karlan, G. R., Smith, S. J., Gray, T., & Silver-Pacuilla, H. (2006). The state of assistive technology: Themes from an outcomes summit. *Assistive Technology Outcomes and Benefits, 3*, 15-33.

Research on AT Outcomes and Large Scale Assessments

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Abstract: Current educational policies require the participation of students with disabilities in state assessments. Their participation has raised a number of issues, among them the need for accommodations. In this article we consider the role that assistive technology (AT) can play to alleviate current accommodations demands, and highlight research and practice on assistive technology outcomes in large-scale assessments. The variability in states' accommodation policies, and the consideration of AT as accommodations, heightens the importance of attending to AT in state assessments. Examples of assistive technology in current state assessments, including Kentucky, Minnesota, and Oregon, are presented. Several current and emerging research activities in this area are highlighted as well. We conclude by suggesting outcomes and benefits, and identifying issues that remain to be addressed.

Key Words: Assessment, Accommodations, Constructs, Accessibility

Today students with disabilities are included in large-scale assessments – state and district tests of achievement – at a rate that probably would not have been thought possible a mere 15 years ago. For some time, these students were purposely excluded, sometimes out of an apparent concern about the stress of the experience of taking a test, but also out of a documented tendency for educators not to want to be held accountable for students they thought would perform poorly (Allington & McGill-Franzen, 1992). Exclusion rates were variable across states (McGrew, Thurlow, & Spiegel, 1993) and districts (Zlatos, 1994), with some states and districts having participation rates as high as 90% when others were below 10%. While most states had participation rates around 10% of students with disabilities in the early 1990s (Shriner, Spande, & Thurlow, 1994), the participation rates in the 2003-2004 school year averaged 97% at the elementary school level, 96% at the middle school level, and 90% at the high school level (Thurlow, Moen, & Altman, 2006)

The increase in participation rates has been due to three primary factors. First, two federal policies have contributed to increased participation of students with disabilities: the (a) Individuals with Disabilities Education Act of 1997 (IDEA '97) required that students with disabilities be included in regular statewide assessments, with accommodations as appropriate (and that those who could not be assessed with regular assessments be assessed through an alternate assessment); and (b) No Child Left Behind Act (NCLB) of 2001 added accountability to the participation requirements. The reauthorization of IDEA (Individuals with Disabilities Education Improvement Act of 2004; IDEIA) reinforced the alignment of IDEIA and NCLB (see Cortiella, 2006).

Second, many educators and policymakers are coming to the realization that the exclusion of students from assessments generally means that they are also left out of the benefits of access to standards-based educational systems. Without the push of the assessment evidence, the drive to focus on the content instruction often is missing. In the current context of quality assessments, content-related evidence is collected through alignment studies to establish links between the standards and test items. As states participate in peer reviews of their assessments and submit evidence of the technical adequacy of both their regular assessment and their alternate assessments, alignment evidence is increasingly being used to refocus the content of assessments. Clearly, students who are not part of an instructional program related to the content standards are at risk of performing poorly on the tests.

Third, the provision of accommodations has contributed to increased participation rates (Koenig & Bachman, 2004). Accommodations are changes in assessment materials or procedures that help ensure that assessments produce valid measures of a student's knowledge and skills. The range of accommodation options that are subjected to research and that are used in practice has increased dramatically during the past decade (Johnstone, Altman, Thurlow, & Thompson, 2006; Thompson, Blount, & Thurlow, 2002; Tindal & Fuchs, 1999; Zinesky & Sireci, 2007). In part, both changes in legislation and implementation have heightened awareness and increased attention to accommodations both in what they mean and in how they can be implemented. Assistive technology (AT) in large-scale assessments was identified as a major national issue at an AT Outcomes Summit in 2006 (Parette, Peterson-Karlan, Smith, Gray, Silver-Pacuilla, 2005). At this Summit, many individuals representing diverse constituencies conducted discussions to clarify the inherent issues related to the effects of AT on educational outcomes.

This article is a follow-up to discussions at the AT Outcomes Summit. We have considered the role that AT can play to alleviate the current accommodations demands, as well as the need for professional development and other implementation issues. Our purpose is to highlight research and practice on assistive technology outcomes in large-scale assessments. First, we review current accommodation policies on assistive technology on state assessments. Then, we present several examples of assistive technology in current state assessments, including Kentucky, Minnesota, and Oregon. Finally, we highlight several current and emerging research activities in this area – research by Jerry Tindal, Preston Lewis, and Cara Cahalan-Laitusis.

State Assessment Accommodation Policies

The National Center on Educational Outcomes has documented state assessment accommodation policies since the early 1990s (Clapper, Morse, Lazarus, Thompson, & Thurlow, 2005; Lazarus, Thurlow, Lail, Eisenbraun, & Kato, 2006; Thurlow, House, Boys, Scott, & Ysseldyke, 2000; Thurlow, Lazarus, Thompson, & Robey, 2002; Thurlow, Scott, & Ysseldyke, 1995; Thurlow, Seyfarth, Scott, & Ysseldyke, 1997; Thurlow, Ysseldyke, & Silverstein, 1993). While there initially was considerable confusion in the field about terminology, there is now general consensus about the need to ensure that the accommodation produces a valid score – one that does not violate the construct being measured. When there are questions about this, states begin to use other terms, such as "modification," "non- standard administration," and "non- allowed accommodation." These distinctions are not all that clear, however, and when we move into the realm of AT, they sometimes become more blurry than usual.

State accommodation policies have become much more complicated over time, with states reflecting the fine distinctions of whether an accommodation may violate the construct being assessed in one content area but not another content area. The complexity of policies has been reflected over time in a changing coding system for documenting the policies (Thurlow, 2007).

It is only recently that NCEO has begun to document AT in states' accommodation policies (Lazarus et al., 2006). To a large extent, this is because AT did not appear in the policies to any great extent until recently. It may be that the students who were using AT were excluded, or that the documentation of the technology was global in nature. While empirical results represent the gold standard, the rapidly changing field often cannot wait for these results, and policy is set based on strong rationale and reasoned judgments.

Assistive Technology Implementation in State Testing

Kentucky Implementation of Assistive Technology in State Testing

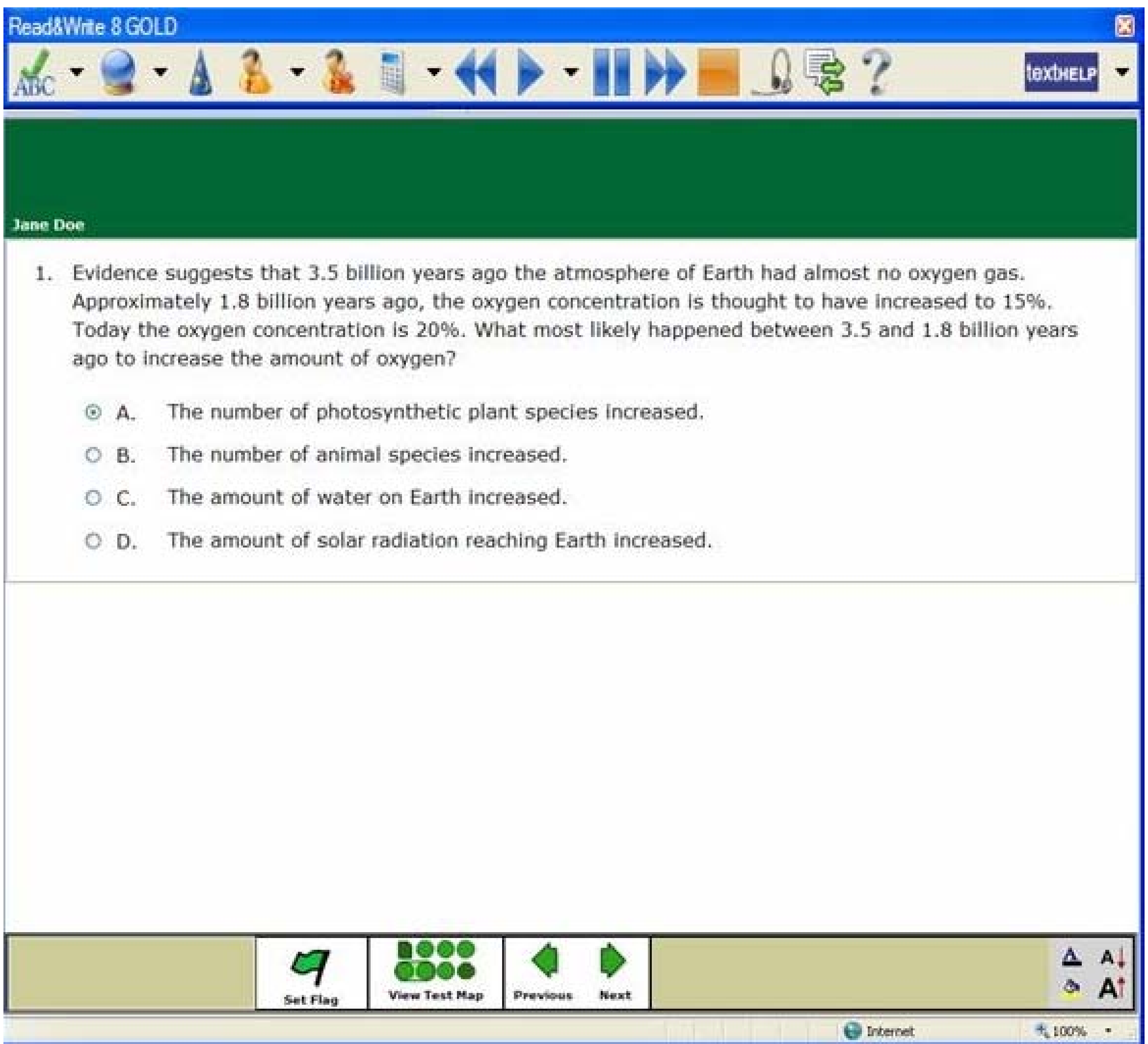
Like most states, Kentucky regulations require that accommodations used in state assessment be based on their ongoing use in the classroom setting: "Accommodations or modifications shall be part of the student's ongoing instructional program and not introduced for the first time during state-required Assessment" (703 KAR 5:070, §6(2). During the state-required assessment, a student with a disability or limited English proficiency may use special equipment, including assistive or adaptive technology described in the student's individualized education program (IEP), 504 Plan or Program Services Plan, which is part of the student's regular instructional routine [703 KAR 5:070, §6(B)]. Historically, AT was used during the state assessment to facilitate access to the print based or audio-taped version of the test (e.g., magnification, amplification, etc.) or to support a student's response (e.g., use of a communication device, word processor). Beginning in Spring of 2003, the use of AT was dramatically changed from primarily use with the paper or audio-taped version of the test, to use of AT to interact with and respond to an accessible electronic version of the test. This was known as Commonwealth Accountability Testing System (CATS) Online.

CATS Online is part of the overall Universal Design for Learning (UDL) initiative of the Kentucky Department of Education (KDE; Kentucky Department of Education, 2007). One of the factors that has accelerated use of AT in both instruction and assessment was the decision by the KDE in 2002 to enter into a volume purchase agreement with an AT vendor (i.e., Texthelp®, Inc.) for provision of text reader technology (i.e., Read & Write

Gold/RWG). This agreement included a 50% discount in the purchase price of RWG by the state education agency, local education agency, or parents. As a result, to date 1350 (95%) of Kentucky schools have acquired a site license for use of RWG. The site license approach has allowed for each school to install RWG on any computer in its respective school, enabling children to have access to the general curriculum given its availability and use both in special and general education settings,.

The infusion of RWG in the classroom accelerated interest in its being available as an accommodation for use with the state assessment, which led to the KDE administrative decision in 2003 to provide an accessible electronic version of the state assessment (i.e., CATS Online). The RWG

Figure 1. Student online view of a typical multiple choice science item, as presented in the 2007 Kentucky CATS Online Assessment. [Note: Sample item is from iTest system by Measured Progress, Inc. (http://www.measuredprogress.org/); Tool bar is from Read & Write GOLD by Texthelp®, Inc. (http://www.texthelp.com). This sample test item is from the 2007 assessment system, not the system described in this article, which is no longer available.]



site license purchase agreement also facilitated availability of the software for simultaneous use on multiple computers during state testing. Participation in CATS Online by students with disabilities has grown from use by 204 students from 29 schools in 2003, to use by 2,306 students from 200 schools in 2006 (Kentucky Department of Education, 2006). A sample test item from the 2007 assessment system is presented in Figure 1.

Important changes have been reported by students and teachers as a result of use of this technology during state assessment. The most frequent comment from students is the newfound independence afforded to students by use of their AT to read and re-read passages, questions and for response (CATS Online Post-Test Student Survey, Kentucky Department of Education, 2005). In post-test surveys, 84% of teachers stated that students were more engaged with the online assessment than with previous use of the paper version (CATS Online Post-Test Teacher Survey, Kentucky Department of Education, 2005). It is of interest to note that 91% of students surveyed said they thought they scored better by testing on computer using their AT. While more aggregated analysis of student results is needed to verify possible impact on student performance, there are instances reported by local school districts of improved results (Henry F. Moss Middle School, 2005; Lawrence, 2005).

Regardless of impact on performance, it is clear that use of this technology changes the way students approach participation in state assessment. As recently stated by one 10th grader, "I like being on the computer and not having someone read to me like a kid" (CATS Online Post-Test Survey, 2005). Given the proliferation of AT and increasing computer access, coupled with SEA efforts to implement the IDEIA 2004 requirements for implementation of universal design of assessment [§ 61216(E)] it seems not to be a matter of "if," but "when" all other states and districts will move into offering similar options for use of AT as an accommodation for

Three other states have piloted electronic accessible assessments. At the 2005 Council for Exceptional Children (CEC) Annual Convention and Expo, a poster session titled,

Table 1
Sample of State Accommodation Policies for Students with Disabilities – 2005

Response Accommodation	*N* States Allowed	*N* State Allowed with Restrictions	*N* States Prohibited
Proctor/Scribe	35	13	0
Tape Recorder	33	4	0
Computer/Machine	27	17	0
Sign Responses	26	4	0
Communication Device	24	4	0
Speech to Text	15	4	0
Spell Checker	13	16	2

Source: Adapted from: Lazarus, S. S., Thurlow, M. L., Lail, K. E., Eisenbraun, K. D., & Kato, K. (2006). *2005 state policies on assessment participation and accommodations for students with disabilities* (Synthesis Report 64). Minneapolis, MN: University of Minnesota, National Center on Educational Outcomes. Used with permission.

"Using Technology for Success in High States Testing for Students with Learning Disabilities," (Pokorni, 2005) presented state assessment efforts in Kentucky and Maryland. The effort in Maryland is based on use of a locally scanned version of the paper test in a few schools using TestTalker software.

In Massachusetts, approximately 249 students with disabilities in grades 3-12 took the Massachusetts Comprehensive Assessment System (MCAS) in 2006 using Kurzweil software to scan and read a paper version of the test (Dan Wiener, personal communication, April 26, 2007). Kansas has offered select grades and content areas online, and has included an option for student use of a built-in text-to-speech system (University of Kansas, 2007).

Except for the Kansas accessible assessment, a notable difference between the efforts of the states mentioned above and the Kentucky online model is that many of the current electronic offerings in other states are based on scanning a paper copy of the test. This is in contrast to CATS Online which consists of total re-creation of each individual question and response option in a single accessible screen. A major difference exists between copying an inaccessible paper design into electronic format and the full scale conversion of the test onto an accessible platform for student access. Students with disabilities have been noted to have difficulty with fundamental testing tasks such as selectively attending to test items when presented sequentially or in columns on a page, which is then often compounded by having to respond on a separate answer sheet. Using a scanned format of the paper version does not overcome these barriers. By having one item at a time on the screen for students to focus on and with navigation tools to move quickly back and forth between items, the CATS Online model is much more conducive to student use. Additionally, the ability to simply click on a radial button for electronic submission of a response overcomes the myriad of problems of finding and acting on the desired response on an answer sheet—a problem experienced by many students with perceptual and or motor difficulties.

Minnesota Implementation of Assistive Technology in State Testing

The use of AT in Minnesota large-scale assessments is an evolving practice. As the participation of students with a range of disabilities increases, so too does the need to broaden the understanding of what constitutes appropriate accommodations for the student's use during testing situations.

The Minnesota Department of Education has been aware of both the need to ensure students have appropriate access to accommodations and the need for the field to have timely information. The Department publishes an annual document providing technical assistance to the field (Minnesota Department of Education, 2007b). This document includes a chapter dedicated to accommodations in testing, and lists a range of supports that are allowable and the appropriate codes to document the type of accommodations used by the student. This document and a range of updates are available online (see Minnesota Department of Education, 2007a).

The discussion of what is "acceptable" is reviewed annually, through discussion between the Assessment office at the Department and the Special Education office. These conversations have occurred for the past 10 years. As a result of these conversations, the use of some accommodations previously determined not to be appropriate have now been included as acceptable. This evolution has occurred as the understanding of the demands of using certain accommodations has been clarified.

Figure 2. Lessons learned about making effective decisions about the use of AT.

1. Collaboration between Special Education and Assessment Divisions as well as with AT personnel, and if computers are used, technology/network personnel, is essential.
2. Discussions about what is “acceptable” need to occur annually (at a minimum) and need to be based on knowledge of testing, potential technologies, and disability.
3. Decisions are facilitated by demonstrations of AT so that the rigor involved in use of AT is evident.
4. It is important to discuss and make clear the conditions placed on the use of AT for assessment.
5. The use of AT may not make testing tasks easier, but it may allow for performance of the task, and thus a more valid representation of the student’s knowledge and skills.

Voice recognition is one technology that was viewed as providing an additional advantage to students in testing situations. This view was changed after a demonstration of the rigor required in the use of the technology.

The use of portable notetakers such as a Neo™ or the Writer™ is also now allowable, as are spellcheckers or word prediction programs if these are accommodations used by a student and included in the IEP as necessary during assessment. Scribes are an allowable accommodation, as are the use of visual templates, large print, Braille or the use of tape recorders to dictate answers. Some tools are allowable for all students, including the use of an abacus or calculators for parts of the math test that do not specifically limit their use (such as estimation).

We have learned that collaboration between the Special Education Division and the Assessment Division is essential in making effective decisions regarding the use of AT in large-scale assessment. A priority for staff in the Special Education Division is to stay aware of changes inherent in the use of AT (Joan Breslin-Larson, personal communication, May 13, 2007). Test developers are generally not aware of the range of AT devices available or that use of a particular technology is not intuitive and will not necessarily provide additional benefit to a student with a significant disability. Presented in Figure 2 are lessons we have learned related to effective decision-making about AT usage.

The use of AT may not make testing tasks easier, but it may allow for performance of the task, and thus a more valid representation of the student’s knowledge and skills.

The Minnesota Department of Education has identified that IEP teams need to make data based decisions in choosing accommodations used in large-scale assessments, including the IEP team considering what technologies a student currently has use of in completion of class work and what challenges might exist in a testing situation. The Department has undertaken a General Supervision Enhancement Grant (Minnesota Department of Education, 2007 Grant No. H326X060008) to determine several points, including whether there is symmetry between student classroom accommodations, including AT, as documented in the IEP and the documentation of AT and other accommodations for large scale assessments.

The Department will remain vigilant in monitoring what technologies are available, what students use in their daily education, and what is important to effectively measure what students know and can demonstrate.

Oregon Computer-Assisted Statewide Testing Program

In Oregon, a computer-assisted test (CAT) is used to present and score reading and mathematics tests. Unlike simply delivering an item to students using a computer (referred to as computer-based testing), a CAT presents items to students using the student's performance levels to dynamically adjust the difficulty level of each successive item. For example, if an item is answered incorrectly, then the next item being presented is easier; in contrast, if an item is answered correctly the next item presented is more difficult. With each item presentation, the reliability of any estimates of the student's performance is calculated; when a specified level of reliability is reached, no new items are presented and the testing session is complete.

This type of testing is considered optimal in that items viewed as most appropriate for the student are used instead of difficult items where the performance levels of the student are low. With item-response theory (IRT; Wikipedia, 2007), where the difficulty levels of items are defined, this type of testing is quite easy to implement. The use of computers to adjust difficulty levels is a form of AT according to Tindal and Crawford (2005). This type of assessment is not possible without a computer, which provides for a dynamic algorithm that adjusts item difficulty according to student ability (or skill proficiency).

Many believe that CAT makes great sense for students with disabilities, even though it may not be accepted for current NCLB assessments. Once a computer becomes the mechanism for delivering a test, regardless of whether CAT is used or not, a number of substantive accommodations also become possible. These accommodations can be grouped into those commonly described in the literature: time, setting, presentation, and response. Of course, some of these accommodations are immediately available while others are likely to be developed in the very near future, especially given the rapid rate of change in technology.

The Oregon statewide testing program is described here as an example of what can be accomplished with computer-based and computer-assisted testing. This is not an exhaustive description of what is being done in Oregon.

Obviously, the way in which *time* is manipulated can be varied on a number of dimensions. First, the test session can be completely flexible with group administration. Rather than having students either given too much time or not enough time, it is possible to individualize time more flexibly (of course, this assumes a computer is available for the student to use). Nevertheless, group administration need not force strict equality in the amount of time and scheduling of that time. For example, it would be possible to begin a testing session in a lab but when the allotted time is used in which most students are done, all students can continue with other school activities with a subset of students needing more time taking the test in another session in their classroom or returning to the computer lab.

Settings are only as flexible as the computer configurations in the building and may vary from computers on wheels to fixed computer labs. In adjusting the setting, students can begin in one setting and then move to another. With a test presented at a URL, access is completely open and the only issues that need to be addressed are those about the standardization of administration. For students needing more quiet or separate places to complete the test, any location with a computer can be selected.

A number of *presentation* accommodations can be used with CBT and CAT. For example, in mathematics, a number of read aloud accommodations are possible. In previous research (Tindal & Ketterlin-Geller, 2004), students have taken the test with headphones and had the opportunity to hear problems and answer options being read. In this research, the read aloud was done with human readers though increasingly sophisticated computer-generated reading is now possible. Dynamic magnification is possible with a computer-based test administration. Web sites can be adjusted to allow text to be expanded both incrementally as well as nearly infinitely (from a mere 2-point increase to a 48-point increase). Obviously, this magnification may create other problems just as it does with paper and pencil testing. For example, while a paper-pencil version would require more pages, the computer version would require more scrolling. Both, in turn are likely to require more time. Finally, any number of 'page layout' options are possible to make dynamically with the following representing a few of the possibilities: (a) the size of the screen; (b) the number of items presented on the screen; (c) the use of horizontal versus vertical juxtaposition of prompts and passages; and (d) supports available (e.g., highlighting tools, erasers, separate screens to take notes) that may be built into the computer. Importantly, all of these changes can be accessed on a 'need to use' basis with individual items rather than a 'have to use' basis with the entire test.

In summary, computer-based and computer-assisted tests are uniquely situated to serve as an excellent host environment for allowing accommodations to be used in a flexible and responsive manner. Both students and teachers can benefit by making these adjustments for individuals and individual items, useful only when they are needed.

Implementation of TextHelp Systems in State Testing

Read&Write GOLD, from Texthelp® Systems, is an award-winning literacy productivity tool designed to help struggling students by allowing them to access curriculum content on a computer and complete reading, writing and research assignments as well as tests independently. Read&Write GOLD levels the playing field for all students, including those with learning difficulties, dyslexia, and English Language Learners. The program allows students with low reading and writing proficiency to work on their own alongside their peers in the classroom.

The product provides a unique approach to AT since Read&Write GOLD is an easy-to-use toolbar that floats on top of any mainstream Windows® application so that documents and tests do not have to be transferred into any other format or scanned into another application. The many features of Read&Write GOLD include: (a) dual highlighting as text is read aloud using natural sounding voices, (b) spell checker, (c) dictionary, (d) calculator, (e) word prediction, (f) internet research tools, (g) Spanish translator, (h) MP3 file creator, and (i) scanning. Texthelp® is continuously adding and refining the features and tools in the product to take advantage of the latest technology innovations and to meet the ever increasing need for solutions for individuals with literacy difficulties.

Read&Write GOLD allows students to complete required testing with the same questions and using the same format as all other students. Texthelp® Systems provides security for the tests online to ensure the integrity of the testing. Read&Write GOLD has been an important support to students not only during testing time but also during their regular classes. For teachers, this addresses the mandate to test in the same manner as one teaches.

The use of Read&Write GOLD is increasing across the country. The Columbus, Ohio, Public Schools secured a license for every school in the district. TextHelp® Systems has provided training for the district so that the use of the software is implemented for the students in a manner to ensure understanding and continued use. It has been found that the use of Read&Write GOLD by non-diagnosed learners (i.e., typical students who independently use the tool) is increasing as users become aware of its advantages.

Over 170 schools in Toronto, Ontario, have been using Read&Write GOLD for the past six years. Steady student progress has been measured since its implementation, and the district has continued to upgrade as the software has improved and strengthened. The state of Minnesota selected Read&Write GOLD for all the pilot schools in its Universal Design for Learning activities (Joan Breslin-Larson, personal communication, May 13, 2007). Conversations with personnel from the Missouri Department of Elementary and Secondary Education have also been initiated regarding the use of Read&Write GOLD in targeted schools (David Baker, personal communication June 7, 2007).

As the use and acceptance of assistive technology matures and similar products come onto the market, Read&Write GOLD is being selected, used, and often required in schools across the country. While there is not yet evidence of the number of students using Read&Write GOLD during statewide assessments, or even of the number of states that specifically allow its use, it is likely that with its increased its instructional use, there will be a corresponding increased use in assessment.

Research on AT and Outcomes

Technology Assisted Reading Assessment

Educational Testing Service (ETS), a non-profit educational measurement organization has long been a leader in standardized large scale assessments. Over the last 25 years ETS researchers have examined the impact of testing accommodations, computer-based testing, and disability-related access on the validity of test scores used for college and graduate school admissions. These projects have included the prototype development and evaluation of a self-voiced test for blind test takers (Hansen, Forer, & Lee, 2004; Hansen, Lee, & Forer, 2002); the comparability of paper and computer-based tests (Gallagher, Bridgeman, & Cahalan, 2002); and the evaluation of psychometric properties of Braille and large print test forms (Bennett, Rock, & Novatkoski, 1989). More recently researchers have begun to focus on improving large scale K12 assessments for students with disabilities and developing assessments specifically for students with disabilities.

In 2006, ETS received a grant from the U.S. Department of Education's National Center for Special Education Research (NCSER) to develop a prototype assessment of Technology Assisted Reading Assessment (TARA) and research the psychometric properties of state K-12 assessments for students who are blind or visually impaired. The preliminary results from the psychometric research indicated that both the Braille and large-print test forms were comparable to the standard test form in terms of relative item difficulty, but that some types of test questions were more likely to change the item difficulty. For example, test questions associated with traditional reading passages (e.g., textbook excerpts, drafts of student papers, letters) were less likely to change in item difficulty between test forms, and test questions based on unique passages (e.g., advertisements. instructional manuals) were more likely to be relatively more difficult for students who took a large print or Braille test form. These results may be due to factors outside of the tests characteristics, such as the curriculum sequence followed by teachers of the visually impaired, access to different instructional materials, or opportunity to learn but can be used to inform both test development and instruction. For additional information on this study see Stone, Cook, Laitusis, and Cline (2007).

In addition to psychometric research another primary purpose of the TARA project is to develop a prototype Technology Assisted Reading AssessmentTM. The purpose of the Technology Assisted Reading AssessmentTM is to measure a student's ability to independently access text using AT (e.g., screen readers, refreshable Braille display, screen magnification) and serve as one part of a modified assessment of reading for the accountability requirements of NCLB. The TARA will be an on-demand performance assessment which requires the student to complete a series of tasks from basic (e.g., open an electronic textbook) to advanced (e.g., scan a printed document and open it or navigate to a particular portion of a document using a screen reader). It is anticipated that student performance will be scored based on both relative speed and accuracy (see www.ets.org/TARA). In preparation for development of this assessment the National Center for Education Outcomes (NCEO) is conducting a survey of AT users (in grades 7 through 9) and their teachers. The results of this survey will serve to inform a test blueprint that will define the construct to be measured (technology assisted reading) and the knowledge, skills, and abilities (KSA) that will be assessed directly. Information on the survey results and progress of the TARA project are available on the project website (see www.ETS.org/TARA).

Accommodation Station

The accommodation station (AS) was developed from two Office of Special Education Program grants (H327A020043 and H324D020015). This web-based assessment system was designed to provide teachers and IEP teams with more objective data to use in making accommodation recommendations. The software in the system includes a number of assessments of students' reading and mathematics skills, a number of survey questions about teacher and student perceptions and perspectives, and a comparison between the use of accommodations and the lack of their use. After students and teachers input their responses, a report is generated that should allow teacher teams to make informed decisions about accommodations. In the initial software, students were assessed on their skills in reading sentences and answering comprehension questions, their silent reading fluency, and their skill in filling in missing words of sentences, as well as mathematics skills. Other useful academic skills can also be entered. Teachers from both general and special education, as well as the parents of students, can address perceptions of abilities, experiences with accommodations, proficiencies, and the proposed utility of accommodations in the decision-making process. Finally, a comparison can be made between pre-trial attempts with accommodations and those attempts made without accommodations to help in making decisions.

Outcomes and Benefits

Use of AT to support student participation in large-scale assessment begins to change the traditional view of AT as an individualized treatment (Rose, Hasselbring, & Zabala, 2004) to the much broader area often reserved for more mainstream instructional technology (IT). Although AT may have been individually prescribed in a student's IEP, once it is to be used for participation in large-scale assessment, a whole series of issues arise that must be addressed systemically well beyond the special education community (see Figure 5).

A fundamental issue is that AT has typically

Figure 5. Issues to address about AT in large-scale assessments.

1. AT needs to be understood by others beside special education personnel; this includes general education practitioners, assessment personnel, and test developers, at a minimum.

2. Partnerships of general education and special education professionals, as well as information technology and network professionals, are essential to address a variety of challenges (networks, firewalls, security, etc.).

3. Various AT software used locally needs to be checked for compatibility with any computerized test that is developed.

4. Simultaneous testing of students online requires multiple copies of AT software, thus requiring exploration of volume purchases or school/district site licenses.

5. The accessibility of the computerized test will need to be addressed so that AT tools work.

6. The use of assistive technologies will need to be considered by test developers because these technologies will have an impact on typical security systems or test delivery methods.

7. Determining how to go about implementation is important; one strategy is to plan big, but start small (phase in by grades, areas of the state, etc.).

8. Identify the minimum hardware specifications required for local online testing (i.e., speed and capacity).

9. Help desk supports that are provided during live testing must be trained, plentiful, and readily available.

10. Online test design needs to include mode for electronic capture and scoring of student responses.

remained primarily in the realm of special education, with a special education teacher or AT specialist the main players facilitating its use. When AT moves into the realm of application during large-scale assessment, a host of new school and district staff have to come to the table to understand its use and integration, especially if it is to be used to support computerized delivery of the assessment. Previously there may have been a tendency by those outside of special education to view themselves as not being responsible for the use of AT; however, AT now becomes embedded within the larger systemic responsibility inherent to administration of accountability assessment.

An array of general education personnel who may have no previous experience with AT design or purpose will need to understand the uniqueness of AT usage. This can include district or school instructional technology personnel, tech support staff, school and district assessment coordinators, school administrators and possibly even the vendors who are involved in state or local delivery of the assessment. While such collaboration between special and general education professional for AT use may have been desired or sought all along, such partnerships are essential if AT is to be used during large-scale assessment. For instance, the tech support staff will want to know how it integrates within the school or district network. There may for example be security issues that arise with the AT and network integration, such as local firewalls that may impede such software or hardware being used.

A major issue is taking AT from individual use to the larger scale required for simultaneous use by multiple students, which raises issues of access to sufficient number of copies of AT software and related cost factors. AT sources and products used are often diverse, even within the same school or class, which means a range of types of AT will need to be tested for local compatibility with the many and varied hardware stations that often need to be employed when all students are expected to be taking the test at the same time. There is also the issue of tech support for AT during state assessment, which may have typically been relegated to one AT specialist, but when being used by multiple students simultaneously to take the state test, then each student must have immediate access to informed support. In these instances, the test cannot be put aside to wait until someone who is knowledgeable has time to visit the school.

If AT is to be used to support student participation in computerized assessment, then a unique set of issues emerge regarding the interaction of the AT with the assessment. While foremost is the need for the assessment to be available in digital format, accessibility of that format is also paramount. For example, if a text reader is to be used, then the test must be made accessible for text selection using a mouse to allow computerized reading. Most computerized assessments are "locked" by design to prevent such access for security reasons. A balance needs to be maintained between the requirements of test security and accessibility of content for interaction with AT tools. Student response is also of concern since there may be AT software tools that need to be selectively disabled during testing such as word prediction, talking dictionaries or spell check programs.

Identifying and planning for how to deal with the extensive number of issues related to AT use during large-scale assessment entails considerable time and communication across many parties. This may require a phased implementation approach, which could include small scale demonstrations. The gradual introduction of AT may be at certain grades or content areas, with initial participation being voluntary. Time is allowed then for the staff training and facility preparation that will enhance the chances of success during live test administration. If a problem occurs, then having it happen during a smaller, pilot administration where security, time, scoring and student or school accountability are not at risk is better. It will also be imperative to have alternative delivery systems for the test available, so that students who use assistive technologies will not be inadvertently excluded from participation in testing due to technology incompatibility or test parameters that do not allow for use of technology.

While a main benefit of AT use during large-scale assessment may be the removal of unintended test constructs (e.g., decoding, vocabulary, word recognition, etc.) unrelated to what is being measured (Dolan, Hall, Banerjee, Chun, & Strangman, 2005), an incidental benefit is the increased understanding and familiarity across the school and district both with the technology and the students who use it, not just for purposes of assessment, but also for ongoing instructional support during daily routines. It has been documented that school administrators and school policies can either facilitate or inhibit the acquisition and or use of technology by students with mild disabilities (Goldman, Semmel, Cosden, Gerber & Semmel, 1987; Higgins & Zvi, 1995; Okolo, Rieth, & Bahr, 1989). The increased use of AT an accommodation during large-scale assessment can serve to bolster administrative understanding and increase support of AT use not only for assessment but also for instruction. This is important to changing the historical view of AT being primarily for individuals with moderate or severe disabilities and overcoming reluctance of school administrators to provide AT for students with mild disabilities (Edyburn, 2005).

When AT usage is connected to student performance on large-scale assessment, interest in its nature and use becomes escalated to an administrative level heretofore not experienced by special education professionals or the students. Although its previous use in accordance with an IEP may have generated little concern outside of the special education setting, the application of AT during large-scale computerized assessment raises attention and interest across school and district staff.

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The Effectiveness of Using a Pocket PC as a Video Modeling and Feedback Device for Individuals with Developmental Disabilities in Vocational Settings

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Abstract: This study evaluated the effectiveness of using a pocket PC to teach two adolescents with mild and moderate cognitive impairments vocational tasks in competitive, community-based settings. Participants were taught three different tasks in their respective work sites through video rehearsal and video feedback strategies. Video files were presented on a pocket PC prior to task engagement and following repeated errors (video feedback). Effectiveness of the video-based strategies and the utility of the handheld device were evaluated using a multiple probe design across tasks and participants. Outcomes of the study indicate that the introduction of the video-based procedures was associated with significant increases in independent responding and participants met criterion on all three tasks within 3-7 sessions (M=5 sessions). Although there were large changes in the level of data once the video-based materials were presented, outcomes are somewhat tempered by the fact that some of the baselines for each participant were slightly ascending prior to the introduction of the independent variable.

Keywords: Video technology, Handheld computers, Developmental disabilities, Vocational training

Vocational programming and support for individuals with developmental disabilities in competitive employment settings has received much attention in the last two decades (Lancioni, O'Reilly, Speedhouse, Furniss, & Cunha, 2000). The goal of vocational programming is to assist individuals with performing their job-related tasks as independently as possible so that they can have the means to support themselves in order to lead productive and self-sufficient lives. Fortunately, there has been a shift away from the assumption that individuals with developmental disabilities will work in sheltered employment settings and more attention and effort has been placed on supporting individuals in community-based vocational settings (Davies, Stock, & Wehmeyer, 2002a). As a result, much of the latest research relating to vocational programming has focused on strategies for increasing independence in job-related tasks. Because there has been a shift from sheltered to community-based settings, it is increasingly important to utilize self-management strategies that will promote task completion while reducing reliance on outside staff or job coaches (Agran, 1997).

To promote independent work-related behaviors and to decrease reliance on staff, several researchers have investigated the effectiveness of using supports and prompts such as picture cards and/or booklets, auditory prompts delivered electronic devices, and visual and auditory prompts delivered on handheld devices to promote self-directed work behaviors.

Several researchers have investigated the use of pictures to encourage self-directed task initiation and completion (Cihak, Alberto, Kessler, & Taber, 2004; Copeland & Hughes, 2000; Fisher, 1984; Martin, Mithaug, & Burger, 1990; Martin, Mithaug, & Frazier, 1992; Wacker & Berg, 1983). For example, Copeland and Hughes used a two-part picture prompt strategy to teach two high school students with severe disabilities to complete work-related skills (i.e., cleaning faculty dining room tables and sweeping; cleaning windows and a mirror in hallways of a hotel). The picture prompt strategy involved teaching participants to touch a picture to initiate a task and then turn a page in a booklet to indicate task completion. Results indicated that once participants acquired the picture prompt strategy, their independent task initiations (associated with picture touching) increased; however, task completion (which was associated with page turning) increased for only one of the participants. In a similar study, Wacker and Berg used a combination of demonstration, error correction, and praise to teach five individuals with moderate to severe disabilities to turn pages in a picture booklet to put together pieces of two different vocational assembly units (i.e., a black valve and circuit board). Once participants acquired the skills, the investigators withdrew all training components except the picture cues and found that the participants generalized their picture cue usage to two additional assembly tasks.

While picture prompts have been effective for prompting independent responding, others have turned to technology using auditory prompting devices to support individuals in employment settings. For example, Taber, Alberto, and Frederick (1998) used a self-operated auditory prompting device to teach 5 students with moderate disabilities to independently transition from completed vocational tasks to other vocational tasks. They compared single- and multiple-word recordings, and although there were no differences between the two types of recordings, both types of auditory prompts resulted in a significant increase in the number of independent task changes made by participants. In addition, the results generalized to other settings without additional training.

Recently, many researchers have combined both visual and auditory prompting systems (i.e., photos and auditory cues) delivered on handheld devices to investigate their utility in promoting independent responding among individuals with developmental disabilities in vocational settings (Davies, Stock, & Wehmeyer, 2002a; Lancioni, O'Reilly, Seedhouse, Furniss, & Cuhna, 2000; Riffel et al., 2005). Davies et al. conducted a pilot study to evaluate the effectiveness of a software program called the Visual Assistant (VA), which was loaded on a palm-top computer. The VA presented step-by-step pictures of task sequences along with audio instructions on the computer to prompt responses. Ten individuals with intellectual impairments participated in the study and were taught two vocational tasks that included a pizza box assembly task and a software-packaging task. Participants received training with the VA and were then given a verbal overview of the tasks as well as demonstrations prior to task engagement. They were then asked to perform each task twice, once with the VA and once without. Results indicated improved accuracy and task independence when participants used the VA as opposed to when they did not. Riffel et al. extended the research on the use of the VA by teaching instructors to use the device to assist four students with mild to moderate intellectual disabilities to perform tasks such as table setting, rolling silverware, and laundry tasks. Results indicated that students increased the percentage of steps completed independently while also reducing prompts from instructors when the VA was used. In addition, participants appeared to prefer the device over instructor assistance as they increasingly self-selected the VA to assist them in completing the task rather than requesting assistance from teachers.

Similarly, Lancioni et al. (2000) conducted two studies that also investigated the effectiveness of using a palm-based computer system for teaching vocational tasks to individuals with severe developmental disabilities. In the first experiment, the authors compared the effectiveness of a palm-top computer that presented line drawings (in conjunction with a special auditory device or vibratory mechanism placed under participants' belts) with a card system that was a booklet containing 25-31 pictures of the steps required in the skill sequences. Six adults participated and were taught different sets of tasks that involved cleaning and food preparation. Results indicated that participants not only had higher percentages of correct responding with the computer system, but also preferred it to the card system. Three of the participants who had acquired a high degree of correct responding in the first study also participated in the second study. In the second study, the researchers taught the same tasks as in study one and presented all stimulus materials using the computer-based system, but compared variations of how the pictures were presented (i.e., the stimulus materials were altered somewhat so that the participants would not have to return to the computer as often during task engagement). Results indicated that clustered presentations were more effective in maintaining correct task performance and participants required less prompting, or instructional opportunities, delivered from the device.

In essence, it appears that handheld computers, when used as prompting systems, are effective for promoting correct independent responding among individuals with moderate to severe disabilities. In addition, handheld devices appear to be effective at reducing external prompting from staff during task engagement and have also been used to encourage time management and scheduling among individuals with mental retardation (Davies, Stock, & Wehmeyer, 2002b) as well as initiation and completion of daily tasks among individuals with ADHD (Epstein, Willis, Conners, & Johnson, 2001). Handhelds are also desirable because they are portable, relatively inexpensive, and used frequently among individuals without disabilities, which makes their use socially acceptable. Although handheld devices appear to be useful for instructing individuals with disabilities, research to date has focused primarily on the presentation of photos, auditory prompts, and cueing systems (vibration or alarms) with these devices. To our knowledge, there has not been any research conducted on the use of video-based materials presented on handheld devices to teach skills to persons with disabilities.

Video technology is emerging as an effective medium for teaching life skills to individuals with developmental disabilities. For example, it has been used to teach complex skills such as purchasing items (Cihak, Alberto, Kessler, Taber-Doughty, & Gama, 2006), vocational tasks (Martin et al., 1992; Morgan & Salzberg, 1992), community skills (Alberto, Cihak, & Gama, 2005; Branham, Collins, Schuster, & Kleinert, 1999), grocery shopping (Ayres & Langone, 2002; Mechling, 2004; Mechling & Gast, 2003), social skills (Goldsworthy, Barab, & Goldsworthy, 2000; Nikopoulos & Keenan, 2004; Simpson, Langone, & Ayres, 2004), and daily living/domestic skills (Bidwell & Rehfeldt, 2004; Graves, Collins, Schuster, & Kleinert, 2005; Lasater & Brady, 1995; Norman, Collins, & Schuster, 2001; Rehfeldt, Dahman, Young, Cherry, & Davis, 2003; Shipley-Benamou, Lutzker, & Taubman, 2002; Sigafoos et al., 2005; Van Laarhoven & Van Laarhoven-Myers, 2006).

Research that has been conducted on the use of video technology within the vocational domain has had mixed results. For example, Morgan and Salzberg (1992) used video-assisted instruction to teach employment-related problem-solving skills to adults with disabilities. They showed participants videos of positive and negative examples and asked a series of questions to provide discrimination training prior to assessing participants in actual work settings. Results indicated that effects did not generalize until behavioral rehearsal was introduced for 2 of the 3 participants. Martin, Mithaug, & Burger (1992) compared several different instructional strategies for teaching assembly skills to secondary students with moderate disabilities in an unused classroom. These strategies included: (a) photographs (a photo of completed piece of furniture); (b) sequenced pictures (comprised of line drawings); (c) sequenced pictures plus modeling (same as previous, only the experimenters also modeled how to perform assembly); (d) picture referencing (used in conjuction with sequenced pictures, the experimenter also pointed back to picture when student made an error or no response); (e) video modeling (participant was shown video clip of step prior to performing step; also called video prompting); and (f) video referencing (used in conjunction with previous, only video clip was played again following errors or no response; also called video feedback) The researchers found picture referencing to be more effective than video modeling and video referencing. However, video referencing (e.g., video feedback) was almost as effective as picture referencing, and video modeling became more robust as students had exposure to it.

To our knowledge, there has not been any research done investigating the utility of using a handheld device to present video-based materials to promote independent responding among individuals with mild to moderate disabilities. The purpose of this research was to determine if video modeling and video feedback, when presented on a portable handheld device, would increase independent responding of two individuals who were employed in community-based environments. The current study extends available research in a couple of ways. First, this study differs from the others in that it evaluated the effectiveness of using video-based instructional materials presented on a handheld device, whereas prior research using this technology evaluated the effectiveness of using picture-based materials. Second, a feedback component was also used to provide error correction. And third, the research was conducted in community-based settings with non-disabled coworkers.

For the purposes of this paper, the video modeling/rehearsal component will be referred to as video rehearsal and will refer to the entire video sequence being presented prior to task engagement. The video feedback component will refer to having the participant view a video clip (displaying correct performance) following errors that occurred during task engagement.

The instructional methods that were compared are built on existing research that demonstrates the success of video modeling and video feedback while employing the latest technology and theory of computer-assisted instruction.

Method

Participant Selection

Participants were recruited from high school programs located in the suburbs of Chicago. To recruit, a description of the study was e-mailed to teachers in several school districts. Of those who responded, a follow-up questionnaire was sent to:(a) identify students who were in the process of obtaining new jobs in community environments, (b) obtain personal information for the participant to obtain informed consent and assent, and (c) obtain information regarding potential job sites in order to request permission from the employers to conduct research in their establishments. Participants were then selected from the pool of respondents based on the criteria listed above.

Participants

Two young men with mild and moderate cognitive impairments, who attended public school programs, participated in the study. Both were recently hired at two different restaurants in the community and neither had any prior exposure to their assigned tasks.

Devon was an 18-year-old student enrolled in a large suburban high school where his educational goals were met through inclusive programming and practices. His full scale score on the Wechsler Abbreviated Scale of Intelligence (WASI; Psychological Corporation, 1999) was 78 and he had a diagnosis of Asperger's syndrome. Much of his coursework was taught at the basic fundamental level by general education teachers, coupled with the assistance and support of special education teachers and/or special education teaching assistants. He had been enrolled in a basic skill computer class and was fairly adept at utilizing a PC computer for basic word processing, PowerPoint™, internet searches, and email activities. Devon also received speech therapy, occupational therapy and adaptive physical education services. He demonstrated a significant "aversion" to any type of job or employment opportunity and initially refused to participate in any capacity. After one year of career counseling, he agreed to "sampling" job tasks for periods extending no longer than 45 minutes per week. Some of these experiences involved light office duties and some food preparation. With some coaxing, he agreed to increase his work hours to eight hours per week and was hired at Red Robin, a large restaurant chain where the study took place. He seemed very motivated to keep this particular job and engaged in frequent discussions regarding his attitude and what types of dispositions were important for employees to possess. His primary job responsibilities involved sorting and sanitizing silverware and rolling silverware.

Marcus was an 18-year-old student enrolled in an inclusive high school. Most of his instructional programming, however, was conducted in a self-contained, life skills classroom taught by special education teachers. He had Down syndrome and his full scale IQ score on the Wechsler Adult Intelligence Scale – 3rd Edition (WAIS-III; Wechsler, 1997) was 47. Marcus required extensive prompting to complete most tasks and was highly cue dependent. Just before he entered the high school environment, he experienced some type of social/emotional setback and was unable to complete academic and work tasks to the degree that he had previously performed them. He also demonstrated a great drop in receptive and expressive communication, social participation, and moving throughout his environment without direction. Previously, Marcus received instruction accessing PC computers for the purposes of word processing, PowerPoint™, and basic email. He could complete basic tasks with visual and/or verbal prompts. His previous work experience involved light custodial and some office work. He was hired at Applebee's, another large restaurant chain, for nine hours per week and this is where baseline and instructional sessions took place. His primary duties involved portioning food for various recipes and cleaning and sanitizing his workspace.

Setting

Baseline and instructional sessions were conducted in the participants' employment settings; Devon was at Red Robin, and Marcus was at Applebee's. Devon worked primarily in an area off the kitchen at Red Robin and was scheduled to work on Friday and Saturday evenings for four-hour shifts. This area could be described as an open area or large hallway that was near the refrigerator and back exit. Most of his tasks were completed at a tall stainless steel rolling table (e.g., rolling and sorting silverware, and sanitizing the rolling table), however, he also had to go to the front of the restaurant to replace completed silverware rolls and to clock in and out. Other aspects of his job required him to also go to the dishwashing area to sanitize sorted silverware or to obtain trays of rinsed silverware that needed to be sorted. This setting was often quite busy, i.e., loud music was in the background and coworkers were rushing around while engaged in work activities. Staff members were very outgoing and friendly and the managerial employees were very supportive and always encouraged him to be part of the team.

Marcus worked in an area behind the kitchen at Applebee's. He was scheduled to work three mornings a week before they opened for lunch and his primary responsibilities involved portioning food for various recipes and cleaning and sanitizing his work area. Most of his tasks were completed while standing at a tall stainless steel counter. He also had to place trays of portioned food in the walk-in refrigerator, bring empty vegetable bins to the dishwashing area, get ice cubes from an ice machine in the kitchen, and clock in and out at the front of the restaurant. Staff members at Applebee's were very supportive of Marcus. They adapted recipe sheets for him, had an assistant kitchen supervisor assigned to train and assist him, and often set up his station before he arrived.

Tasks

Devon had three tasks that were targeted for instruction. These included: (a) rolling silverware, (b) sorting and sanitizing silverware, and (c) clocking in and out. Marcus also had three tasks targeted for instruction including: (a) portioning recipes (i.e., 4 oz house salads, 8 oz salads, 8 oz stir fry veggies, & 5 oz side veggies); (b) clocking in and out; and (c) cleaning and sanitizing his work space. Task analyses of each task are available from the first author.

Instructional Materials

An HP iPAQ hq2700 series Pocket PC™ (that operated with the Microsoft Pocket PC 2003, 2nd edition software™) was used as the prompting device. Videos were taped in each participants' vocational site and were comprised of a combination of "self" models (the participant performing the task), and "other" models (both male and female adults that were either one of the first two authors or another employee). Videos were edited using Pinnacle Studio 8™ (Pinnacle Systems, 2002) and each task was edited to show the entire sequence from start to finish (e.g., clocking in sequence). Video segments were comprised of a combination of wide angle (full view of the model in context) and zoom shots (showing the hands of the model). A photo of the most salient feature of the sequence (e.g., sliding employee card in computer) was "grabbed" out of the video and placed at the beginning of each video segment and voice over narration was added to highlight critical components of the task. Prior to videotaping each task, task analyses were written to ensure that all of the steps would be represented in the video model. Each step in the task sequence was videotaped and then all of the steps in the sequence were combined together through the use of transition "swipes" to create a step-by-step video of the task. Once the video sequences were edited and rendered, they were then compressed to Windows Media Video (.wmv) file formats using the free download of Easy AVI/VCD/DVD/MPEG Converter™, version 1.1.8 software (8864soft.com, 2005). This was necessary, or the videos would not play on the Pocket PC.

Once the videos were compressed, each sequence was then placed on a presentation slide using Pocket Slides™, version 4.0.100.1190 presentation software (Conduits Technologies, Inc., 2005). This presentation software was used to make it easier for the participants to select the correct video that corresponded with the tasks they were to perform at work. The slides also had text above the pictures to describe the content of the video file (e.g., rolling silverware).

Unfortunately, we were unable to find presentation software that would allow for videos to be embedded within the slideshows. Unlike PowerPoint™, which can embed videos within the presentation, the software for handheld devices at the time the study was conducted did not have the capabilities to do so. In order to view the videos, the software had to open Windows Media Player™, and then that had to be closed to return to the slideshow. Originally, we intended to use video prompting to present clusters of steps (two to three steps) within the skill sequence; however, that would have involved frequent opening and closing of the media player, thereby making it more difficult to use. We felt that it would be easier to use the device for presenting full sequences of the task prior to task engagement (video rehearsal) and also chose to use video rehearsal strategies due to the nature of the tasks that were being performed. The participants needed the use of their hands for most aspects of their tasks.

In addition to the video-based materials, additional visual supports were provided to assist Marcus with using the scale to portion food recipes. These support included small, color-coded Post-It® flags that were placed on the correct number of ounces needed for each recipe on Marcus' scale. The Post-It® flags were added beginning on session seven. This was done to highlight the correct number on the scale and to assist him with lining up the arrow within the acceptable "range" of ounces needed (rather than aligning the arrow exactly on the number on the scale).

Design

A multiple probe design across tasks was used to evaluate the effectiveness of the video-based procedures on independent responding and percentage of prompts and was replicated across students (Gast, Skouge, & Tawney, 1984; Horner & Baer, 1978). Baseline data were collected for all three tasks prior to the introduction of the independent variable on the first task. Once the students met criterion on the first task (i.e., 80% correct independent responding for three consecutive sessions), baseline probes were then conducted on the other two tasks in the second and third tier. Baseline probes were again implemented for the third task once participants met criterion on the second task.

Baseline and Maintenance Procedures

Baseline consisted of observing participants engaging in their assigned tasks without access to the handheld device. Data were collected only on the first attempt for each task (e.g., first attempt at rolling silverware). During initial training, participants were given several demonstrations from their coworkers on how to perform each task in their job description (and videotaping was conducted during this time). Participants were then expected to attempt the tasks themselves and were given assistance from the researchers or job coach and this is when baseline data were collected. During this time, participants were first given an opportunity to attempt the task independently. If there was no attempt within five seconds or an error was made, they were given a verbal prompt, followed by a gestural/physical prompt if the verbal prompt was ineffective for each step in the skill sequence. Maintenance sessions were conducted in the same manner as baseline sessions; however, a demonstration was not provided.

Instructional Procedures

Participants were given the handheld device and shown videos of each instructional sequence prior to engaging in the required task. For example, when they first arrived at work, participants were met at the door by the researchers or job coach and were given the handheld device and shown the clocking in sequence. Participants independently put on headphones, held the device, and were prompted to select and play the correct videos using a system-of-least prompts prompting hierarchy. After viewing the videos, participants gave the handheld back to the job coach and/or researcher, who then carried the device to the location of the next task. When it was time for them to switch to a different job task, participants were prompted to get the handheld and watch the video sequences prior to engaging in the next task. They were only given prompts when necessary.

It should be noted that although Marcus had four different recipes to portion (and a different video for each), they were all very similar in that they involved weighing food and placing it in bags. There were only subtle differences between the steps required to complete each recipe and they varied in terms of the type of food that was weighed, the number of ounces needed, and the types of baggies used. The recipes changed across days depending on the needs of the restaurant and he was often required to portion two or three different recipes within one work session. Each recipe constituted a session and he may have had two or three recipe sessions in one day (on most days, he would portion only one or two recipes). Similarly, Devon needed to shift back and forth between rolling and sorting and sanitizing silverware throughout his shift. Depending on the level of customer volume, he may have had three to four sessions of each of these tasks within one shift. There were also only subtle differences between clocking in and clocking out. Therefore, clocking in constituted one session and clocking out constituted another. Participants were shown videos prior to engagement with each task as they changed during their shifts. After viewing the video, the participants immediately engaged in the task and were given prompts as needed.

Training Participants to Use Technology/Photos

Prior to engaging in instructional sessions, each participant was given instruction on operating the handheld device. One of the researchers met with participants individually and demonstrated how to use the device using a model-lead-test format. A video that was not used in the study (i.e., how to set an alarm clock) was used for instruction on device operation; however, neither participant met criterion (which was set at 80% independent correct responding for three consecutive sessions), and both needed assistance in operating the device throughout the study. Unfortunately, there was very little time to provide instructional sessions on device operation prior to the start of the study. Parent permission slips were returned at the end of the regular school year and students were out of school for a couple of weeks prior to the beginning of the summer session, which is when the study took place. Both participants were hired during the summer session and began work within two days of being hired. As a result, only three 20-min instructional sessions could be scheduled for each participant prior to intervention. Due to the relatively short period of time between their being hired and beginning work, neither participant met criterion on device operation. Marcus needed prompting on how to use the device throughout the study. Devon learned to operate it independently by session 15, but needed assistance if he accidentally selected the incorrect video or if he accidentally opened the wrong application. Although the timing of the study prevented sufficient instruction on device operation, we are confident that both participants could have met criterion had there been more time for instructional sessions.

Error correction. A two-level prompting hierarchy was used during both baseline and instructional phases. In the event of an error or no attempt within 5 seconds of the natural discriminative stimulus, participants were given a verbal prompt to respond. If the verbal prompt was not sufficient to prompt a correct response, a gestural or physical prompt was provided (depending on what was necessary for the particular step) to ensure correct responding. During instructional phases, participants were also shown a positive video model of the skill sequence following every fifth error in that specific skill sequence. For example, when portioning vegetables for the recipe task, if Marcus made an initial error when putting on gloves, and then made an error on the weighing step for the next four bags of vegetables, he was shown the video for that task. In essence, participants were given video feedback once there were five errors within a skill sequence, however, verbal, gestural, or physical prompts were given during the intervening errors; this was done to reduce the number of times the participants needed to stop their work to watch the video. Five errors was arbitrarily selected as a point to provide video feedback and this was decided prior to intervention.

Independent Variables

Video rehearsal. Participants viewed a video-based multimedia sequence on the handheld device prior to engaging in the task.

Video feedback. Participants were shown a video of the skill sequence following every fifth error in the skill sequence. Participants were shown the entire sequence and given positive verbal feedback from the researchers on steps that were performed correctly and constructive feedback on steps that were performed incorrectly. The only exception was that a special feedback video was created for Marcus that showed adding or removing vegetables from the bag on the scale during the recipe sequences. He made several errors on that particular step, and watching the full sequence (including handwashing, putting on gloves, etc.) seemed unnecessary.

Data Collection Procedures

During baseline, instructional, and maintenance phases, task analytic data were collected with correct/incorrect responses and prompt levels being reported on each step of the skill sequence. A '+' was recorded for independent correct responses, a '-' was recorded for incorrect attempts, an 'n' was recorded for no attempt, and a '√' was recorded for each prompt given at each step (with a maximum of two per step). In the event that one of the steps was completed by a coworker, an 'NA' was recorded and that step was not included in the total number of steps during data summarization. Data were recorded on the first attempt of the task immediately following the video rehearsal procedures (e.g., the initial silverware roll). In addition, tic marks were made on the data sheet after the initial attempt of the task to keep track of errors (to know when to provide video feedback).

Dependent Measures

Percentage of independent correct responses. Participants were assessed on how independently they performed the skills selected for instruction prior to engaging in the instructional sequences (baseline), during instruction, and following instruction (maintenance for Marcus). The score was determined by dividing the number of steps with independent responding by the total number of steps in the skill sequence and multiplying by 100. Baseline and maintenance sessions differed from instructional sessions in that participants were expected to perform the skill without viewing videos on the handheld device.

Percentage of prompts. Participants were assessed on the number of external prompts they needed to complete the skill sequence during all phases of the study. The score was determined by dividing the number of prompts given by the total number of prompts possible (i.e., two per step) and multiplying by 100. Video feedback was not included in this total.

Number of sessions to reach criterion. The acquisition criteria for each skill sequence was a score of 80% or higher for three consecutive sessions as measured by percentage of independent correct responding following the introduction of the video-based materials.

Data Analysis

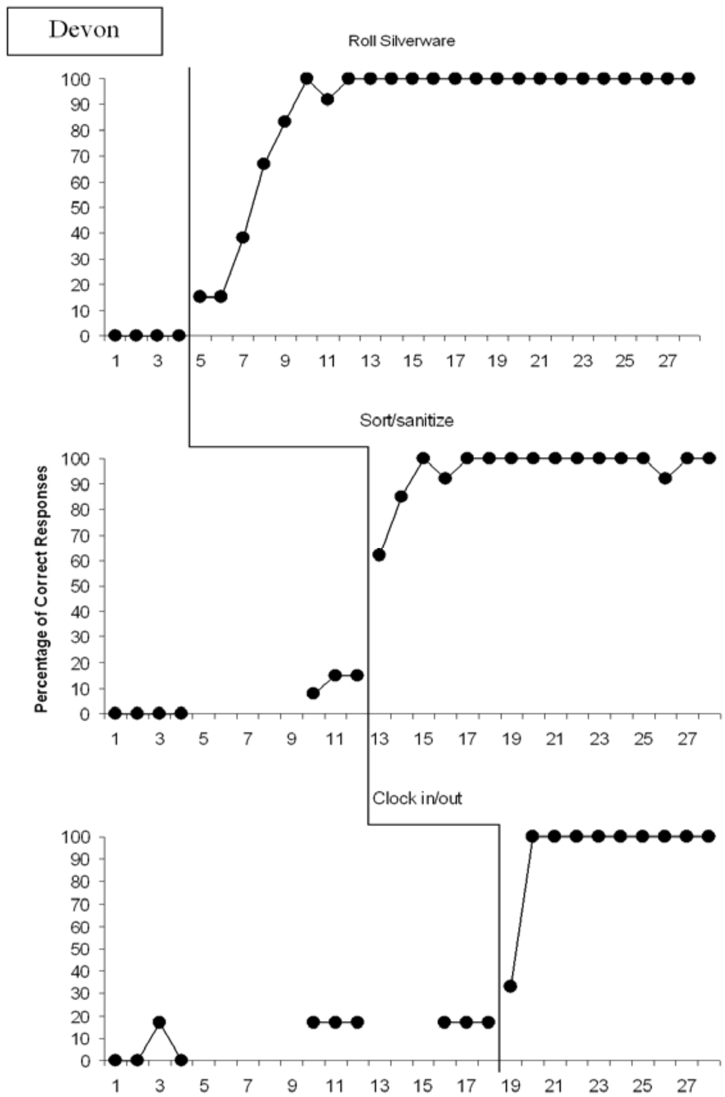
Experimental control was determined primarily through visual inspection of the data and through comparisons of means and trends for each phase and changes in the level of data across phases. With the multiple probe design, experimental control is demonstrated by a consistent change in level and/or trend of the data from baseline phases to intervention phases and lack of changes in the untreated behaviors (Wolery, Bailey, & Sugai, 1988).

Reliability

Reliability sessions were conducted on 27% of all sessions for Devon and 45% of all sessions for Marcus (including baseline and instructional sequences). The percentage agreement index (i.e., number of agreements divided by number of agreements plus disagreements and multiplied by 100) was used to calculate inter-observer agreement. A research protocol was written and shared with all observers regarding methodology and data collection procedures. All observers practiced data collection during practice sessions in the restaurant settings until they achieved scores of 90% agreement or higher for three consecutive sessions.

Agreement for correct responding for Devon across sessions resulted in a mean score of 98% (range = 92-100) and agreement for prompts resulted in a mean score of 95% (range = 85-100). Agreement for correct responding for Marcus across sessions resulted in a mean score of 97% (range = 90-100) and agreement for prompts resulted in a mean score of 95% (range

Figure 1. Percentage of independent correct responses for Devon.



= 86-100). In addition, the second observer collected procedural reliability data (Billingsley, White, & Munson, 1980). These measures included the following: (a) checking to ensure that the correct video was shown for the intended task for each participant, (b) checking to determine if video feedback was delivered following five errors, and (c) checking that the prompting hierarchy was delivered as intended. Reliability was calculated by dividing number of correct measures by total number of assessed variables and multiplying by 100. Procedural reliability agreement averaged 100%.

Results

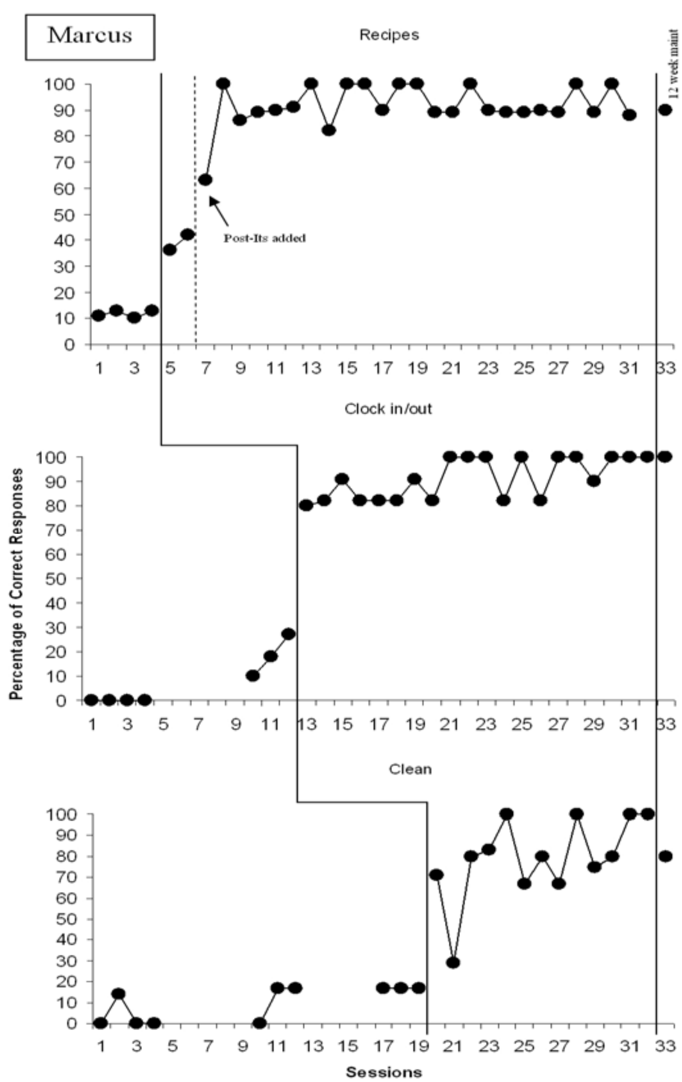
The introduction of the video-based materials appeared to be associated with an increase in independent responding and a reduction in prompting for both participants.

Percentage of Independent Correct Responses

Figure 1 presents data for Devon's independent correct responses. Although the data were ascending slightly in the second and third tier, the introduction of the video-based materials were associated with a marked change in level from baseline to instructional phases with a rapid increase in correct responding following one to three sessions with video instruction. However, there were no dramatic increases with the other tasks during this time, which suggests that the presentation of the videos were responsible for the increase in correct responding. When the means of each phase were compared, there were large differences in the percentage of correct independent responding for each task across baseline and instructional phases. For the rolling silverware task, the baseline mean was 0% as compared to 88% during the instructional phase, while the baseline mean for sorting and sanitizing task was 5% as compared to 96% during the instructional phase. The clocking in/out task also had large increases with the mean baseline being 12% as compared to 93% during the instructional phases. Unfortunately, no maintenance data were collected for Devon because he was laid off for a while and obtained a different job before being hired back at Red Robin.

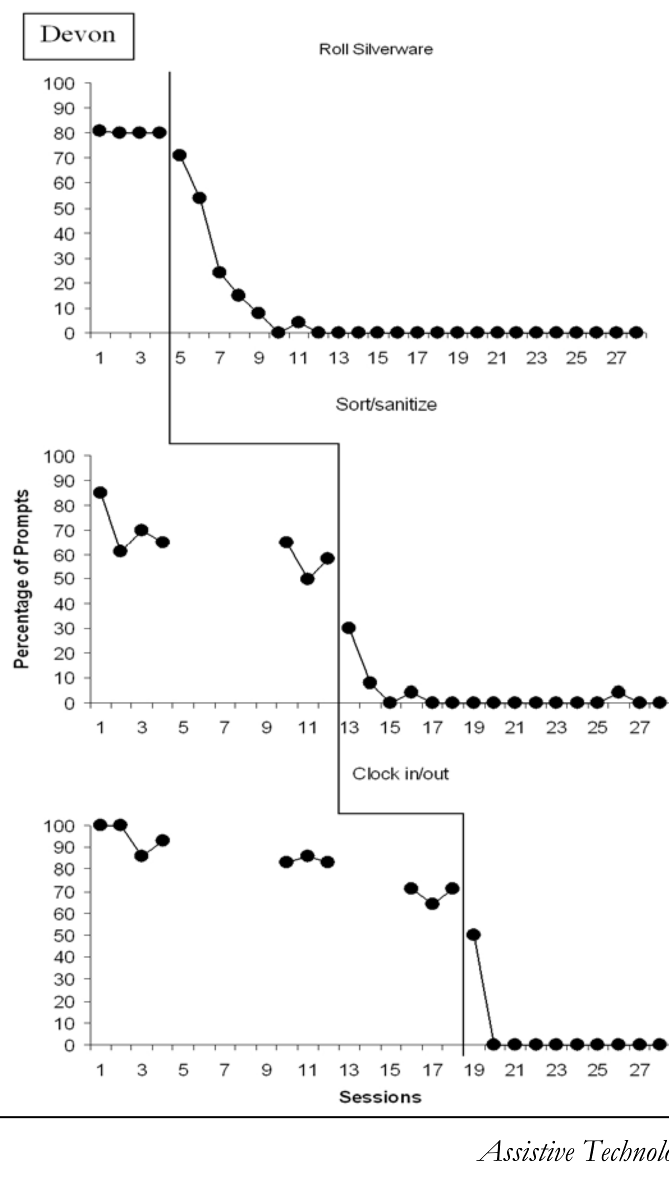
Figure 2 presents a graphic representation of data for Marcus' independent correct responses. Although the data were ascending slightly in the baseline of the second tier, the introduction of the video-based materials were associated with a marked change in the level of data from baseline to intervention. During the instructional phase

Figure 2. Percentage of independent correct responses for Marcus.



for recipes (top tier), Post-It® flags were placed on Marcus' recipe sheet by staff and he was expected to place the flag on the corresponding number on the scale. This support was added beginning with session number 7 because he was having a great deal of difficulty judging if he had "enough" or "not enough" food in his portion bag and was making frequent errors on this step. We felt that it was necessary to highlight the correct number of ounces needed and to give him an acceptable "range" in which to align the arrow of the scale. There were times when he would spend an inordinate amount of time trying to align the arrow with the exact tic mark associated with the number of ounces needed and it was important for him to move quickly. With the Post-It® flags, he needed to have the arrow somewhere within the area covered by the flag. In addition, a feedback video was created that provided specific instructive information for that step. These videos demonstrated that food needed to be added if the arrow was "before" the flag, and that some food needed to be removed if the arrow was "past" the flag. Although the addition of the Post-It® flag and special feedback video reduced subsequent errors on that step, prior to their introduction, there was still an abrupt change in level of data between the

Figure 3. Percentage of prompts for Devon.

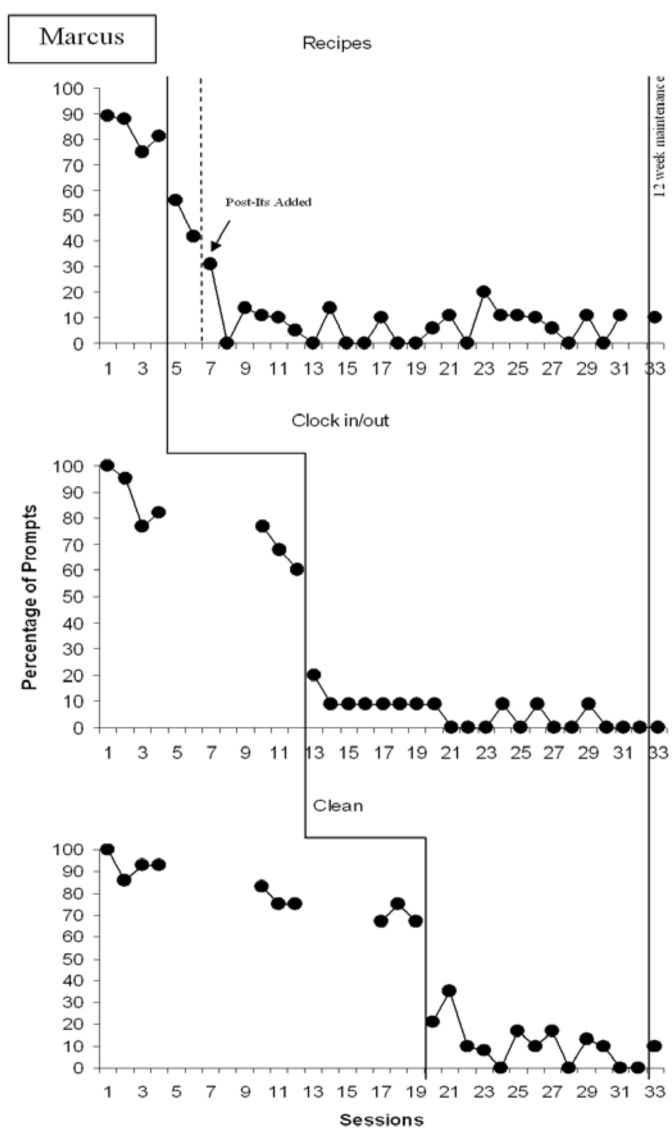


baseline and intervention phase. Also, the addition of these supports only affected one step in the sequence and did not influence the scores significantly, suggesting that the video materials were still responsible for the rapid increase in correct responding. When the means of each phase were compared, there were large differences in the percentage of correct independent responding for each task across baseline and instructional phases. For the recipe task, the baseline mean was 12% as compared to 92% during the instructional phase, while the baseline mean for the clocking in/out task was 8% as compared to 91% during the instructional phase. The cleaning task also had large increases with the mean baseline being 10% as compared to 79% during the instructional phases. In addition, performance was maintained on all three tasks when assessed 12 weeks following intervention.

Percentage of Prompts

When the percentage of prompts were analyzed, there was also a rapid reduction in prompts for both participants once the video-based materials

Figure 4. Percentage of prompts for Marcus.



were presented. Figure 3 presents a graphic representation of Devon's percentage of prompts during baseline and intervention phases. Although the data were descending somewhat in tiers two and three, there were changes in the level of data with each introduction of the independent variable followed by a rapid reduction in prompts by the second or third session with the video-based materials. When the means of each phase were compared, there were large reductions in the percentage of prompts for each task across baseline and instructional phases. For the rolling silverware task, the baseline mean was 80% as compared to 7% during the instructional phase; the mean baseline for sorting and sanitizing task was 65% as compared to 3% during the instructional phase, and the clocking in/out task also had large decreasees with the mean baseline being 84% as compared to 5% during the instructional phases.

Figure 4 presents a graphic display of Marcus' percentage of prompts and like Devon, he also had a drastic decrease in the percentage of prompts needed from baseline to intervention phases. These results are somewhat tempered by the fact that the data are gradually decreasing in each baseline prior to the introduction of the independent variable; he was obviously relying less on staff to perform the skills (i.e., he needed fewer gestural/physical prompts to complete some of the steps). However, there were abrupt changes in the level of the data for all three tasks when the video-based materials were introduced, which provides evidence that their introduction was responsible for the reduction in prompts needed to perform the skills. When the means of each phase were compared, there were large reductions in the percentage of prompts for each task across baseline and instructional phases. For the recipe task, the baseline mean was 83% as compared to 11% during the instructional phase; the mean baseline for the clocking in/out task was 80% as compared to 6% during the instructional phase, and the cleaning task also had large reductions with the mean baseline being 81% as compared to 11% during the instructional phases. Prompts were further reduced when assessed during the 12-wk maintenance probe.

Sessions to Criterion as Measured by Independent Correct Responding

In order to meet criterion, participants had to score at least 80% or higher as measured by independent correct responding for each task. Both participants required an average of five sessions to reach criterion with the tasks once the handheld devices were introduced, which suggests that the video rehearsal and feedback were very powerful instructional techniques.

Outcomes and Benefits

The purpose of this research was to determine if video modeling and video feedback, when presented on a portable handheld device, would increase independent responding of two individuals who were employed in community-based environments. Results of this investigation indicate that the introduction of the video-based materials was associated with an increase in independent responding and a reduction in prompting for both participants. In addition, both participants met criterion with each of their three tasks very quickly once the handheld was introduced, suggesting that this was a very powerful instructional tool. In terms of social validation, both participants informally indicated that they liked using the handheld and Devon stated that he would like to participate in future studies and both participants indicated that they liked watching videos. The employers and other coworkers also communicated that they believed the handheld device was a very beneficial tool.

Although the intervention appeared to be effective, there are several limitations to this study. First, prior to the introduction of the video-based materials, some of the baselines were slightly ascending which would indicate that the participants were learning to perform the skills with prompting alone. However, once the intervention was applied to each task, there was a marked change in the level of data from baseline to instructional phases followed by a rapid increase in correct independent responding and a decrease in percentage of prompts required for each participant across all tasks. This change in level followed by rapid changes in behavior only in the instructional phases suggests that the application of the independent variable was responsible for those changes and experimental control was established. Second, because there was no component analysis conducted, it is difficult to determine if the video rehearsal or video feedback conditions were responsible for changes in behavior, or if the combination of the two were responsible for the change in student responding. Future research should be done to compare the effectiveness of the two procedures to determine if they are equally as effective when presented in isolation. Third, although the video-based instructional sequences increased independent responding across tasks, they were used in conjunction with a prompting system (i.e., verbal and gestural/physical prompts). As a result of using this combination, it cannot be stated that the video procedures alone were responsible for the changes in student responding. However, prior to the introduction of the video-based materials, neither of the participants acquired the targeted skills when taught with prompting alone. Therefore, it seems likely that the video-based materials did have an impact on how quickly participants acquired the skills. And finally, both participants needed assistance operating the technology which ultimately made them dependent on staff.

Unfortunately, there was insufficient training time with the device due to the brief period of time between the participants being hired and their first day of employment. Devon was eventually able to operate the device by the 15th session, but still required assistance if an error was made in application selection or if he selected the incorrect video for the task. Marcus had a great deal of difficulty operating the device and needed assistance throughout the entire study (primarily with selecting the correct application and the correct video). Lack of training time and limited exposure to the use of handhelds contributed to these difficulties, but we believe that the complexity of the navigation system was what ultimately prevented the participants from operating the device independently. Prior to initiating this study, we attempted to address this issue by investigating various software applications for handheld devices to see if there was presentation software that had the capability to embed video files within slideshows to make the navigation easier for the participants. Unfortunately, software that is available for handheld devices is still somewhat limited in terms of its compatibility and functionality in operating video files. As a result, participants were required to view video files in Windows Media Player™ and then had to close the player to return to the slide show, making the navigation somewhat more difficult. However, we are confident that with advances in technology, handheld devices will eventually function as effectively as laptop or desktop computers and that software will continue to improve, making independent operation of the devices more likely among individuals with intellectual impairments. Although the navigation systems may need to be simplified in order to promote independent use of handheld devices, presenting video-based materials within the employment setting appeared to be very effective.

In particular, we believe that the video rehearsal and feedback strategies were very beneficial for focusing the participants' attention on a model immediately prior to task engagement and following errors, especially when the tasks changed frequently within one work session. Because this study was conducted in a competitive employment setting, participants were required to perform tasks that changed based on the immediate needs of the employment setting. For example, Marcus had a difficult time remembering the subtle differences between the recipes and would make frequent errors as soon as he switched to the new recipe. His errors decreased considerably after he was given the opportunity to view the videos prior to switching the the new recipes and following feedback trials, which ultimately led to an increase in independent responding.

One of the reasons we believe the videos were so effective is because the participants were able to focus their attention on the relevant features of the task in a very controlled manner. By focusing their attention on the handheld screen and listening to the narration through headphones, we were able to reduce the distractions that were abundant in the employment settings (e.g., loud music, coworkers). In addition, we believe that the way the videos were created also assisted with focusing the participants' attention on the critical dimensions of the tasks. For example, when creating the videos, we zoomed in on the salient features of the task (e.g, the arrow on the scale) to ensure that the students were attending to the correct and relevant stimuli. In doing so, we were able to focus the participants' attention on the correct model while also reducing the distracting stimuli in the environment. Using zoom shots were also important due to the fact that the handheld devices have smaller screens. It was important to make the videos as large as possible so that the participants could see the modeled tasks clearly. Widescreen shots were only used when the tasks required the learner to move from one location to another and when it was important for them to pay attention to the environmental cues (e.g., carrying the sorted silverware to the dishwashing station). In addition, we also made the videos as short as possible to maintain the participants' attention and to reduce the amount of time spent using the handheld device.

Even though technology was beneficial, the value of natural supports in the environment are also critical. Perhaps using a combination of natural supports as well as technology-enhanced prompting is the answer. In several work environments, it is quite natural for employees to work cooperatively with coworkers. It is in the best interest for workers with disabilities to establish, build, and access naturally occurring supports and relationships within the vocational realm because these supports are already available. Coworkers could conceivably assist in the operation of the devices if necessary. As in most employment settings, minor modifications and/or adaptations to the environment and/or job responsibilities may need to be adjusted.

In conclusion, video rehearsal and video feedback strategies, when delivered on a handheld device, appeared to be effective in promoting independent responding for the individuals who participated in this study. Hopefully, with continued research and advancement in technology, presenting video-based materials on portable devices will become a viable instructional technique.

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Providing Curriculum Access to Young Children: Online Workshops for Educators

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Abstract: Nine online workshops developed by the Early Childhood Technology Integrated Instructional System (EC-TIIS) at Western Illinois University meet the need for training for educators and families on evidence-based practices related to assistive technology (AT) and young children. Results of a research study conducted by EC-TIIS indicate that the online workshops are effective in increasing knowledge, skills, and attitudes of participants. This paper describes the online data collection system, which includes both quantitative and qualitative measures, and data results. Research groups include early childhood educators, families, university faculty, and students. As a result of their participation in the online workshops, educators indicate changes made in their classrooms to make materials more accessible to children. By incorporating the workshops into course content, faculty provide a valuable resource to their students, who in turn gain information and strategies to guide them as educators in making curriculum accessible to all children.

Key Words: Online workshops, Early childhood, Assistive technology, Preschool technology integration

Despite the ever-increasing development of new technologies and educational strategies, many educators and families still struggle to provide their young children with disabilities access to educational materials and activities. Although research shows that young children with disabilities can benefit in many ways from assistive technology (AT), lack of training on AT is a barrier to its use (Hutinger et al., 1994). Educators may know that assistive technology should be considered for a child as part of the Individuals with Disabilities Education Improvement Act of 2004 (IDEIA, 2004), but being able to implement AT into daily routines and curriculum requires a unique set of skills. Teachers need training on different technologies and strategies to integrate those technologies into the curriculum and impact children’s learning (Berard, 2004). Educators who do not use technology to its full extent blame lack of time and lack of awareness of training opportunities (Judge, 2001).

Two groups with national focus recently identified AT implementation training as an important issue in the education field. Results from a recent study on AT use by the National Assistive Technology Research Institute (NATRI) at the University of Kentucky indicate that AT implementation plan use is inconsistent across the ten states surveyed (Bausch, Hasselbring, & Ault, 2006), suggesting lack of training as a possible problem. Experts participating in the 2005 AT Outcomes Summit identified professional preparation as one of the themes and specifically the need for technology implementation training, going beyond computer basics and connecting curriculum and technology (Parette, Peterson-Karlan, Smith, Gray, & Silver-Pacuilla, 2006).

AT Training Needs in Early Childhood

Although technology training opportunities are documented throughout the media, the majority of content addresses K-12 with little or no mention of preschool or AT applications. The Tots n Tech Research Institute (see http://www.asu.edu/clas/tnt), funded through the U.S. Department of Education, conducted a survey of early intervention programs and providers to determine what type of training providers and families were currently receiving. Out of 450 responses, 321 (71.3%), indicated they attended face-to-face trainings, while 150 (33.3%) engaged in "self-study on the Internet," a training category identified on the survey. Despite the fact that training was offered in early childhood, the study revealed that the majority of training materials targeted school-age students rather than infants and toddlers (Sawyer, Milbourne, Dugan, & Campbell, 2005).

In April, 2006, The National Child Care Information Center compiled a listing of training opportunities (i.e., Distance Learning in Early Childhood Education), divided into five categories, correspondence courses, Internet/Web-based courses, interactive media courses, satellite training courses, and television/video courses. The 12 listings for Internet/Web-based courses were courses offered for continuing education credit or university credit. None of the descriptions included AT or technology integration as a topic.

Although there appear to be many online training opportunities for early childhood, the majority are courses offered through community colleges or universities. According to The National Early Childhood Technical Assistance Center (NEC-TAC; 2007), the U.S. Department of Education currently funds only two early childhood projects which address online training in a format other than university coursework connected to personnel preparation grants. NEC-TAC lists 117 projects which meet the descriptor "distance learning/web-based model or components" criteria. However, out of 117 projects, only 40 are currently funded and only 2 of those offer online training to a large audience. Twenty-three of the 40 projects are personnel preparation for a small number of students; six are state implementation grants; seven use other technologies, such as distance education, video conferencing, and use of website for dissemination purposes; one is a regional center for nine states using technology as a networking method; and one is a national center that makes no mention of online or distance education in their project description (National Early Childhood Technical Assistance Center, 2007).

Besides the need for AT training as inservice for educators, there is also a need for preservice undergraduate programs to address AT to access curriculum. After surveying 231 institutions of higher education (IHEs), NATRI reports fewer than 30% of undergraduate and 50% of graduate programs include AT in coursework (Bausch, 2006). Over half of the 131 undergraduate programs reported limited or no access to AT devices as part of their program. An AT Outcomes Summit in 2005 also stated concern over the lack of preparation of preservice students to implement technology when they enter the classroom (Parette et al., 2006). When necessary training and support in assistive technology is lacking, the result is an increasing number of children not having opportunities to access the curriculum and meet their full potential.

Online Training Opportunities

Although many online training opportunities are geared toward college credit, educators and an increasing number of families are taking advantage of the versatility and benefits that other types of online training offer. The main advantages are the convenience of access from any location and at any time and the self-paced mode for learning. Individuals have constant access to outside links and experts around the world. Links provide the most up to date information on equipment and materials (Butler, 2003; Mariani, 2001; Minotti & Giguere, 2003). Online workshops provide a way for educators and families to get initial information on AT and return at a later time for updated information.

An increasing number of early childhood educators are using online training as a mode for professional development (Donohue, Fox, & Torrence, 2007). Childcare providers in California can access a variety of training options from the Child Development website (www.childdevelopment.org) which maintains lists of workshops including online options for professional development credits from organizations across the country. Another informational venue for early childhood educators is online newsletters produced by organizations, such as Childcare World (2006) and the Family Center on Technology and Disability (2007)). Early childhood organizations, such as the National Association for the Education of Young Children's Technology and Young Children Interest Forum (www.techandyoungchildren.org) post information about online training options on their listserv, as do other national and regional education groups.

The use of online training for families and educators is supported by the Council for Exceptional Children's Division for Early Childhood (DEC) as one of its recommended practices concerning technology applications (Sandall, Hemmeter, Smith, & McLean, 2005). DEC recommends that families and professionals use technology to access information and support. Although many websites provide information on early childhood topics, few address evidence-based practices in the use of AT with young children with disabilities.

EC-TIIS Website

To answer the need for evidence-based AT training and to address the current trend in online opportunities, the Early Childhood Technology Integrated Instructional System (EC-TIIS), in the Center for Best Practices in Early Childhood (the Center) at Western Illinois University (WIU) developed nine online workshops for educators and families of young children. Since 2000 EC-TIIS has received funding as a Steppingstones of Technology Innovation for Students with Disabilities Project through the U.S. Department of Education, Office of Special Education Programs (Hutinger, Robinson, & Schneider, 2004). EC-TIIS staff developed the website during Phase 1 (product development) funding and tested it with selected groups during Phase 2 (research with small groups; Hutinger, Robinson, Schneider, Daytner, & Bond, 2006). The Project, which began Phase 3 (research with large groups) in 2004 and is currently one of only two federally funded early childhood projects focusing on online workshops for a broad audience, is researching the effects of using the online workshops on educators and families and the results for young children with disabilities.

EC-TIIS' nine online workshops address the integration of AT into early childhood curriculum. Workshop topics include *Adaptations, Curriculum Integration, Computer Environment, Expressive Arts, Emergent Literacy, Math, Science, and Social Studies, Technology Assessment, Software Evaluation, and Family Participation*. Figure 1 contains a brief description of the workshops.

Figure 1. EC-TIIS workshop descriptions.

Adaptation

The Adaptations Workshop has information and resources on a variety of adaptive input methods as well as portable communication devices and customized activities for young children.

Computer Environment

The Computer Environment Workshop includes strategies to design and adapt the physical environment, a checklist of considerations for setting up the computer center, and ideas for managing computer time.

Curriculum Integration

The Curriculum Integration Workshop contains ideas to integrate technology into the early childhood curriculum, activity planning information, and a wide variety of classroom examples.

Emergent Literacy

The Emergent Literacy Workshop focuses on curriculum applications, adaptations, and assessment techniques for using technology to support emergent literacy development in young children.

Expressive Arts

The Expressive Arts Workshop highlights techniques to incorporate technology into expressive arts for young children, including environmental design considerations, curriculum activities, and adaptations.

Family Participation

The Family Participation Workshop contains information on levels of family participation, workshop strategies, and resources to assist families in using technology with their young children.

Math, Science, and Social Studies

The Math, Science, and Social Studies workshop emphasizes strategies for designing computer activities, off-computer materials, and adaptations to engage young children in the learning process and help them meet early learning standards.

Software Evaluation

The Software Evaluation Workshop provides guidelines for selecting developmentally appropriate software, classifying and evaluating children's software, and suggests software for supporting classroom themes and children's learning preferences.

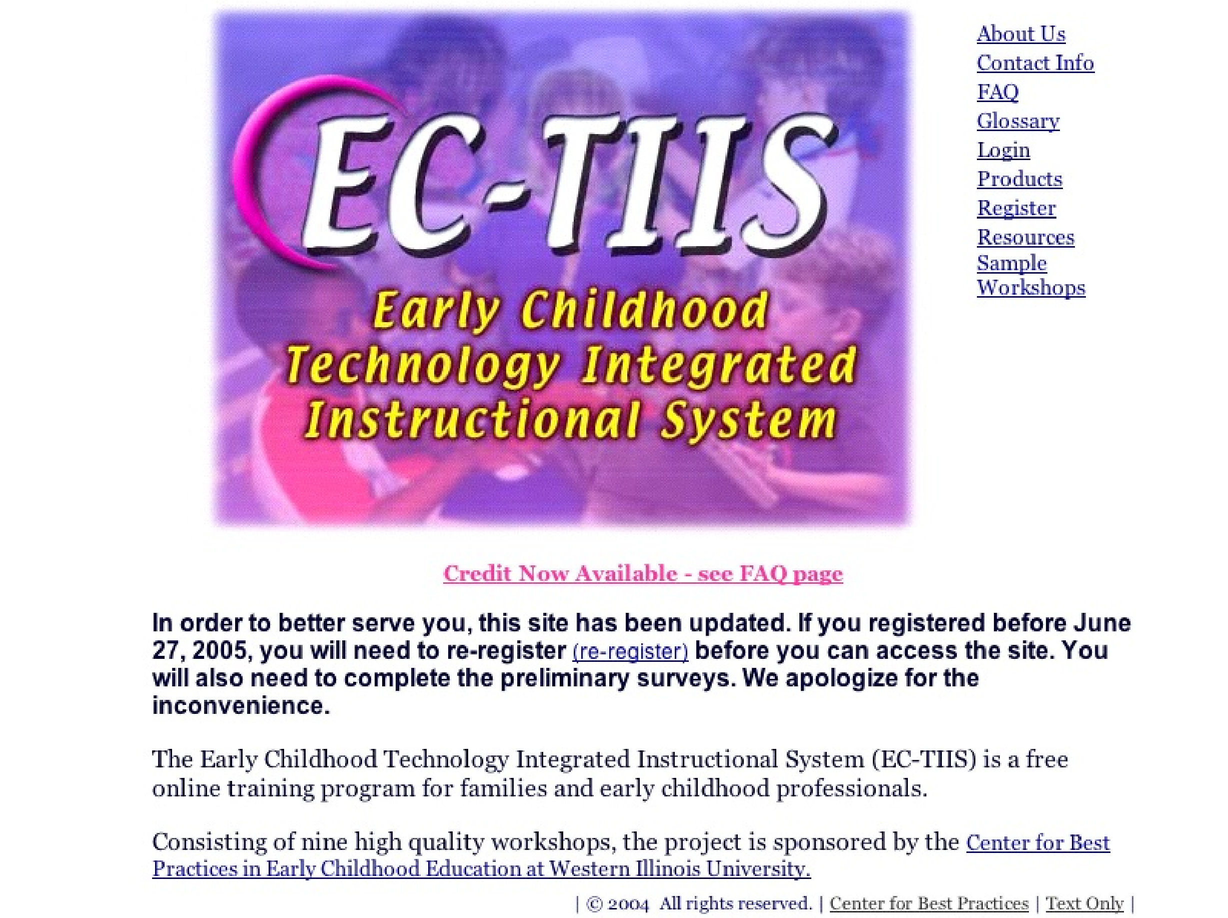
Technology Assessment

The Technology Assessment Workshop contains team process procedures to assess a young child's technology needs and techniques to make equipment, software, and activity recommendations.

Evidence-Based Content

EC-TIIS curricula content is evidence-based, demonstrated to be effective in assisting young children in development of early skills through the Center's demonstration, outreach, and research projects and other studies in the field. Technologies serve a variety of purposes and function as educational tools for young children. Research demonstrates that young children with a wide range of disabilities can use technology, and many of them use it easily and effectively and retain elements of software use over time (Hutinger, Bell,

Figure 2. EC-TIIS Website Homepage



Johanson, & McGruder, 2002; Hutinger, Betz, Johanson, & Clark, 2003; Hutinger & Clark, 2000; Hutinger, Johanson, & Rippey, 2000). AT equalizes learning opportunities for children with mild to severe disabilities. Research and practical experience indicate that young children who have experiences with technologies can participate more fully in the regular curriculum and are less likely to be left behind than those without such access (Hutinger, Johanson, & Stoneburner, 1996; Lewis, 2000; Lewis, Ashton, Haapa, Kieley, & Fielden, 1998/1999).

Technology not only provides a way for children to *do things differently* (i.e., communicate, draw, write), but also enables them to *do different things* (e.g., make and use individualized multimedia software or establish a web site; Bell, Clark, & Johanson, 1998; Hutinger & Clark, 2000; Hutinger, Clark, & Johanson, 2001; Hutinger et al., 2001). Children's participation range from simple experiences (touching a key or switch) with immediate consequences to more complex experiences with interactive multimedia activities.

Using technology, educators and families can document learning and enhance activities for young children. Digital cameras, video cameras, scanners, and the Internet can be used to collect images for use in tool software. Children and adults together can develop individualized stories and activities, using authoring software that incorporates drawings, videotape, sound, animation, and text (Bell, Clark, & Johanson, 1998; Hutinger, et al., 2001; Robinson, 2003). If these many benefits of technology are to be realized by young children, training for early childhood staff and families is needed. Without adults' appropriate knowledge and skills to integrate technology into early childhood curricular experiences, children's potential will remain unmet. EC-TIIS nine workshops meet the training needs of educators and families.

EC-TIIS Format

The workshop website (www.wiu.edu/ectiis/) includes text, graphics, slideshows, links to outside resources, and a variety of downloadable files containing articles and curriculum activities. The workshops meet accessibility guidelines and are available free of charge to any educator or family member of young children for the duration of the project's funding. The homepage (Figure 2) contains a sidebar of choices including Sample Workshops. To view the full workshops, participants must first register at the website. Registration consists of (a) completing a Registration Form (i.e., *Technology Survey*) and one other survey--either the Classroom, Family, Faculty, or Student Survey; and (b) the Pre Assessments for all nine workshops.

Since 2005 professional development credit has been available for workshop participation. Participants may earn a Certificate of Completion, Continuing Education Units (CEUs) from Western Illinois University, Continuing Professional Development Units (CPDUs) from Illinois State Board of Education, or graduate credit from WIU's Instructional Design and Technology Department.

Website Content

Each workshop opens to a page containing links to subtopics. The three workshops focusing on curriculum--*Emergent Literacy, Expressive Arts, and Math, Science,* and *Social Studies*-- have sections on environment, technology integration strategies, adaptations, and assessment.

At the end of each workshop there is a list of Performance Indicators that can be used for group discussions, activities during an inservice, or as assignments for undergraduate or graduate students. Instructors may choose to assign one or two of the Indicators to students as part of their class credit. Faculty can supplement their course content with EC-TIIS workshops and use the Performance Indicators to test students' knowledge on topics.

Another feature on the EC-TIIS website is the Discussion Board. Participants are randomly assigned to 'access' or 'no access' to the Board immediately following the registration process. All university faculty and students have access to the Discussion Board so it can be used in courses if desired. Faculty can request EC-TIIS staff to create a special forum for their students to discuss issues related to course content. Any participants with access to the Discussion Board can use existing forums and post new topics in any of them.

Data Collection

EC-TIIS staff obtain initial data from workshop participants through online surveys and pre assessments completed during the registration process. The Registration Form provides user information such as name, address, e-mail, how the user found the site, his or her current position, and what workshops are of interest to the individual.

All participants are required to complete the *Technology Survey* consisting of questions related to participant's experience with the Internet and other computer applications, such as creating word processing documents, downloading digital pictures from a camera, sending e-mail attachments, and installing or removing applications. All educators who serve children in a classroom setting complete the *Classroom Technology Survey*, a 27-item questionnaire. Questions focus on the teacher's access to and use of different technologies, such as printer, scanner, and digital camera, along with adaptive equipment, including switch, IntelliKeys®, touch screen, and adaptive mouse devices. The second part of the survey relates to children's use of technology in the classroom. Questions include what technologies the children use, time children spend at the computer, how the computer is used, and what children do while they are using software. Teachers are also asked how they integrate technology into their curriculum.

Families complete the *Family Survey* during the registration process. The survey consists of 10 items including what technologies the child uses outside of the classroom, whether the family member uses software at home with the child, how much time the child spends on the computer outside of school, what the child does at the computer, and whether the family has participated in a technology assessment. A post version of the *Classroom Survey* and *Family Survey* is completed by participants at the end of the study.

Faculty and students are asked initially to complete a brief survey with questions related to their use of the Internet and discussion boards in coursework. EC-TIIS staff obtain information on how the workshops are used by faculty during an end-of-the-year interview. University students complete a short questionnaire at the end of the semester in which they used the workshops.

Data on workshop effectiveness is obtained through an analysis of the *Workshop Pre-Assessment* and *Post Assessment*. Educators and university students are required to complete a pre-assessment for each of the workshops before their initial entry into any of the workshops. The *Workshop Pre-Assessment* has 8-10 items related to knowledge, skills, and attitudes toward the workshop topic. Participants are asked to complete the online *Workshop Post Assessment* after finishing a workshop. A Progress Page listing the workshops and the user's completion of *Post Assessments* is created for each participant and is accessible when the user logs into the website. Users are asked to complete an online *Workshop Evaluation* upon completion of all workshops.

Participants requesting credit provide additional data to the project. All are required to complete an *Exit Survey* for each workshop. The survey consists of five questions regarding (a) workshop completed; (b) skills and knowledge acquired; (c) how those will be applied to the learning environment; (d) benefits seen for children; and (e) how their program, home, or learning environment will benefit from their workshop participation. In addition, those earning CPDUs must evaluate each workshop by rating their gain of knowledge and skills, the relevance of the workshops to teaching standards, and the organization of the content. They also indicate the workshop's best features and provide suggestions for improvement.

All data received online is formatted for direct retrieval to the *Statistical Package for Social Sciences* (SPSS). Analysis is then conducted according to the nature of the data. For each of the Workshop Assessments, all items were compared from pre to posttest using paired sample t-tests. Effect sizes were calculated for all comparisons. Confidence intervals were then determined for each effect size (Coe, 2005).

Results and Discussion

The following discussion of EC-TIIS results is based on Phase 2 data collected and analyzed between October, 2002, and May, 2005 (Hutinger et al., 2006).

Participant Profile

During Phase 2, 415 individuals from 33 states and 15 countries registered on EC-TIIS website. The largest percentage of participants (53.7%) were located in Illinois (*n*=223). Michigan (*n*=26) and California (*n*=25) had the next highest percent of participants, 6.3% and 6%, respectively. Thirty other states were represented, each having fewer than 5% of the total participants.

Besides the U.S., 14 other countries were represented. The United Kingdom had three participants (6.5% total), while the 13 other countries each had less than 5% of the total participants. Countries represented included Germany, India, Vietnam, Barbados, China, Turkey, Butane, Thailand, Papua New Guinea, Canada, Nigeria, Malaysia, and New Zealand.

Table 1 presents positions held by the 415 registrants.

Technology Background

The majority of participants had access to a computer and Internet from home. Details on location of access can be found in Table 2.

Participants indicated on the *Technology Survey* their specific computer skills related to a variety of applications, ranging from using word processing to creating websites to using Personal Digital Assistants (PDAs). (Table 3 contains a summary of participants' responses.

Participants were asked, prior to accessing EC-TIIS workshops, if they needed more technology training. Of the 415 responses, 272 (65%) said 'yes,' 36 (9%) said 'no,' and 107 (26%) did not respond. The type of technology training that participants needed most was curriculum integration at 52% (*n*=216), followed by adaptations 41% (*n*=171), emergent literacy 36% (*n*=151), family participation 36% (*n*=150), software 36% (*n*=148), technology assessment 30% (*n*=124), math science and social studies 29%

Table 1
Positions Held by Workshop Registrants (*n*=415)

Position	*n*	%
University Student	203	50
Early Childhood Educator	70	17
Early Childhood Special Educator	23	6
Pre-K teacher	20	5
University Faculty	20	5
Administrator	19	4
Head Start Teacher	10	2
Family Member	8	2
Support Personnel	5	.5
Program Assistant	3	.5
Other	34	8

Table 2
EC-TIIS Participants' Computer and Internet Access

Location	Computer Access		Internet Access	
	n	%	*n*	%
Home	271	65	363	63
University	183	44	191	46
Classroom	137	33	134	32
Library	117	28	121	29
Work	100	24	96	23
No Answer	101	24	129	31
Other	11	3	13	3

(*n*=122), expressive arts 28% (*n*=118) and computer environment 23% (*n*=94).

Effectiveness of EC-TIIS Workshops

An analysis of pre and post workshop assessment data from Phase 2 shows a significant increase in educators' knowledge, skills, and attitudes in each of the nine workshops (Hutinger et al., 2006). Teachers implemented technology strategies and made materials more accessible for children as a result of EC-TIIS participation. Since participants are not required to review all workshops or complete all post assessments, unless they are requesting professional development credit, the number of participants completing assessments varied with workshops.

The findings across workshops consistently showed gains in self-reported knowledge, attitudes, and skills. Analysis of data from three workshops follows.

Computer Environment Workshop. Ninety participants completed both the pre and post assessments for the *Computer Environment Workshop*. Statistical significance was found for all seven items. Effect sizes ranged from .31 to 4.97. The item with the smallest effect size related to evaluating a computer center. Participants reported high efficacy for this skill as demonstrated by a mean of 4.03 at pre.

Table 3
EC-TIIS Participants' Computer Skills

Computer Skill	*n*	%
Creating word processing documents	293	71
Sending or receiving attachments from email	281	68
Using other computer applications	230	55
Burning a CD	230	55
Using a scanner	204	49
Downloading digital picture from a camera	210	48
Installing/removing applications from computer	187	45
Manipulating/altering digital pictures	186	45
Creating a personal website	106	24
Using a personal PDA	55	13

The item with the largest gain was the knowledge item related to setting up technology for independent access by children. Participants reported a mean of only 1.22 at pre (see Table 4).

Curriculum integration workshop. A total of 47 participants completed the pre and post assessments for the *Curriculum Integration Workshop*. Statistical significance was found for all six items. Effect sizes ranged from .51 to 1.45. The smallest effect size was for the attitude item related to incorporating technology into the early childhood curriculum. The largest effect size was found for the knowledge item related to using technology in the preschool classroom (see Table 5).

Technology assessment workshop. A total of 40 participants completed the pre and post assessments for the *Technology Assessment Workshop*. Statistical significance was obtained for all nine items as shown in Table 6. Effect sizes ranged from .81 to 2.01. The smallest effect size was for the attitude item related to the benefits of a technology assessment for children with disabilities. The largest effect size was for the knowledge item related to the information that needs to be gathered prior to a technology assessment.

Table 4
Computer Environment Workshop Assessment Results

Workshop Assessment Items	*n*	Pre *M*	Post *M*	*t* (2-tailed)	Effect Size	95% Confidence Interval for Effect Size
Knowledge						
I know how to set up the computer and software so that children can access them independently.	90	1.22	4.32	31.80***	4.97	(4.36, 5.54)
I know strategies to help encourage turn taking at the computer.	90	3.20	4.40	8.58***	1.22	(.90, 1.54)
I know materials and resources needed to make off-computer props, which relate to software content.	88	3.51	3.95	3.21**	.46	(.16, .76)
Attitude						
Children's time at the computer should be carefully managed by an adult.	88	2.51	3.81	7.78***	1.11	(.79, 1.42)
Children can learn to handle software and operate the computer independently.	89	3.58	4.39	5.50***	.83	(.52, 1.14)
Skills						
I can evaluate a computer center for appropriate equipment placement and adaptations.	90	4.03	4.31	2.35*	.31	(.01,. 60)
I can devise a method to make CD-ROMs easily accessible for children.	90	3.10	4.29	9.41***	1.22	(.90, 1.53)

*p<.05
**p<.01
***p<.001

Table 5
Curriculum Integration Workshop Assessment Results

Workshop Assessment Items	*n*	Pre *M*	Post *M*	*t* (2-tailed)	Effect Size	95% Confidence Interval for Effect Size
Knowledge						
I know what curriculum integration means in terms of using technology in the preschool classroom.	47	2.91	4.36	8.30*	1.45	(.98, 1.89)
I know how to use technology to develop off computer materials that can be used to integrate children's software into my curriculum.	46	2.98	4.22	7.38*	1.31	(.85, 1.75)
I know how to select appropriate software for use with thematic units.	47	2.98	3.98	6.33*	1.01	(.57, 1.43)
Attitude						
Technology should be incorporated into the early childhood curriculum.	45	3.60	4.22	3.50*	.51	(.08, .92)
Skills						
I can develop a plan that contains elements recommended for technology integration activities.	46	2.83	4.07	8.28*	1.43	(.96, 1.88)
I can integrate current ideas and materials into technology related activities in the classroom.	46	3.07	4.26	7.60*	1.29	(.83, 1.72)

*$p<.001$

Results from the other six workshops show statistical significance on the majority of items.

EC-TIIS Use in Coursework

Faculty data. Seven faculty members from University of Tennessee, Eastern Michigan University, Western Illinois University, and Lincoln Christian College (Illinois) used the EC-TIIS workshops as supplements to coursework in Special Education, Early Childhood, and Instructional Technology and Telecommunications during the 2003-2004 and 2004-2005 school years. EC-TIIS staff sent an e-mail questionnaire at the end of each year asking faculty three questions related to benefits of using EC-TIIS workshops, plans for incorporating the workshops into coursework, and suggestions for other faculty about using the workshops. Six out of the seven faculty responded directly to the questions. The seventh faculty member just started to use the workshops in her course and made participation optional for the students. She sent an e-mail with the following comments as feedback: "A few of my students use the workshops. They were very pleased with them. They felt that the workshops were informative and that they learned useful information."

When asked what benefits faculty members saw for themselves and their students when using EC-TIIS workshops, all six indicated that their students gained increased knowledge on technology and AT. Three thought the links were beneficial to students and that the website served as a good resource for them and their students.

Student data. Although 203 university students registered at the EC-TIIS website during Phase 2, feedback on a follow-up questionnaire was received from 37 Early Childhood undergraduates, 25 Instructional Technology and Telecommunications undergraduates, and 27 Early Childhood graduates. None of the Special Education undergraduates responded to the questionnaire.

When undergraduate students were asked what benefits they gained from the workshops, responses included (a) "The workshops gave me a lot of useful information on how technology can be integrated into the curriculum"; (b) "Overall, the workshop helped me see the possibilities for many activities and assessment strategies I could use in the classroom"; and (c) "The one resource that was really useful was finding the different adaptive input devices that can be

Table 6
Technology Assessment Workshop Assessment Results

Workshop Assessment Items	*n*	Pre *M*	Post *M*	*t* (2-tailed)	Effect Size	95% Confidence Interval for Effect Size
Knowledge						
I know the purpose of a technology assessment.	40	3.18	4.40	6.10*	1.19	(.71, 1.66)
I know the procedures of a technology assessment.	40	2.45	4.33	8.96*	1.90	(1.35, 2.40)
I know what materials are needed for a technology assessment.	40	2.53	4.25	9.84*	1.80	(1.26, 2.30)
I know who should be included in a technology assessment.	40	2.63	4.40	8.44*	1.68	(1.15, 2.17)
I know what information needs to be gathered prior to a technology assessment.	40	2.42	4.50	9.61*	2.01	(1.45, 2.52)
Skills						
I feel that I could contribute to an effective technology assessment for a child.	40	2.53	4.25	11.06*	1.73	(1.20, 2.22)
I can identify children who could benefit from a technology assessment.	40	2.83	4.10	8.40*	1.29	(.80, 1.76)
Attitude						
Technology assessments are a vital resource for children with disabilities.	40	3.95	4.70	5.28*	.95	(.48, 1.41)
All children with disabilities can benefit from a technology assessment.	39	3.92	4.64	4.17*	.81	(.34, 1.26)

*p<.001

used to help children use technology."

Undergraduate students were also asked what effects they thought the workshops would have on their future teaching. Responses included (a) "I will remember many of the ways to address the curricular areas using technology and/or adaptations"; (b) It will give me ideas such as how to set up a computer environment and how to integrate literacy in a positive way in the classroom"; and (c) "If I have a child with special needs in my classroom, I will be able to refer to these workshops to adapt the curriculum to him/her."

Graduate students were also asked to comment on benefits they gained from the workshops. Although some felt the information was basic for teachers, they commented on the usefulness of new information on technology applications. When asked how they integrated workshop content into their curriculum, 21 of the 27 graduate students indicated that they already integrated content or that they planned to integrate in the near future. A few of the graduate students noted using specific strategies from the workshops, such as using the computer sign-up for emergent literacy, putting more options on the computer for the expressive arts, and trying the parent involvement ideas.

Graduate students were also asked how their participation in the workshops impacted the children in their classroom. All 27 students responded to this question with comments related to children's increased skill development and choice-making, benefits gained from an appropriate environment set-up, and increased access to materials and increased time on computer.

Outcomes and Benefits

The EC-TIIS nine online workshops provide much-needed training in early childhood and AT for families and educators. As a result of participation in EC-TIIS, users are more knowledgeable and skilled in using technologies in the early childhood environments. Participants gained new knowledge in areas related to technology and curriculum integration, and made specific gains in emergent literacy and expressive arts knowledge. Follow-up data indicate that educators made changes to the classroom as a result of knowledge gained in the workshops. They made equipment more accessible to children, designed the computer environment more appropriately, and integrated specific strategies at the computer, such as use of a sign-up sheet.

Early childhood staff who used the online workshops observed many benefits for children resulting from participation in EC-TIIS. Children have more time on the computer and more choices in the writing center. The reported changes made by educators to their centers, and specifically, the computer center, indicated that materials became more accessible to children both on and off computer. Participants also described children as more excited and interested in learning; and more creative and interactive when learning. They reported child gains in many skills, including communication, social, problem solving, and cooperative play. Children are more interested in art as a result of changes made in the art center after their family or teacher participated in the .

Expressive Arts Workshop

Children have more opportunities to gain independence and self-esteem as a result of materials and activities being more accessible. Participants who used the information from the workshops to make changes in their classroom and curriculum reported increased access to technology and integrated activities for children in the classroom.

Through participation in EC-TIIS, faculty have access to AT content to incorporate into early childhood or special education courses. As a result, university students have information and strategies to guide them as educators in making curriculum accessible to all children in their classroom.

Summary

EC-TIIS provides evidence-based AT training in an accessible online format for early childhood educators and families. When incorporated into university coursework, the online workshops also meet the AT preparation needs of preservice students. Data collected through the project's online system provides evidence on the effectiveness of web-based training as a tool for educators and families in advancing educational opportunities of young children with disabilities.

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Visual Features That Convey Meaning in Graphic Symbols: A Comparison of PCS and Artists' Depictions

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Abstract: Research on AAC symbols has focused almost exclusively on iconicity and complexity, and thus has not established whether additional visual features are necessary for conveying meaning in graphic representations. Despite variations in individual depictions of an "apple," we understand the underlying concept due to shared consensus on the set of necessary visual elements. This initial investigation examined 25 concepts depicted in Picture Communication Symbols (PCS) in terms of a diverse set of visual features and principles. Additionally, seven artists drew the same concepts to determine whether patterns emerged across artist groups and within semantically related concepts. While visual profiles of PCS and artists' renditions differed for most concepts, they were identical for some concrete concepts. Additionally, common patterns were noted for semantically related concepts. These findings suggest that a broader set of visual features may be useful for analyzing how meaning is conveyed in existing AAC symbol sets and for developing novel symbols.

Keywords: Graphic symbols, Semantics, Visual representation

Language, spoken and written, is a shared social construct. It is because we agree on a set of common meanings that we can engage in meaningful interaction. How is this shared knowledge negotiated when interacting using graphic symbol representations? The old adage 'a picture is worth a thousand words' must be borne from the fact that we often negotiate meanings when communicating through pictures.

While spoken language is typically an arbitrary mapping between the referent and the word, communication using graphic symbols is usually tied to physical experience and embodiment. When we draw a picture to depict an action or an object, the drawing is tied to the physical world in how it appears, how it moves, its shape, its color, etc. We do not draw arbitrary and indistinguishable scribbles for each item and expect that our communication partner will understand what we mean. Although each person may produce a different drawing to convey the same concept, there must be a set of necessary visual features that convey meaning. We understand drawings produced by children, those produced by novice adults, and those produced by artists because we share common experiences with these individuals that are then communicated via drawing.

Conveying one's ideas, needs, and desires through graphic symbols is of utmost importance for individuals who are unable to communicate using speech. The clinical practice of augmentative and alternative communication (AAC) is consequently aimed at enabling these individuals to convey their intentions using means such as sign language, gestures, and graphic symbols. The study of graphic symbols in AAC has focused primarily on an analysis of symbol learnability and complexity (Fuller & Lloyd, 1987, 1991; Soto, Cassidy, & Madanat, 1996) and categorized in terms of iconicity (Fuller, 1997; Fuller & Lloyd; Lloyd, Fuller, & Arvidson, 1997; Soto et al.; Schlosser, 1997a, b). Iconicity refers to the visual relationship of a symbol to its referent and varies along a continuum from transparent to opaque. When a symbol to referent relationship is clear and obvious, the symbol is said to be a <transparent> depiction. In contrast, if the symbol bears little or no visual resemblance to the referent, it is said to be <opaque>. Depictions that lie somewhere between transparent and opaque in terms of iconicity are considered <translucent>.

Previous work has attempted to discern the interaction between symbol iconicity and learnability. For example, Picture Communication Symbols (PCS) are thought to be easily learned due to a transparent or translucent relationship between symbol and referent (Fuller & Lloyd; Soto et al., 1996). In contrast, Blissymbols are less learnable than PCS since they combine a finite set of arbitrary visual elements which are less transparent and translucent to a layperson (Fuller & Lloyd; Huer, 2000; Mizuko, 1987; Musselwhite & Ruscello, 1984; Radhakrishnan & Fristoe, 1990).

Earlier studies have also explored the multifaceted relationship between iconicity, complexity and learnability. Symbol learnability appears to be influenced by the referent's part of speech. For example, symbols for nouns are easily learned given that they are concrete and therefore easier to depict visually. [See Fuller (1997) for results in non-impaired adults and children; see Koul and Harding (1998) for similar results with adults with global aphasia.] In contrast, verbs, which contain a high level of abstract semantic information, tend to yield symbols that appear more visually complex and less iconic (Fuller & Lloyd, 1987). In addition, verbs may be more complex to depict due to the difficulty in rendering a dynamic event using static images (Bloomberg, Karlan, & Lloyd, 1990). For example, to depict the verb "to fly" requires indicating movement perhaps using wavy lines or arrows near part of the object that is performing the flying action, while depicting the noun "bird" only requires a static rendition of the object. Attempts to enhance the concreteness and learnability of verbs by animating symbols on computer programs have not been successful with adults with aphasia (Koul & Harding). It remains unclear which visual features can adequately convey the meaning of these concepts without imposing increased processing demands on learners who may already be burdened with visual and cognitive impairments.

The interaction between visual complexity and learnability is further complicated by the finding that typically developing children seem to benefit from complex symbols (Fuller, 1997). Fuller noted that children were able to assign idiosyncratic meaning to symbols that had no visual relationship to their referents, and could map meaning onto any arbitrary symbol. In fact, the more complex a symbol, the more scaffolding it provided the child for assigning meaning to the symbol. Similarly, Raghavendra and Fristoe (1990) demonstrated that adding iconic embellishments to Blissymbols helped children without disabilities to understand and learn these symbols. While a complex, less iconic system may be appropriate for children with adequate cognitive and abstract reasoning skills, such a system may be challenging for many individuals who use AAC. In order to design graphic representations that can be easily learned, it is important to identify which visual features lead to perceived complexity.

Table 1
List of 25 Commonly Used Vocabulary Items for Which Drawings were Elicited

Again	*Feelings*	*In*	*Pain*	*That*
All	*Friend*	*Like*	*Pet*	*Thing*
Animals	*Give*	*Maybe*	*Pretty*	*This*
Better	*Hard*	*More*	*She*	*Want*
Eat	*He*	*None*	*Talk*	*Yes*

Fuller and Lloyd (1987) suggest that the processing required for comprehension and use of symbols is tied to visual elements such as the length, area or number of lines in the symbol. Thus, complex symbols may contain unnecessary visual information that clutters the communication board, taxing the learner's visual and cognitive processing. While recent software makes it convenient to modify or create new symbols and add colors to meet preferences, these modifications may impose further demands on visual processing. Although Musselwhite and Ruscello (1984) found that perceived appeal did not affect perceptions of symbol complexity, improving appeal did not enhance learnability either. Further research is warranted on identifying a broader set of visual features that can elucidate the interactions between symbol complexity, learnability, and appeal.

The design of a successful AAC symbol set must meet the demands brought on by the conflicts of "compactness, iconicity, and semantic transparency/translucency" (Carmeli & Shen, 1998, p. 181). Many symbol sets currently used in AAC have been developed on an ad hoc basis, without systematic analysis of linguistic principles or graphic representation. For example, Schlosser (1997a, b) found that convergence, a relationship between superordinate, basic, and subordinate taxonomies, was present in Blissymbols and PCS symbols. Within the PCS symbols, however, most superordinates were merely collections of several basic level symbols and most subordinates were not represented at all. Furthermore, he noted that PCS symbols lacked visuo-graphic links between subordinates within categories, indicating that convergence in PCS symbols exists only in a limited fashion and not by design. Since users of AAC must rely upon graphic symbols for concept formation, or as a primary language, further research is required for determining which visual features are most effective for depicting category concepts.

Perhaps previous work on semantic primitives can inform the study of visual primitives in graphic representations. Wierzbicka (1996, 1997) performed a thorough lexical analysis of five diverse cultures (English, Polish, German, Russian, and Japanese) in search of a finite set of concepts that encompass all basic human notions. She termed this a "universal mental language independent of the specific oral languages and underlying them all" (Wierzbicka, 1980, p. 2), and proposed a set of 55 "innate and universal semantic primitives" (Wierzbicka, 1996, p. 17) that were common to all cultures and that could be used to define any other concept. If such core concepts exist in a mental language, how might they be represented graphically?

To broaden the study of graphic representation in AAC beyond traditional comparisons of iconicity, we turned to the study of visual arts. Horn (1998) conducted a comprehensive visual analysis of a diverse collection of Western media including comic books, maps, advertisements, computer interfaces, architectural diagrams, logos, and trademarks. He found patterns among the visual elements used to convey the underlying semantic content of graphic representations. To optimize the effectiveness of communication through graphics, Horn attempted to establish what he refers to as the linguistics of visual language. He formulated a morphology and syntax of visual elements within a set of visual principles.

The present study applied Horn's visual principles to the analysis of graphic symbol representations in AAC. This initial investigation sought to identify the set of visual features used to convey the meaning of 25 commonly used concepts as depicted in Picture Communication Symbols, a popular AAC symbol set. Additionally, seven artists drew the same 25 concepts to determine whether the visual features used in PCS extended to depictions by other artists and whether patterns emerged across semantically related concepts. The goal was to identify a set of shared visual features used to convey meaning across the artist groups.

Method

Participants

The third author, a former graphic artist, sent requests for participation via email and letters to approximately twenty artists from across the USA. This initial communication stated that the purpose of the research was to examine visual features in graphic representations. To avoid limiting the scope of the study or biasing the artist's renditions, there was no mention of the target population or of AAC symbols. Artists were simply told that they would be asked to depict a set of concepts using whatever media they preferred. They were informed that the task had to be completed independently within a time frame of six weeks. If interested in participating, they were asked to return a signed consent form and await further instruction. The group that responded consisted of seven male and female visual artists (mean age 33) from a variety of racial and ethnic backgrounds. While the artists varied in skill and style, all participants had some formal training in fine arts and/or design and were working as professionals in the capacity of teachers, designers, and/or illustrators.

Vocabulary Stimuli

A finite set of 25 commonly used vocabulary items was identified using several criteria. In order to generate a diverse set of items appropriate for users of AAC, initial vocabulary lists for young children (Bristow & Fristoe, 1984; Bruno, 1989) and a list of frequently used vocabulary items for adults (Beukelman, Yorkston, Poblete, & Naranjo, 1984) were consulted. From these sources, overlapping concepts were first selected. Next, concepts that also occurred in Wierzbicka's (1996) list of 55 semantic primitives were selected. This initial set was then used to determine whether these concepts were represented in the PCS lexicon (Johnson, 1981). To constrain the drawing task to a manageable size, the resulting list was further reduced to 25 items (Table 1) from various semantic categories that spanned the concreteness/abstractness continuum.

Visual Features and Principles

Artists' renditions and PCS illustrations were analyzed in terms of 27 visual features that spanned five principles as defined by Horn (1998) and Fuller and Lloyd (1987). See Table 2 for a description of visual features within each visual principle. Drawings were also categorized in terms of their level of iconicity (i.e., <transparent>, <translucent> and <opaque>).

Since Horn's taxonomy of visual features includes elements from a variety of graphic representations, the present study only focused on features used for representing meaning. Specifically, drawings were analyzed in terms of the gestalt, semantic attributes, cartoon conventions, and compositional distinctions principles (Horn, 1998). The gestalt principle includes visual features of (a) <proximity>, (b) <similarity>, (c) <common regions>, and (d) <connectedness> which are used to convey the spatial grouping of elements. For example, the visual feature <common regions> may be used to convey the concept "family" as a collection of people enclosed by a circle given the tendency to perceive elements enclosed by a line as a single unit. The semantic attributes principle encompasses the features <increment>, <anthropomorphism>, <possible outcomes>, and <examples> which convey underlying meanings or metaphorical representations. The <examples> feature may be particularly relevant for depicting types of items (e.g. dog, cat, horse, etc.) within a category (e.g. animal). The cartoon conventions principle includes the visual features <emotion>, <motion>, <physical phenomena>, <speech balloons>, <embodied experience>, <cartoon metaphors>, and <arrows> which pertain to the use of simplified imagery from cartoon culture. For example, the <cartoon metaphor> of a 'heart' may be used to depict the concept "love." The compositional distinctions principle includes the visual features <symmetry>, <asymmetry>, <repetition>, <singularity>, <juxtaposition> and <exaggeration> which pertain to the graphic layout and arrangement of visual elements within an image. Thus a comparative concept such as "biggest" may be illustrated using <juxtaposition> of two or more items.

Fuller and Lloyd (1987) also argue that visual elements such as area, length, and number of lines, aid symbol comprehension and use. Horn (1998) grouped these elements within a principle called line interpretations that includes the visual features <horizontal lines>, <vertical line>, <active lines>, <converging line> and <diverging lines>. For example, the <active lines> feature may be used to convey movement in verbs such as "to fly" or to convey abstract concepts such as "busy."

Procedures

Drawing Procedures. Subsequent to receiving informed consent, an instructional letter was mailed to participating artists. Each artist received a list of 25 concepts and was instructed to "draw one picture for each of the words." The artists were not given any guidelines upon which to base their drawings, and were allowed to use any type of media. While some artists used electronic media to create their drawings, most used pen or pencil on paper. To avoid imposing the experimenters' biases on the artists, there were no explicit directions in terms of drawing size, level of detail, level of abstraction, etc. Additionally, artists were not provided with any information about the target population. They were merely asked to depict each concept as they understood it. For concepts that had multiple meanings, artists were free to decide which meaning to illustrate. Once they had completed all 25 illustrations, they were asked to return them via mail.

Table 2
Glossary of Visual Principles and Corresponding Visual Features with Definitions and Exemplar Illustrations © 2007, Rupal Patel. Used with permission.

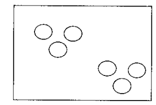
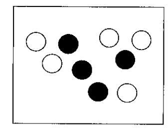
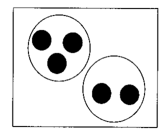
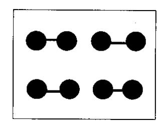
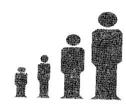
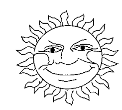
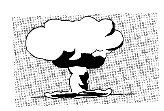
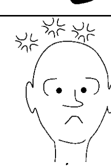
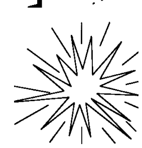
Principle	Visual Feature	Definitions	Exemplars
Gestalt	Proximity	Tendency to group elements which are closest to each other.	
	Similarity	Tendency to group elements which appear similar in size, shape, color, or darkness.	
	Common region	Tendency to perceive elements enclosed by a line as a unit.	
	Connectedness	Tendency to perceive points, lines or region as a single unit.	
Semantic Attributes	Increment	Showing progression from lowest to highest.	
	Anthropomorphism	Representing an inanimate object as human.	
	Possible outcomes	Depicting a consequence of an event or action.	
	Examples	Using token exemplars to define a conceptual category.	
Cartoon Conventions	Emotion expression	Use of facial expressions to depict human emotion.	
	Motion	Use of lines to indicate mode, direction, or intensity of movement.	
	Physical phenomena	Use of simple drawings to capture natural or physical phenomena.	

Table 2
Glossary of Visual Principles and Corresponding Visual Features with Definitions and Exemplar Illustrations (continued)

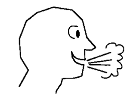
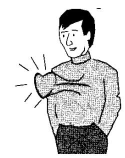
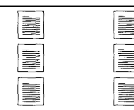
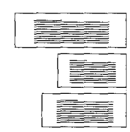
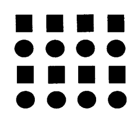
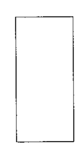
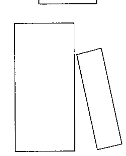
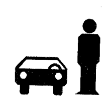
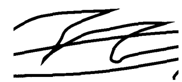
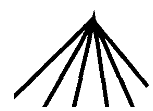
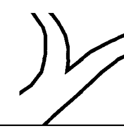
Principle	Visual Feature	Definitions	Exemplars
Cartoon Conventions (continued)	Speech balloons	Using speech balloon content, size, and form to convey emotions or ideas.	
	Embodied experience	Using the whole body or body parts for expression.	
	Cartoon metaphors	Visual expressions of metaphors used in spoken language.	
	Arrows	Use of arrows to represent direction, flow, transformation, force, or time.	
Compositional Distinctions	Symmetry	Depicting equivalence among parts of the image.	
	Asymmetry	Depicting a lack of symmetry among visual elements.	
	Repetition	Repeating all or part of an image.	
	Singularity	Depicting a unique element such that it stands alone.	
	Juxtaposition	Depicting contrast through adjacent placement of visual elements.	
	Exaggeration	Using size, shape, or color for emphasis.	

Table 2
Glossary of Visual Principles and Corresponding Visual Features with Definitions and Exemplar Illustrations (continued)

Principle	Visual Feature	Definitions	Exemplars
Line Interpretation	Horizontal lines	Use of lines extending in a horizontal plane.	
	Vertical lines	Use of lines extending in a vertical plane.	
	Active lines	Use of lines that have quick changes of direction, sharp angles, or forceful curvilinear movements.	
	Converging lines	Use of lines that meet at a point.	
	Diverging lines	Use of lines that split into different directions.	

Coding Procedures. Drawings from each artist were scanned and resized to 2" x 2" illustrations. Once all the illustrations were collected, an array of the seven artists' drawings and the representative PCS symbol was compiled for each concept. The drawings were analyzed by two raters (the first and third authors) according to a set of 30 visual features and principles outlined by Horn (1998) and Fuller and Lloyd (1991). Both coders were certified speech language pathologists. Given the subjectivity of the task, prior to analysis, the coders jointly established a reference glossary that defined each visual principle and the corresponding visual features. To ensure that both coders agreed on the interpretation of each visual feature, a representative illustration supplemented the definitions (see Table 2).

Each coder independently analyzed all illustrations using a master checklist of potential visual features. For each illustration, the coders marked whether a given visual feature was present using a binary scale (0 = not present; 1 = present). Given the breadth and diversity of the visual features studied, coders could refer to the reference glossary when making their judgments.

Measures

Post-coding, the ratings of both coders were analyzed on a concept by concept basis. Ratings of the artists' drawings were analyzed separately from the ratings for PCS. Initial inter-rater agreement was 77.9% across all concepts within PCS and the artists' depictions. Inter-rater discrepancies were most noteworthy for the following abstract concepts: "hard," "none," "pet," "pain," "pretty," "that," and "want." Specifically, the visual feature <examples> (i.e., using token exemplars to define a conceptual category) was interpreted by one coder as requiring the depiction of multiple tokens within a concept while the other coder believed only a single exemplar was required. Within the compositional distinctions principle, coders were not always in agreement on the presence of the visual features <asymmetry>, <singularity>, and <juxtaposition>. Subsequent to agreeing upon the interpretation of the discrepant visual features (i.e. examples, asymmetry, singularity and juxtaposition), inter-rater agreement improved to 89.6% across all concepts within PCS and the artists' depictions.

In order to quantify similarities across artists, a visual feature was considered to be commonly used for a given concept if both coders indicated that it was present in 4 or more artists' drawings. Similarly, a visual feature was considered to be present in PCS drawings if both coders rated it as such. These operational definitions provided an initial metric of analysis for an inherently subjective task.

Results

The set of commonly used visual features for each concept rendered in PCS and depicted by the artists are presented in Tables 3 and 4, respectively. In the interest of brevity these results are not reiterated here. Instead, we describe general trends in the visual features used in PCS and by the artists. Additionally, we present the results in terms of common visual features shared across concepts with similar semantic functions in PCS and the artists' drawings.

Commonly Used Features Within Each Visual Principle

All four visual features within the gestalt principle were commonly used within PCS as well as in the artists' renditions. Moreover, these features were common across artists' and PCS renditions for a similar set of concepts. For example, both artist groups used gestalt features to depict the concepts, "all," "animals," "friend," "pet," "in," and "more."

Both the artists and PCS drawings used features within the semantic attributes principle with similar frequency. Only the <anthropomorphism> feature (i.e., representing an inanimate object as human) was not used in the 25 concepts depicted. This finding may be an artifact of the relatively finite set of concepts depicted herein.

PCS renditions were most noteworthy for their use of visual features from the cartoon conventions principle. In particular, the <arrows>, <emotion expression>, and <embodied experience> features were used with far greater frequency in PCS versus the artists' drawings. Both the artists and PCS, however, used all visual features within this principle except <speech balloons>.

There was little agreement among artists' drawings and within PCS in terms of the necessary features within the line interpretations principle. Interestingly, both artists and PCS depicted the concepts "pain" and "talk" using the same visual features within this principle.

With the exception of the <exaggeration> feature, all other visual features within the compositional distinctions principle were commonly used to convey meaning in the artists' drawings and in PCS. Artists and PCS used compositional distinctions to depict a similar set of concepts. In particular, "again," "all," "better," "friend," "he," "more," and "thing" were depicted using features within this principle.

In terms of iconicity, the majority of PCS and artists' renditions were found to be either <transparent> or <translucent>. The artists' renditions, however, were more varied in

Table 3
Visual Features Used to Depict the 25 Studied Concepts in Picture Communication Symbols

Concept Depicted	Visual Principles					
	Gestalt	Semantic Attributes	Cartoon Convention	Line Interpretation	Compositional Distinctions	Iconicity
Again			Arrows		Symmetry, Repetition	Translucent
All	Similarity, Common region, Proximity				Repetition	
Animals	Proximity	Examples			Juxtaposition	Transparent
Better		Increment	Arrows, Emotion expression		Asymmetry, Juxtaposition	
Eat			Embodied experience			Transparent
Feelings	Similarity	Examples	Emotion expression		Juxtaposition	Transparent
Friend	Connectedness		Emotion expression		Symmetry, Repetition	Transparent
Give		Possible outcomes	Arrows, Embodied experience, Motion		Asymmetry	Transparent
Hard			Cartoon metaphors			
He			Arrows, Embodied experience		Singularity	Transparent
In	Common region		Arrows			Transparent
Like			Emotion expression			Translucent
Maybe			Arrows, Cartoon metaphors, Motion		Repetition	Translucent
More	Proximity, Similarity	Increment	Arrows		Asymmetry, Juxtaposition	Transparent
None	Common region					Translucent
Pain		Possible outcomes	Embodied experience	Diverging lines		

Table 3
Visual Features Used to Depict the 25 Studied Concepts in Picture Communication Symbols (continued)

Concept Depicted	Visual Principles					
	Gestalt	Semantic Attributes	Cartoon Convention	Line Interpretation	Compositional Distinctions	Iconicity
Pet	Connectedness					Transparent
Pretty			Embodied experience			Translucent
She			Arrows, Embodied experience		Singularity	Transparent
Talk		Possible outcomes	Physical phenomena, Embodied experience, Cartoon metaphors	Active lines		Transparent
That			Arrows			Translucent
Thing					Singularity	
This			Arrows			
Want		Possible outcomes	Cartoon metaphors			
Yes			Emotion expression, Cartoon metaphors			Translucent

terms of iconicity. While some artists used a particular iconicity level (i.e. <transparent>, <translucent>, or <opaque>) for all concepts, others adapted the iconicity level to reflect the concept's abstractness.

Common Visual Features Across Semantically Related Concepts

In this section, we present the results in terms of the visual features shared across semantically related concepts. Rather than grouping concepts by grammatical roles, we focus on semantic relationships in order to explore whether certain visual features are associated with the underlying meaning of concepts. However, since artists were only provided with a list of words, several concepts were interpreted differently across artists. For example, "like" was depicted by some artists as a term of affection, and by others as a comparison as in alike. Similarly, "hard" was interpreted by some artists as difficult and by others as a description of material characteristics as in the hard surface. Furthermore, given the finite set of concepts depicted herein, not all concepts fell into semantically related groups. Moreover, since many concepts could play several semantic roles, the groupings presented below may not be exhaustive.

Concepts conveying animate agents such as "he" and "she" were depicted using the <embodied experience> (i.e., representations that include the whole body or body parts) and <singularity> (i.e. the use of a unique visual element to indicate that it stands alone) features in the artists' drawings and in PCS (Figure 1). Additionally, in PCS, these concepts were also depicted using <arrows> as pointers. In contrast, for the inanimate

Table 4
Visual Features Used to Depict the 25 Studied Concepts in the Artists' Renditions

Concept Depicted	Visual Principles					
	Gestalt	Semantic Attributes	Cartoon Conventions	Line Interpretation	Compositional Distinctions	Iconicity
Again			Arrows		Symmetry, Repetition	
All	Similarity, Proximity				Repetition	
Animals	Proximity	Examples			Juxtaposition	Transparent
Better					Asymmetry, Juxtaposition	
Eat			Embodied experience			
Feelings	Similarity	Examples	Emotion expression		Juxtaposition	
Friend	Similarity, connectedness				Symmetry, Repetition	
Give			Motion			
Hard						Opaque
He			Embodied experience		Singularity	Transparent
In	Common region		Arrows			Transparent
Like	Similarity				Symmetry	Translucent
Maybe			Cartoon metaphors			
More	Similarity	Increment			Asymmetry, Juxtaposition	Translucent
None			Cartoon metaphors			Translucent
Pain		Possible outcomes	Embodied experience, Cartoon metaphors	Diverging lines		

Table 4
Visual Features Used to Depict the 25 Studied Concepts in the Artists' Renditions (continued)

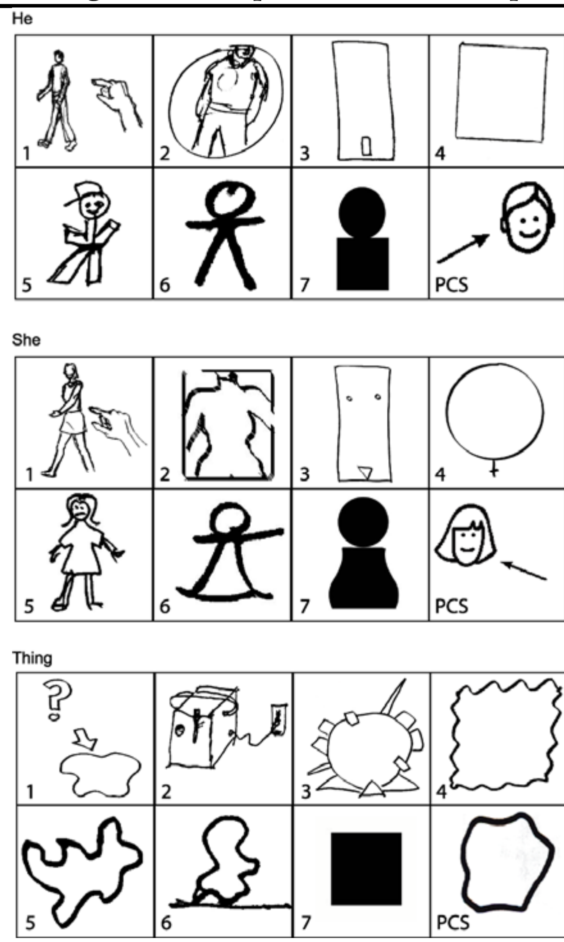
Concept Depicted	Visual Principles					
	Gestalt	Semantic Attributes	Cartoon Conventions	Line Interpretation	Compositional Distinctions	Iconicity
Pet	Connectedness					
Pretty			Emotion expression			
She			Embodied experience		Singularity	Transparent
Talk		Possible outcomes	Physical phenomena, Cartoon metaphors	Active lines		Transparent
That			Arrows		Juxtaposition	
Thing					Singularity	
This			Arrows		Juxtaposition	
Want			Cartoon metaphors		Juxtaposition	
Yes			Cartoon metaphors			Translucent

agent "thing," only the <singularity> feature was common among the PCS and the artists' illustrations.

Relationship concepts such as "friend" and "pet" were conveyed using the <connectedness> feature in the artists' and PCS renditions (Figure 2). Both groups of artists also used compositional distinctions of <symmetry> and <repetition> to convey the concept "friend." It should be noted that "pet" was depicted as both an action and a noun in PCS and by one artist.

In PCS, action concepts such as "eat," "talk," and "give" were all conveyed using the <embodied experience> feature. Additional cartoon conventions were also used to illustrate these concepts in PCS. The artists' renditions used a variety of cartoon convention features which did not overlap across concepts. Both PCS and the artists' drawings used the same visual features to convey these concepts. For example, "talk" was illustrated using <active lines>, "give" was depicted using <motion>, and "eat" was illustrated using the <embodied experience> feature. PCS and artists' drawings, used cartoon metaphors to depict concepts such as "maybe" and "yes" which convey level of certainty and <arrows> to depict concepts such as "this" and "that" which are used to show or point out something directly (Figure 3). The artists also used <juxtaposition> (i.e., conveying differences among element through

Figure 1. Agents were conveyed using the <singularity> feature which casts the visual focus on a single element within the drawing. © 2007, Rupal Patel. Used with permission.



adjacent placement) to contrast the meaning of these concepts.

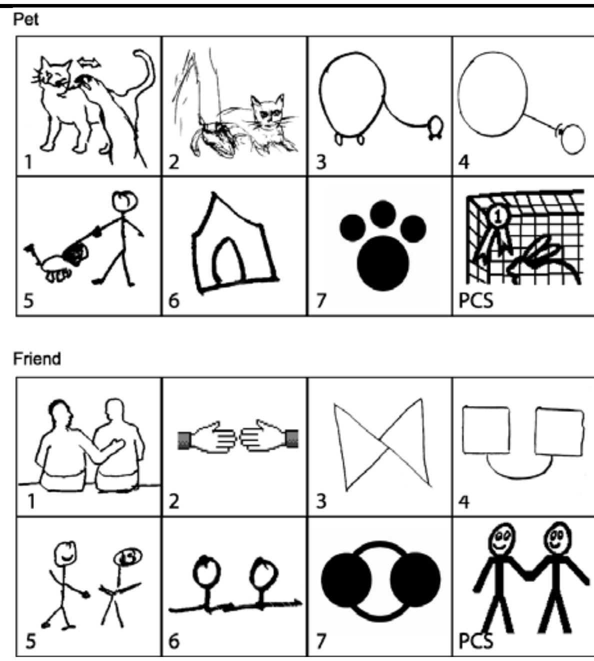
The artists and PCS conveyed comparisons such as "better" and "more" using compositional distinctions of <asymmetry> and <juxtaposition> (Figure 4). Additionally, <arrows> and <increment> (i.e., depicting progression) features were used to convey these concepts in PCS.

Artists and PCS used similar features to convey categorical concepts (see Figure 5). For example, the superordinate classes "animals" and "feelings" were depicted using the <examples> and <juxtaposition> features by both artist groups. Gestalt features such as <proximity> and <similarity> were also used to depict these category concepts.

Discussion

To date, the study of graphic representations in AAC has focused on categorizing symbols along the iconicity continuum (cf. Fuller & Lloyd, 1987, 1991; Soto et al., 1996). The present study sought to provide initial insights for identifying a broader set of visual features for the analysis of graphic representations. The results suggest that it may also be fruitful to analyze graphic representations in terms of visual features within the gestalt, semantic attributes, cartoon conventions and compositional distinctions principles in order to understand which features are necessary for depicting the meaning of concepts. Although line interpretations may also be useful for conveying abstract concepts (Fuller & Lloyd), these features were only commonly used

Figure 2. The <connectedness> feature was used to convey relationships. © 2007, Rupal Patel. Used with permission.



across artists and in PCS for illustrating the concepts "talk" and "pain" in the present study. This finding may be due in part to the limited size and breadth of concepts depicted.

Compared to all other visual features, PCS relied most heavily on cartoon conventions.

Figure 3. Deictic (pointer) concepts were conveyed using <arrows>.© 2007, Rupal Patel. Used with permission.

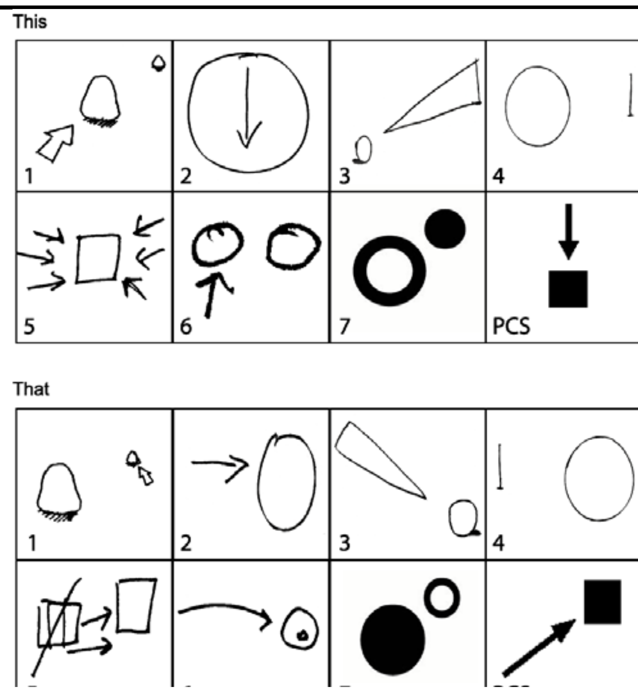
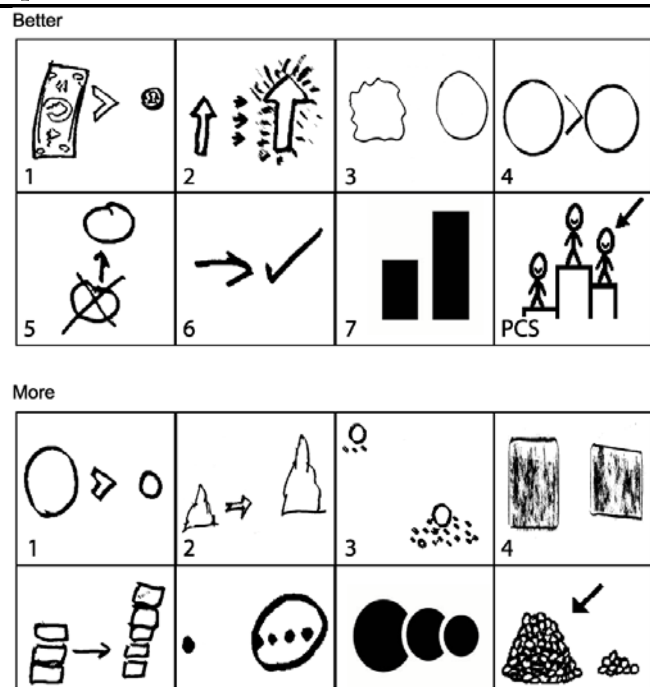


Figure 4. Comparisons were depicted using <asymmetry> and <juxtaposition> features. © 2007, Rupal Patel. Used with permission.



While these conventions may be appropriate for some users of AAC, they may not be obvious to older users or to those from other cultures. [See Huer (2000) for an analysis of differences in interpretations of graphic symbols across cultures.] The use of additional visual features may address a broader range of ages and cultures. Given that Wierzbicka (1996, 1997) identified a set of core semantic primitives that extend across cultures, perhaps a set of visual primitives may also exist for symbol communication. It is possible that these features may be combined to create a novel symbol system appropriate for a diverse group of individuals who use AAC.

With respect to iconicity, PCS and the artists' depictions differed along two main themes. First, artists differed among one another in the degree of iconicity used to depict concepts. Second, PCS were biased toward one end of the iconicity spectrum, namely <transparent> and <translucent>, for all 25 concepts studied. In contrast, the artists tended to use a broader range of the iconicity spectrum (i.e. they also used <opaque> representations). Tying iconicity to a given symbol set may limit the ability to adequately represent the range of concepts from concrete to abstract. Instead, if iconicity were an index of abstractness, users may have additional cues for deciphering the underlying meaning of the concept being depicted.

The visual profiles of a small set of concepts, namely, "again," "animals," "feelings," "pet," "eat," "in," and "thing," were identical across the artists' and PCS renditions. For all other concepts, different patterns of visual features were noted in the artists' and PCS drawings.

An examination of the results in terms of semantic relations revealed patterns in the visual profiles of related versus unrelated concepts. Concepts that differed in meaning also differed in visual profiles. For example, the set of visual features used to convey "better," "eat," and "this" were distinct from one another. On the other hand, semantically related concepts shared common visual features. For example, relationship concepts such as "pet" and "friend" were conveyed using the <connectedness> feature.

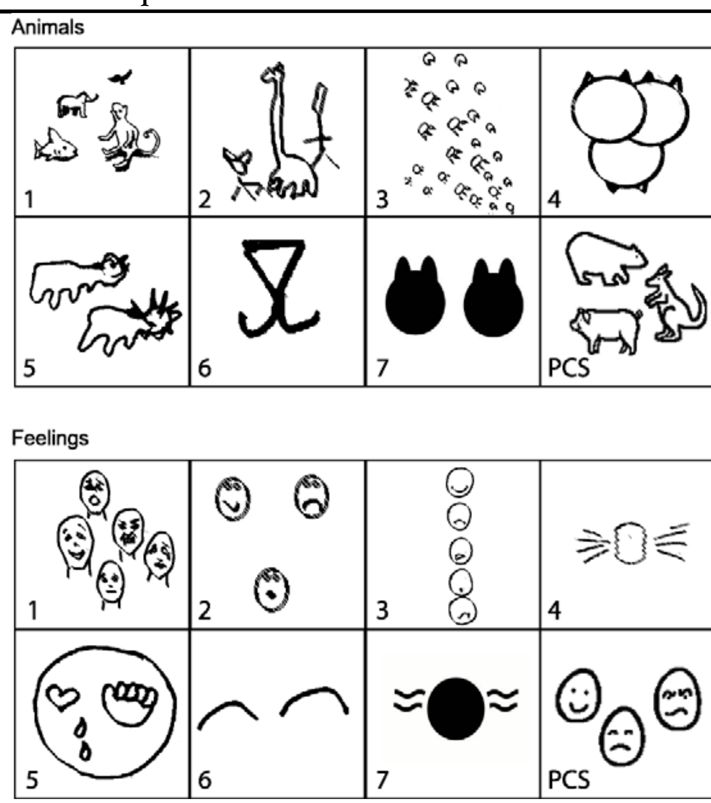
In terms of taxonomic concepts, Schlosser (1997a, b) has noted that existing AAC symbol sets lack visuo-graphic links between representations. The categories "animals" and "feelings" were depicted using the <examples>, <juxtaposition>, and either <similarity> or <proximity> features in PCS and by the artists. Thus gestalt and compositional distinction principles appear to be helpful for visually portraying relationships between elements of a taxonomic category.

In summary, the findings of this preliminary investigation suggest that PCS and artists' renditions included a broad range of visual features to convey conceptual semantics. Further inquiry into the extent to which particular features are used to convey individual concepts or groups of similar concepts is warranted. This additional information would be critical for studying how meaning is conveyed in existing symbols as well as for developing new symbols.

Outcomes and Benefits

The present study sought to identify a broad set of visual features for convey meaning in AAC symbols. To extend beyond iconicity, visual features within five visual principles as defined by Horn (1998) were used to analyze the illustrations of seven artists and PCS. A total of 20 visual features within the gestalt, semantic attributes, cartoon conventions, and compositional distinctions principles were commonly used across concepts. While the visual profile of the PCS and artists' renditions were identical for a small set of concrete concepts, the two groups differed in the features used to depict a majority of concepts. PCS renditions relied on cartoon conventions. In contrast, a broader range of features were present within the artists'

Figure 5. Category concepts were illustrated using the <examples> and <juxtaposition> features. © 2007, Rupal Patel. Used with permission.



renditions. The two groups also differed in the degree of iconicity across concepts. While the artists' depictions spanned the iconicity continuum, PCS renditions tended to be either <transparent> or <translucent>. Despite differences among artists' and PCS depictions of individual concepts, common visual patterns were noted among both groups for conveying related versus unrelated concepts. These findings suggest that a broader set of visual features may be useful for analyzing how meaning is conveyed in existing symbol sets and for developing novel symbol systems.

While this initial investigation provides interesting insights into a broad set of visual features that may be useful for studying graphic representations, it also evokes many open questions that require further inquiry. Furthermore, the results must be interpreted with caution in that the set of concepts depicted was limited. A larger set of conceptual items are required to generalize these findings. Providing artists with definitions of each concept would reduce the confounding effects of different word senses. Methodological changes in subsequent investigations should consider the homogeneity of artists with regard to training, cultural backgrounds, and level of experience. In addition, informing artists about the target population's needs and abilities may yield findings that are more relevant to users of AAC. With regard to the set of visual features and principles studied and the coding scheme, this investigation was a first step in extending visual analysis of AAC graphic representations beyond iconicity and complexity. Some visual features proved difficult to interpret and thus a more detailed glossary of feature descriptions may be necessary to improve rater agreement. Future work may also benefit from focusing on the subset of visual features that were reliably and commonly used in the present study.

In terms of implications of this work, additional research is required to assess whether individuals who use AAC and their communication partners may benefit from graphic representations that utilize a broad spectrum of visual features and whether these elements help in decoding the semantic content. The study of age and culture specific differences in interpreting graphic representations may also be fruitful.

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Universal Design for Learning: Critical Need Areas for People with Learning Disabilities

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Abstract: The primary market research outlined in this paper was conducted by the Rehabilitation Engineering Research Center on Technology Transfer to identify critical technology needs for people with learning disabilities. Based on the research conducted, the underlying context of these technology needs is Universal Design for Learning (UDL). The paper will review demographics of the target population, the role of mainstream and assistive technologies within this context, and the emerging concept of UDL in modern education. The study investigates the educational technology industry from various expert perspectives and provides insight into its current state, unmet needs, and future course of action for the adoption of UDL in classroom settings. The intended primary outcome of this research is the facilitation of development and transfer of educational and assistive technology solutions through inclusion of data in marketing materials, business planning, and grant development. However, the benefits of the research include informed policy makers, improved pre-service teacher training, and increased knowledge and awareness of the need for UDL environments.

Key Words: Universal design for learning, Assistive technology outcomes, Learning disabilities, Education technology, Classroom technology

Today's classrooms are comprised of more diverse learners than ever before. Reflecting recent educational and societal movements, over 95% of students with diagnosed disabilities participate in the general education classroom alongside their peers (U.S. Department of Education, 2001). For many education professionals, students with disabilities are seen as an encumbrance as they may need accommodations (i.e., time, technology, or changes in curriculum) to succeed. The hindrance to content mastery is seen as residing within the student and not within the teaching paradigm (McDonald & Riendeau, 2003). McDonald and Riendeau stated that providing a classroom where all students can learn is really more of an issue of "learning diversity" (p. 87) where individual differences are not only expected, but celebrated. This idea is certainly optimistic, but it captures some of the key components of other more popular movements in education such as Universal Design for Learning (UDL) proposed by the Center for Applied Special Technology (CAST, 2006).

This research, conducted at the Rehabilitation Engineering Research Center on Technology Transfer (T2RERC), presents the outlook of experts on current trends and unmet needs in the realm of technologies for education. Although the population of interest was students with learning disabilities (LD), the study was conducted in the backdrop of UDL as an emerging concept to *seamlessly* *accommodate* those with LD in an inclusive learning environment. In doing so, the main focus was to identify *critical needs* in the form of technological solutions and improvements that would facilitate the application of UDL. The study also elucidates carriers and barriers to the advancement of UDL from the perspectives of technology development, pedagogy, and public policy.

Universal Design for Learning

UDL is an approach to instruction, learning, curriculum development, and assessment that, in part, uses technology to respond to a variety of individual learning differences. A central focus of UDL is to promote the development of new curricular materials and learning technologies that are flexible enough to accommodate the unique learning styles of a wide range of individuals, including children with disabilities (CAST, 2006). CAST's co-executive director, David Rose, is quoted as saying:

> A universally designed curriculum is a curriculum that has been specifically designed, developed, and validated to meet the needs of the full range of students who are actually in our schools, students with a wide range of sensory, motor, cognitive, linguistic, and affective abilities and disabilities rather than a narrow range of students in the "middle" of the population (as cited in Hitchcock & Stahl, 2003, p. 45).

The current trends toward innovative teaching methods embrace the idea that classrooms are becoming increasingly diverse. Teaching methods must adapt to reflect this diversity. In any well established system, the introduction of a novel approach meets barriers. Likewise, in the educational system, barriers slow the acceptance of learning diversity and the implementation of UDL concepts.

A curriculum designed with the principles of UDL is by definition appropriate to all students. Students with specific LD will be focused on in this article, as they represent 45% of students with disabilities in today's classroom (Snyder, Tan, & Hoffman, 2004).

Learning Disabilities in Context

A learning disability is a general term used to describe a student with specific learning problems that effect reading, writing, listening, speaking, reasoning, and doing math (National Dissemination Center for Children with Disabilities, 2004). A majority of students who experience learning disabilities have difficulty mastering content in a traditional classroom environment. A key problem for these students is that the preponderance of materials, including textbooks, workbooks, worksheets, trade books, and tests, are provided in inaccessible standard print format that students with LD, and those at-risk of failing in schools, cannot comprehend.

In 2001, the U.S. Department of Education reported that some form of LD affects nearly 5% of children in public schools and that an estimated 2.9 million students currently receive special education services for learning disabilities (National Center for Learning Disabilities [NCLD], 2004). Recent data from the U.S. Department of Education estimates that 2.7 million students between the ages of 3 and 17 years have a specific LD and were served by an individualized education program (IEP) during the 2003 school year (Ideadata.org, U.S. Department of Education, 2004). Alarmingly, this data also indicated that an estimated one-third of children are *at-risk* for academic failure and continue to struggle with some form of undiagnosed LD (Shaywitz, 2003). Given the high unemployment rate (76%) and dropout rate

(27.1%) for students with LD, this is a serious concern that can and should be addressed through a supportive learning environment for all children (Bridges to Practice, 2002; Hurst & Hudson, 2001; National Institute for People with Learning Disabilities, 2007; U.S. Department of Education, 2001).

This is an important consideration for educators and an opportunity for people developing technology. Many members of this undiagnosed population of children have been identified as *at-risk* for academic failure. According to Thurlow, Sinclair, and Johnson (2002), students at-risk for academic failure "include children with disabilities, students from low-income families and communities, and students with non-European American or non-Asian, single parent backgrounds" (p. 2). They may in the future be diagnosed as having LD or they may simply remain labeled as at-risk and fail. Regardless of whether they are formally diagnosed, the opportunity to address the needs of these children, using curriculum and technology encompassing the UDL philosophy, must be capitalized upon. Failure to provide these children with appropriate support academically and technologically will ensure that schools do not meet the Annual Yearly Progress (AYP) outlined in the No Child Left Behind Act of 2001 (Thurlow, Sinclair, & Johnson). Students with a LD and those labeled at-risk for failure are also likely to leave the school environment without a diploma or certificate of completion, placing them at a greater risk of facing significant obstacles after leaving the secondary education environment (Grumline & Brigham-Alden, 2006). These risks include incarceration, unemployment, or underemployment (Thurlow, Sinclair, & Johnson). The opportunity to assist these students though UDL classroom technologies provides technology developers with new business opportunities.

By modifying how information is provided, educators can ensure that all students can access information in ways that are understandable to them. Many children today have grown up with technology. Leveraging their knowledge of technology provides an opportunity for efficient and effective instruction in school environments (Peterson-Karlan & Parette, 2005).

Role of Technology

In order to understand the role of technology in today's schools, it is first important to understand the difference between what is defined as assistive technology (AT) and what is meant by educational technologies. According to the Technology Related Assistance for Individuals with Disabilities Act of 1998:

> 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 individuals with disabilities. [§3(a)(3)]

The term technology in education, or *educational technology*, "consists of a wide range of hardware, software, and technical equipment used in schools to promote learning" (North Central Regional Education Laboratory, 1997).

The boundary between AT and education technology is blurring in American schools. AT devices are often considered to be education technologies when used by students without disability labels. However, in order to maintain funding mandates for students with disabilities who require technology, any technology that is needed by a student with a learning disability to participate in the general curriculum is considered an AT (Edyburn, 2000). In order to overcome such contradictory definitions, the technologies that are of interest to this study are referred to as *classroom technologies*, regardless of whether they are used by students with LD exclusively.

Due to recent legislation and societal trends, many commercial technology developers now include features in their products that enable learners with diverse abilities, languages, and learning styles to successfully use their products. Software features such as changeable displays, text highlighting, keyboard commands, progress monitoring, and speech options are more frequently included in mainstream education technology products. Before this trend began, many of these capabilities were primarily found in assistive technologies; those designed for individuals with disabilities. When a company designs for all using UDL principles, it can also sell to all. This allows the company to take advantage of the larger resources available to American schools for funding technology.

Many companies are embracing the principles of UDL that support the idea that any technology used in classrooms should enhance all students' academic performance. In spite of this industry trend, an artificial distinction remains between what is considered education technology and what is considered AT. As students with and without disabilities learn together in the same classrooms, all students should have the opportunity to benefit from an expanded inventory of well designed classroom technologies.

In a curriculum incorporating UDL principles, technology becomes part of the classroom for all students. It supports the "multiple means of expression, multiple means of representation, and multiple means of engagement" that are core principles of UDL (CAST, 2006). UDL recognizes that all students learn differently and promotes a multi-modal curriculum to ensure that all students have access to the information presented in the classroom (Meyer & Rose, 2000). While technology can and does facilitate access to materials, and supports the offering of learning materials in multiple formats (Montali & Lewandowski, 1996), it cannot ensure that students will actually learn the materials. Rose (2000) reminds us that merely providing access to classroom materials does not immediately translate into access to learning. There is still a need for AT devices in the classroom, because many students with disabilities require the specialized access that AT provides. In fact, some AT can benefit *all children* in the classroom. For example, students who are English language learners can reap great benefits from captioning as they master their second language (Koskinen & Wilson, n.d.). According to the National Captioning Institute (n.d.), "captioned television improves reading and listening comprehension, vocabulary, word recognition and overall motivation to read among students who are learning English as a second language." Children who are learning to read or who are labeled at-risk can also benefit from captioning (Caption First, n.d.). The innovative application of technology, whether AT or simply educational technology, enhances learning for all students whether or not they have a disability.

The T2RERC is a federally funded Center whose mission is to facilitate the transfer and commercialization of innovative technologies to the marketplace to meet the needs of people with disabilities and the elderly. The *Demand Pull* Technology Transfer project at the T2RERC was designed to identify critical technology needs in specific industry segments (Bauer, 2003). Within the segment of educational technology, the project focuses on critically needed technology for children with learning disabilities and, by extension, those labeled at-risk for academic failure.

Research Objectives

In the preliminary phase of the project, extensive secondary market research was conducted to recognize the state of the educational technology industry and to provide a basis to conduct further primary market research to examine unmet technology needs. The output of this study sheds light on the movement towards adoption of UDL in the field of education. The document also lists and describes a vast array of technologies and products in the educational technology that can be classified in four primary domains: (a) computer applications for students, (b) hand-held devices, (c) presentation and media applications, and (d) teaching and instruction tools and training.

In consideration of this scenario, the primary market research conducted in this study had two major objectives: to (a) validate the concept of UDL as a fundamental basis for the development and improvement of classroom technologies, and (b) identify *critical needs* that must be addressed to facilitate the use of classroom technologies in a UDL environment.

The goal of this project is to disseminate this critical information to manufacturers and other technology developers thereby providing them a strategic guide to the market demands and expectations of experts in the field. The expected outcome, as per the T2RERC mission, is the introduction of novel and improved classroom technologies that would benefit people with learning disabilities and those at risk of academic failure.

Method

In order to fulfill the research objective, the study was designed through the active participation of industry experts in the field of educational technology. A series of interviews was conducted with industry experts, including manufacturers, researchers, and practitioners to identify broad categories of critical technology needs. This interview data was used to establish a framework that reflected the current state and emerging trends in the educational technology industry and to categorize critical technology needs as outlined by the experts.

Expert Interviews

Sample. Twenty experts with broad experiences in the field of LD and AT were interviewed. These experts were members and active participants the Assistive Technology Industry Association, who demonstrated prior experience in developing and commercializing assistive or universally designed technologies. Researchers and practitioners qualified as experts if they had significant publication and training histories in research and practice. The sample size and the sample composition (40% manufacturers, 30% researchers, and 30% practitioners) were preset and considered appropriate to optimally address the research objectives.

Interview Protocol and Instruments

All interviews were conducted by two researchers with extensive experience in technology for students with LD, and a notetaker who captured key points of the interviews. The interview protocol was developed over the nine years of conducting the *demand pull* technology transfer (Bauer, 2003; Lane, 1999) and *Industry Profile* (Bauer & Stone, 1999) projects at the T2RERC. The interview protocol consists of three main categories of inquiry: (a) needs identification, (b) state of the practice, and (c) future technologies and products.

Table 1
Generic Expert Interview Questionnaire

Needs Identification
1. What needs are poorly met?
2. Why are these needs important?
3. Who is most affected?
4. In which roles and contexts are these needs most critical?
State of Practice
5. What products now address these needs?
6. What are the strengths and weaknesses of these products?
Future Technology and Products
7. What new or improved products are needed?
8. What research and technology is needed?
9. What barriers delay product development?
10. How might these barriers be overcome?

The questions asked were generic, but were also designed to address specific critical needs in each AT area explored. In order to avoid interviewer bias, the concept of UDL was not addressed in the questions. This approach seemed rational because the focus of the study was not to understand or conceptualize UDL, but to use it as a frame of reference in the analysis to link and describe the identified *critical* and *specific* technology needs. The generic questionnaire is presented in Table 1.

In order to provide a common ground and structure to the interviews, the questionnaire was derived from the Industry Profile on Education Technology (Strobel, Arthanat, Fossa, Mistrett & Brace, 2006), which highlighted the current state, trends, and domains in educational technology. The interview protocol was developed in one month and was reviewed by the Industry Profile project manager, the principal investigator, and the T2RERC evaluation expert.

Interviews were scheduled at the convenience of the experts over a two-month period. Prior to each interview, experts were emailed an explanation of the project goals and a list of the questions that would be asked during the interview period. They were advised that it was not necessary to answer the questions in writing, as the intent was to foster dialogue via the teleconference call with each expert. In order to respect the time constraints of the experts, each interview was scheduled for and conducted in a one-hour time period. The

Table 2
Coding Process: Examples of Codes and Critical Needs in UDL

Raw Data	Code	Critical Need	Frequency
We need tools that can help 90% of the students and that can be adapted to the rest 10%	Customizable technologies for general classroom	Novel technologies	2
UDL technology is mutually beneficial for teachers and students. Teachers' time required for each individual student will be saved and kids love to learn through technologies as well	UDL concept enhances teacher student interaction and is mutually beneficial	Carriers	5
Teachers need to be skilled in assessing students' strengths and weaknesses within an inclusive setting	Application of technologies by teachers for all students is challenging	Barriers	1
Technology needs to be simpler and user-friendly for both students and teachers as well	Need to improve usability and accessibility of current technology	Needed improvements	1

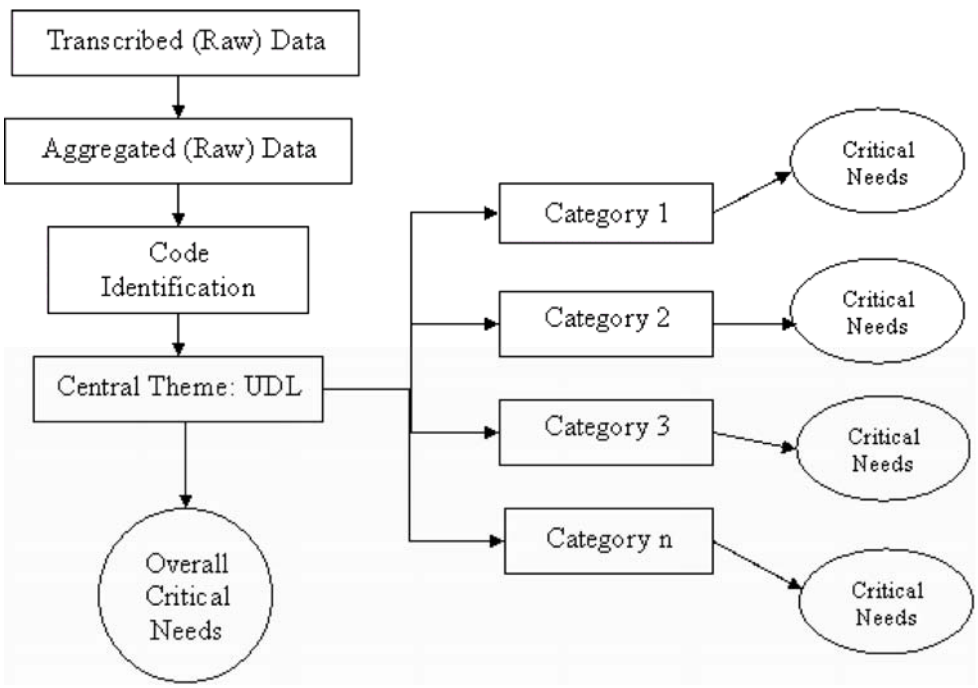
interview sessions were recorded and transcribed for coding and analysis.

Data Analysis

The data from each individual interview transcript was aggregated and all proprietary information (relating to specific technologies) was removed. The aggregated data were analyzed to identify salient themes and critical needs as expressed by the 20 experts interviewed. Based on methods outlined on *content* or *thematic analysis* (Boyatzis, 1998; Krippendorf, 1980; Strauss, 1987), an inductive approach was used to analyze the transcribed data. Inductive reasoning is *data-driven* and is a proven method in qualitative enquiry by which themes, conclusions, or theories are drawn by the researcher based on the identified codes in the data (Boyatzis).

The Industry Profile project manager first reviewed the transcribed data several times to identify open codes, which in this context denoted any piece of perceptible information in the expert statements that highlighted changing trends, expectations and unmet needs in the educational technology industry. The codes were analyzed to validate the central theme of UDL in the interview data. Technology needs relevant to the UDL theme, referred to as *critical needs*, were identified and reported as relating to a *novel technology* and *improvements to existing technology*, and *carriers* and *barriers* for meeting those needs. The frequency of codes (the number of needs and the number of experts expressing a particular need were recorded to reflect their significance in the data. Technology-specific or domain-specific codes in the central theme were categorized as *specific needs* based on their relevance to various areas or domains in classroom technology. In summary, the interview content was conceived as being

Figure 1. Stages in the coding and analysis of UDL based critical needs.



composed of one central UDL (theme) component that embodied the emerging trend and future path of the educational industry with several related sub-themes and categories. The theme and its categories in essence served as a framework by which the expressed technology needs (codes) in the data could be classified into corresponding *components*.

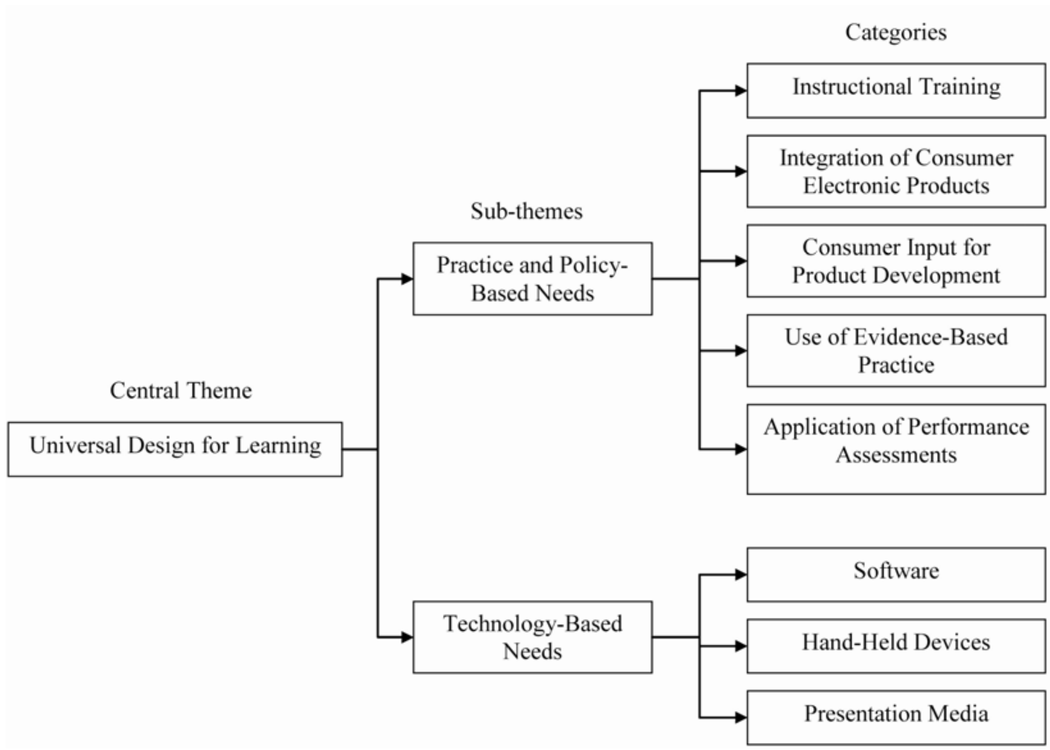
The categories in the theme (components of the framework) were defined and described in order for reliable classification of the identified technology needs. Critical needs that were not specific, but generally vital to the adoption of UDL were listed as *overall critical needs,* while the needs specific to each category of the UDL theme were described exclusive to the categories. Figure 1 illustrates the stages involved in the coding of the data and the analysis of the overall critical needs and category-specific needs. Table 2 presents four distinct pieces of information in the data that were subsequently coded to identify and categorize the critical needs.

Codes that were extraneous to the central UDL theme, if found, were to be analyzed, listed and described separately. To ensure reliability in the analysis, the developed theme and its categories were further refined after review by other members of the research team. Subsequently, the transcribed data was further reviewed by two members of the research team, who validated the existence of the identified critical needs and ensured that they were categorized appropriately within the developed theme.

Results

In terms of participant demographics, the 20 experts interviewed included nine manufacturers of AT or UDL tools. The remaining 11 were six researchers in the field of educational technology and five AT practitioners with experience in school

Figure 2. Sub-themes and categories within UDL.



settings. The findings from the critical needs analysis are discussed below sequentially beginning with the overall critical needs within UDL, and then progressing to the description of the categories and their corresponding needs.

Critical UDL Needs from Expert Interviews

All 20 experts unanimously and overwhelmingly stressed the importance of teaching students in an inclusive environment, the analysis of the interview data indicated. The underlying premise of UDL from the perspectives of new technologies and improvements to existing technologies was clearly evident in varying explicit and implicit degrees.

The primary market data revealed that nearly 92 statements in total reflected the general importance of the need to adopt UDL concept in classrooms. Among those, 37 distinct comments from the experts supported the premise that UDL was imperative to effective instruction and technology integration into today's classrooms. For example, 16 of the experts explicitly stated that the curriculum used in schools should be accessible to all students, using tools such as cognitive rescaling (as defined by Edyburn, 2002), curriculum sharing, and meaningful assessments. Another key comment was that technology tools should be made accessible to 90% of the student body and be adaptable for the remaining 10%.

The central UDL theme was composed of two broad sub-themes: (a) practice- and policy-based needs; and (b) technology-based needs. The *practice- and policy-based* improvements needed to facilitate the

Table 3
Practice and Policy Categories and Representative Statements from the Experts

Category	Exemplars
Instructional Training	Remediate learning problems by assessing the overall organizational approach as opposed to the task- by-task approach. Search engine for teachers to identify appropriate technology as needed. More efficacy studies are needed to validate what teachers should do to intervene with technologies and accommodations. To recognize what technology accommodations children require, performance based assessments should be used. Need for teachers to be creative and open to changing teaching strategies.
Integration of Consumer Electronics Products	Incorporate consumer electronics products as educational tools.
Consumer Input for Product Development	Feedback from teachers and consumers is helpful for developing next generation products.
Use of Evidence-Based Practice	Results from evidence-based practice should be disseminated to teachers.
Application of Performance-Based Assessments	Teachers should be better at using performance based assessment to identify student's strengths and weaknesses in an inclusive setting.

adoption of UDL in schools were related to five major areas: (a) instructional training; (b) integration of consumer electronic products; (c) consumer input for technology development; (d) use of evidence-based practice; and (e) performance assessments. The technology based needs were specific to software, portable devices, and presentation media. Figure 2 displays the sub-themes and their corresponding categories that stemmed from the central UDL theme.

Practice- and Policy-Based Needs for UDL Adoption

There were many practice- and policy-based needs identified by the expert interviewers. These included instructional training for teachers, integration of consumer electronics products into the classroom, consumer input into product development, use of evidence-based practice for classroom technology, and the application of performance-based assessment in the classroom (See Table 3).

Instructional Training

A major portion of the interview data (nearly 100 statements) attested to the needed improvements in training for teachers and administrators to improve the implementation of technology and the delivery of curriculum in the schools. The reasons for these statements varied. Some experts stated that because students are so comfortable with current technologies, teachers must know how to use it correctly to ensure that it is beneficial in the learning environment. Interestingly, four experts characterized teachers as "digital immigrants" and their students as "digital natives." Thus, if teachers hoped to implement technology in the classroom appropriately, they need sufficient training to keep up with their students. Others stated that technology integration was a *carrier* in ensuring that students were engaged in the classroom and in learning.

Forty-one comments regarded the need for training on technology — both technology used for teaching and technology to enhance student performance. For example, 12 comments addressed the need to provide teacher training on accessibility features of current technology. Another 10 stated that teachers needed ongoing training on available technology. Another expressed need was that teachers required specific training on technology that supported math instruction and performance.

As a novel concept (technology), some experts even specified tools that should be created and maintained to make this task easier, such as a database or search engine that would help identify needed technologies. According to experts, this database would include available technologies and a search mechanism that allowed for inputting functional limitations to identify "ideal" technology for a specific student. Experts recommended a number of novel tools that would enhance teacher training, including web-based training tools that would allow for "anytime" training to accommodate teacher's busy schedules. As a barrier that needed to be overcome, experts stated that many school administrators were not supportive of a rigorous training regimen necessary to ensure the appropriate levels of technology literacy in school staff. Others felt that it was the responsibility of manufacturers to provide training to teachers on their specific products.

Eleven experts stated that teachers require training on the implementation of the broad teaching styles that would engage today's students. As a *barrier*, some experts felt that some teachers' unwillingness to be creative and open to changing teaching strategies means that they fail to engage the diverse student population in their classrooms. Finally, 36 expert comments identified the need for training for teachers that would help them accommodate and understand the functional limitations associated with disability labels. They stated that many teachers tend to give the same accommodations to all students with disabilities, despite the difference in the needs of each group. These typical accommodations were identified a (a) extra time to complete work; (b) task break-down into smaller, more manageable pieces; (c) priority seating; (d) color coding materials; (e) providing typed notes; and (f) and reading aloud.

The experts in this study outlined a number of *barriers* to the success of accommodations like those described above in the classroom. The first *barrier* to successful accommodation was an inability to effectively measure the impact of these accommodations. Furthermore, since the accommodations provided to a student in a classroom one year are often not recorded in any meaningful way, it is impossible to replicate that success as the student moves from grade to grade or from school to school. Second, experts stated that many accommodations were seen as 'cheating' by many in the school district and as a result, those who used them were sometimes stigmatized. This barrier was labeled as more an attitudinal barrier than a limitation of the accommodations themselves.

Integration of Consumer Electronic Products

The second theme identified by 14 expert statements was the need to include current, popular technologies (i.e., MP3 players and digital phone technology) in the classroom. Experts stated that these technologies were ideal for classroom implementation because they are relatively inexpensive, simpler, more user friendly, and applicable to a wide range of students. The reasons given to support this statement addressed the reduction of stigma around the use of AT. Experts agreed that many students were concerned with how they appeared to others when using technology that was not normally used by students. Others raised the issue of students' tendencies to abandon AT. Some experts believed that these simple classroom technologies would stimulate and encourage learning in students. However, one of the expressed barriers was the misuse of these technologies while students were supposed to be attending to classroom instruction.

Consumer Input for Technology Development

Consumer input into product design and marketing of new products was the third theme identified by experts with 10 expert interview statements. This was seen as a valuable tool for development due to the knowledge that this generation of children has regarding the use of technology. According to the experts interviewed, school personnel could also offer insight into what the products needed to do to work in the classroom. Consumer input was also seen to be a great benefit to manufacturers who continuously incorporate new product features and functions to improve their products.

Use of Evidence-Based Practice

Experts wanted to see an increase in the efficacy testing of new technology products to ensure that the tools used would be effective in the classroom. Ten experts stated that there was a need to improve research on teaching methods, data collection and analysis, and impact data for varying teaching methods. The experts listed several *barriers* that prevented this research from being conducted effectively. Lack of funding was a barrier, and as a result, small companies face difficulty in conducting research effectively. They also stated that the limited population of students who received services under the Individuals with Disabilities Education Improvement Act of 2004 (IDEIA, 2004) limited the pool of research candidates under the current system. Finally, experts stated that the requirement to conduct evidence-based research delays product introduction.

Application of Performance Assessments

The final issue identified was the need for performance-based assessment for children with disabilities. As a barrier, experts stated that there is currently a lack of meaningful assessment and testing for many students with disabilities because of the methods used to deliver standardized assessment and the exclusion of many classroom technologies in administering these tests. One of the stated needs was school personnel should more adeptly assess the strengths and weaknesses of their students. They also felt that school personnel should focus more on the knowledge gained versus teaching the confines of a standardized test. Experts also stated that performance-based assessments, in a universally designed learning environment, would allow a clearer picture of skill sets versus diagnosis and disability labels.

Some of the expert comments related to instructional training were also tied to performance testing, as assessment and planning were identified as other areas in which teachers required training. While experts were excited about the development of web-based assessment tools, they expressed concern that teachers required additional training on how to conduct effective assessments and how to implement performance-based assessments. The lack of knowledge on how to include classroom technology in assessments and on standardized tests was seen as a major *barrier* to the success of students. Experts also stated that teachers needed additional training on how to write and implement effective IEP and other intervention tools.

Table 4
Technology-Based Needs Categories and Exemplars from the Experts

Category	Exemplars
Software	Teachers must be able to optimize software for the student through the use of a set-up wizard.
	Math software must be more than drill and practice.
Handheld Devices	A wider variety of tools should be available for handheld devices.
Presentation media	Organization of multimedia presentations should be facilitated using graphic organizers in programs, such as Inspiration or Spark Space.

Technology-Based Needs

Experts identified several technology-based needs they wanted to see implemented in classrooms. These included improvements in software used in the classroom, improvements to hand-held devices such as PDA's and MP3 players, and improvements in presentation media used by both teachers and students. Table 4 illustrates identifies these categories and representative statements from experts.

Software

According to experts, there is a tendency to use computer software for the classroom as it is shipped, with little regard to the potential customization that is possible with the application. No expert explained why this phenomenon occurred, but 35 expert comments pointed to the need to develop a set-up feature, or set-up "wizard," that would take the teacher/student through the potential features of a product to determine the optimal set-up for an application. Comments included a list of potential features that should be included on software systems to allow for optimal customization. Features described did not include common accommodations already available (i.e., spell check, auto-summarize, etc.). However, additional features for consideration included: font and background color selection; picture supported text; improved text to speech; improved speech recognition; contextually based word prediction; organizational support; dictionary support; scanning input; and phonetic spell checking.

Experts also stated that they were concerned that accessibility features found in programs such as Microsoft® Word were commonly overlooked despite their availability and easy set-up. They stated that the set-up wizard may not only alert users to the availability of these features, but would also encourage customization of software applications for specific users. Some experts stated that including a set-up wizard with all of the features listed above would be too costly and burden developers. They suggested instead the use of portable features that could be included in a USB drive and given to all students with the personalized accommodations that they needed. Others saw this as an unsuitable solution as students were likely to lose the portable drives.

Although Instant Messaging language was suggested as an input mechanism into software applications, it was a highly contested issue. Some experts felt that it would enable many students to input text more effectively and efficiently, as they are highly socially motivated to use this input system. Others felt that it was a *barrier* and would negatively impact students writing skills.

Experts also stated that there was a need to develop additional math software. They stated that math software needed to offer more than just drill and practice, and should be developed with an eye towards learning and understanding concepts without giving the answers to specific questions. Experts stated that they wanted math software that was geared toward grade 5 and above, as many products were available that addressed basic math skills. Finally, they stated that math software should be interactive to ensure that students were engaged in the lessons.

Handheld Devices

Forty-three expert comments focused on the development of handheld devices (i.e., PDAs and digital phones) that would enhance student learning. Recommended improvements to these devices included increasing the ease of use for K-12 students with disabilities. Experts stated that because students enjoy using these technologies, there would be no stigma associated with their use. The following specific needs were included in the list of needed improvements: (a) wider variety of tools should be made available, (b) alternative input systems should be incorporated into the system, (c) larger buttons should be created, (d) increased display space for text should be made available, (e) devices should be made available at lighter weights, and (f) cost should be reduced.

Many experts saw these devices as easy to incorporate into classrooms activities; however they also had reservations. First, ensuring that all students had access to these systems was seen as a very large barrier to implementation in classroom environments. Second, many comments expressed concern that these devices would give students the opportunity to "play" (i.e., to send instant messages or email) with the devices rather than to pay attention to the teacher.

Presentation Media

Experts identified improvements that should be made to presentation media for the sake of both teachers and students. Sixteen expert comments stressed the need to ensure that the presentation media used should use a multi-media format. Experts stated that presentations that did not employ multi-media could be too difficult for many students with processing disorders that often accompany LD. Many expressed concern over the common use of printed material despite their lack of accessibility.

Formatting issues were identified as a major issue by 13 experts. They identified the need for novel tools that would potentially improve the effectiveness of existing presentation media technologies. These included: (a) tools to improve the clarity of the information presented, (b) tools to improve the timing of presentations, (c) tools to improve the organization of presentations, (d) tools to promote interactivity between the audience and the presentation, (e) tools to improve summarization of important information, and (f) incorporation of concept mapping in designing presentations. Additional comments encouraged the use of the Internet as a tool for presentations.

Experts stressed that no single presentation tool would be effective for all and therefore suggested improvements to several visual presentation media. Projectors were seen as effective tools for presentations in group environments. However, many experts considered their cost to be a barrier to universal availability. They also stated that projectors should have better lighting and should be effective for use in large rooms. Microsoft® PowerPoint was identified as an excellent tool for multi-media presentations and one that appeals to students. They felt the additions of the tools listed above would enhance its usability and ensure higher quality presentations. Interactive whiteboards were also seen as effective tools for multi-media presentations and as being especially effective tools for math instruction. However, the cost of these tools was seen as prohibitive to widespread implementation. Experts also stated that virtual learning environments and video-conferencing should be more widely utilized in schools.

Experts recommended improvements to the way audio material was presented in classrooms. Specifically, six experts promoted the use of sound-field systems in the classroom. They listed a number of benefits to this presentation media, including: (a) high quality audio output to all students regardless of their location in the room; (b) the ability of these systems to overcome issues such as noise, reverberation, and distance; (c) the ability of these systems to provide sufficient amplification; and (d) the benefits to students with auditory processing disorders. An expressed barrier was that teachers had difficulty maintaining these systems effectively.

MP3 files and players were also recommended as effective tools for the presentation of audio files. Experts identified the ease of conversion of audio files into MP3 formats, the large storage capacity of portable systems, and the ubiquity of the systems as benefits of using this technology in schools. However, experts expressed concern over the possibility of inappropriate use of these systems during class time. They also stated that the headphone technology used with these systems should be improved to increase comfort and prevent damage to hearing.

Discussion

Expert interviews established that needed technology most often contains elements of UDL. The interviews centered on the theme of UDL and identified critical needs for its overall advancement. The underlying premise of the topics addressed during each interview was the need for an educational environment that supported universal design for learning: In other words, an environment that allowed all children to learn in a common environment while allowing students to optimize the educational opportunity by using a variety of individualized tools that fit seamlessly into the classroom environment.

Experts credited the large numbers of students labeled at-risk for failure, which they estimated at approximately 50% of students in the classroom, as the practical reason for including UDL concepts in education and AT applications. Experts often recognized the standardized testing requirements created in NCLB for identifying these children. These children have not been identified as having a learning disability, but still struggle with standardized tests because of poor reading skills and inability to excel in current school environments. Consumers also supported the UDL concepts but emphasized benefits derived from the elimination of stigma around the use of assistive technology.

The most important educational concern, cited by a majority of experts, was for students with an inability to obtain meaning from print. This problem is most pressing when combined with the need for timely access to curricular materials. Participants indicated that the ability of students with LD to advance academically is significantly hindered by delayed access to materials. The overarching need for UDL classrooms and technologies to complement assistive technologies is clear.

This study clearly identified the need for schools, teachers, and students to embrace inclusive educational technology and AT to meet the needs of all students in the classroom. Participants made it clear that the current approach to accommodation is not working for many students. Although there was no formal reliability analysis of the coding, multiple reviews, discussions and iterations of the identified codes within each category by the research team merited the analysis.

Prior to this work, secondary market research was collected on a variety of topic areas and reported in the *Industry Profile on Education Technology: Learning Disabilities Technologies and Markets*. As a reference, the Industry Profile offers an overview of the learning disabilities, demographic and market information, a review of technology, legislation and funding, and appendices that include a manufacturer index, an index of national organizations and associations, and a listing of relevant national conferences. This document can be downloaded from the T2RERC website at http://cosmos.buffalo.edu/t2rerc/. As a continuation of our work on this project, primary market research was also conducted with consumers to examine unmet needs within specific domains of educational technology: reading, writing, and math. The analysis and reporting of this work is currently being carried out and will be published as a consumer oriented perspective of the educational technology industry.

Outcomes and Benefits

In summary, embracing UDL concept in the design, development and use of technologies for education may allow us to overcome the striking paradox of *educational technology* and *AT* by factoring out *disability* and the need for *partial* accommodations. This study adds to the body of knowledge characterizing UDL needs of students and teachers, and the solutions, technological and otherwise, required to meet these needs. Information presented in this article will facilitate the development and commercialization of UDL and classroom technology products to benefit all students, including those with learning disabilities. Study results support the need to incorporate UDL concepts in teacher training, pedagogy, infrastructure, and products. In terms of acceptance, teachers support technology use when all students benefit, while students with learning disabilities prefer technology typically used by all students.

An outcome is a measurable change consequent from a perturbation introduced to a system. In the realm of AT, Edyburn (2003) elaborates that "outcomes may be multidimensional … rather than something that can be captured in a single score" (p. 54). In the UDL context, there are several relevant systems including: governments, post-secondary institutions educating teachers, accrediting bodies for teachers, manufacturers of UDL materials and educational and AT products, K-12 school systems, and K-12 classrooms. Stakeholders within each system may in principle be informed by this study and institute systems change consequent to knowledge gained.

An immediate and demonstrable outcome of this study will be to inform stakeholders of the critical needs identified experts in the field of education. As indicated, thematic analysis of the transcripts and notes collected during the expert analysis resulted in the identification of needs in computer applications for students (including both software and portable device applications); presentation and multi-media applications; and teaching and instruction tools and training. The T2RERC will use this study and the *Industry Profile on Education Technology: Learning Disability Technology and Markets* to inform manufacturers about the critical needs in educational technology as defined by industry experts, and suggest educational and assistive technology product solutions that might satisfy these needs. The current study and the *Industry Profile on Education Technology* will be used to develop strong Small Business Innovation Research (SBIR) proposals, a critical funding source for new product development. In addition, information derived from this study will be used to develop marketing materials, guide business planning, and inform grant development efforts.

Conclusion

The critical need areas identified in this research are based on primary market research with experts in the field of education. Many of the needs outlined in this research may require additional research to fully identify specific technology specifications.

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Enhancing Access to Situational Vocabulary by Leveraging Geographic Context

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Abstract: Users of augmentative and alternative communication (AAC) aids could benefit from novel methods for accelerating access to contextually relevant vocabulary. This paper describes our initial efforts toward improving access to situational vocabulary through the use of geographic context to predict vocabulary. A corpus of spoken data produced by one able-bodied male speaker across various locations was collected and used to mine location-specific vocabulary clusters. We describe the data mining algorithm and illustrate how context-driven vocabulary organization and prediction can be integrated into an iconic communication system. Correlations between user and algorithm-generated vocabulary patterns highlight discrepancies between actual versus perceived frequency statistics. Thus, device customization may be achieved through a hybrid human-algorithmic approach to vocabulary selection. Endowing the communication aid with knowledge about the user's location-specific vocabulary patterns may help to balance the burden of communication between the system and the user to yield substantial gains in accessing situationally appropriate vocabulary which may in turn accelerate communication rate.

Keywords: Augmentative and alternative communication, Fringe vocabulary, Vocabulary prediction, Situational context

Communication is a slow and effortful process for nearly two million Americans with severe speech impairments who must rely on AAC devices. Communication efficiency is an especially important issue for AAC users who are fluent in the language and thus require access to large vocabularies. Current AAC devices employ a number of techniques to enhance access to frequently used words including message encoding, semantic compaction, and dynamic layouts. All of these methods, however, have practical limits in terms of the number of words that can be retrieved and the cognitive burden imposed on the user. While a significant portion of an AAC user's message consists of core vocabulary items which are common across contexts (Beukelman, Yorkston, Pobleto, & Naranjo, 1984), situational vocabulary (also referred to as fringe or extended vocabulary) may change substantially as the user encounters different topics and settings throughout a day. Although access to situational vocabulary is essential for engaging in timely and relevant conversations, it imposes additional challenges when designing efficient visualization and navigation schemes. Leveraging knowledge about the user's geographic context to guide situational vocabulary prediction has the potential to improve communication efficiency and thereby contribute to optimizing educational, social, and vocational opportunities. This paper reports on an initial exploration aimed at harnessing location-specific vocabulary usage patterns to improve access to less frequently used situational vocabulary.

Background

Communication using AAC devices is significantly slower and effortful compared to typing or speaking (Beukelman & Mirenda, 1998; Goldman-Eisler, 1968; Szeto, Allen, & Littrell, 1993). This mismatch in communication efficiency between AAC users and their able-bodied peers (a) impacts upon the number and type of communication opportunities available (Demasco, 1994; Higginbotham & Wilkins, 1999; Light, Collier, & Parnes, 1985; Müller & Soto, 2002; Simpson, Beukelman, & Sharpe, 2000); (b) contributes to perceptions of cognitive incompetence (Beck, Kingsbury, Neff, & Dennis, 2000; Goodenough-Trepagnier, Galdieri, Rosen, & Baker, 1984; Light 1985, 1988; Hoag, Bedrosian, Johnson, & Molineux, 1994); and (c) limits social and vocational options for AAC users (Beck & Dennis, 1996; Beck, Fritz, Keller, & Dennis, 2000).

In an effort to speed and ease communication most current AAC devices employ some method of enhancing access to frequently used words, including, dynamic layering or thematic organization of vocabulary (Demasco, 1994; Wilson & Fox, 1993), message encoding schemes (Light & Lindsay, 1992), and Semantic Compaction™ (Baker, 1982, 1986). A common metric used for assessing enhanced access to vocabulary items is keystroke savings (see Higginbotham, 1992 for a comparison of keystroke savings across several AAC devices). In other words, measuring the number of physical entries required to construct a message, with and without a given access method. Semantic Compaction™, an encoding scheme in which each icon has multiple meanings, has been shown to improve efficiency by reducing the item set on a visual display (Baker, 1987). Similarly, letter and number encoding schemes in which particular sequences of letters and/or numbers activate words or messages reduce keystrokes (Baker, 1982, 1986; Gardner-Bonneau and Schwartz, 1989; Vanderheiden & Lloyd, 1986). Although encoding schemes may be easier to process and recall, they impose limitations on the size of vocabulary set for reasons of practicality and cognitive load and thus may not be appropriate for fluent users who require access to a large and diverse vocabulary set.

In order to accommodate larger vocabulary sets that cannot be visualized at once, some devices employ dynamic layouts in which single meaning icons are organized into semantically related clusters. To provide the user with a sufficiently rich lexicon, it is essential to have multiple vocabulary pages. There are trade-offs, however, between vocabulary size, the cognitive load of vocabulary management, and the physical load of vocabulary selection.

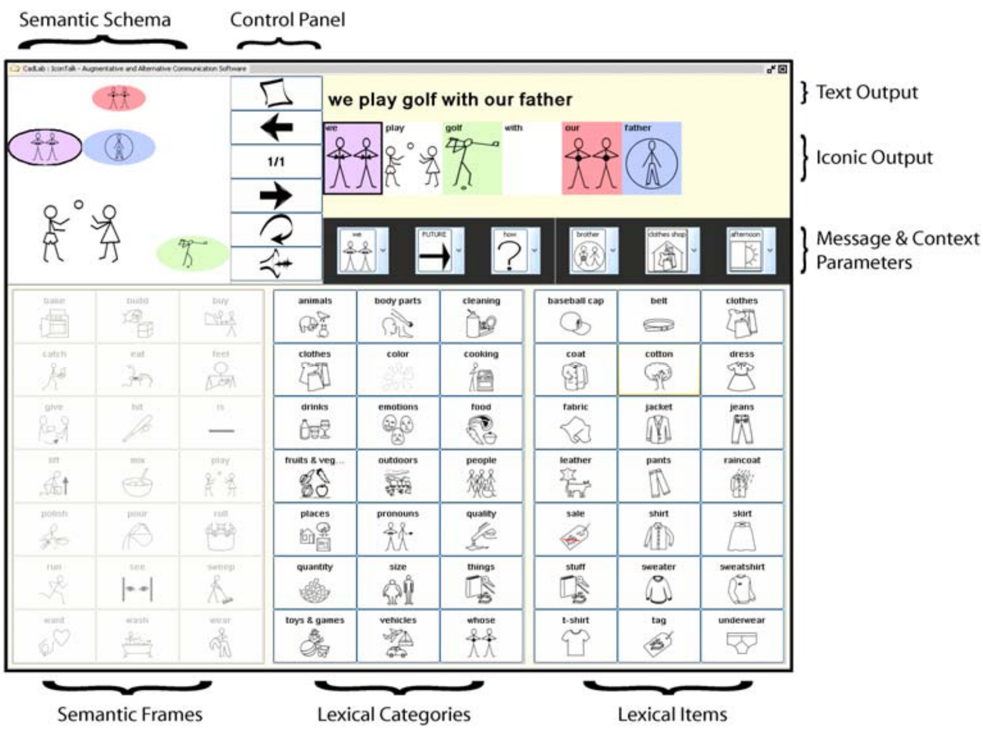
While the above methods can improve access to core vocabulary items, the overall gain is not sufficient to place AAC users on par with their able-bodied peers. AAC users also use words that are not in this core. Beukelman, Yorkston, Pobleto, and Naranjo, (1984) reported a core vocabulary of 500 words based on conversational samples across five non-speaking adults. Across the five participants, only 33% of any given user's communicative utterances could be generated using only those 500 core vocabulary items. One potentially effective strategy for improving vocabulary access for fluent AAC users may be to focus on situationally-dependant words that a user may need in everyday communication. Endowing the communication aid with knowledge about the user's vocabulary patterns in his/her daily routines may balance the burden of communication between the system and the user.

Word prediction is one method of enhancing access situational vocabulary (c.f. Alm, Arnott, & Newell, 1992; Carlberger & Hunnicutt 1998; Copesake, 1997; Foulds, Soede, & van Balkom, 1987; Hunnicut, 1986; Newell, Arnott, Beattie, & Brophy, 1992; Swiffin, Arnott, & Pickering, 1987). Traditional word prediction approaches use statistical information such as frequency and recency of use to order and present a list of the most likely lexical candidates. Although there is almost no learning curve in using word prediction systems compared to encoding schemes, it is not clear whether the keystrokes savings of word prediction translates into improved communication rate or access to the appropriate vocabulary (Higginbotham, 1992; Koester & Levine, 1994, 1997; Lesher, Moulton, & Higginbotham, 1998; Venkatagiri, 1994). The costs incurred by switching between selecting icons or letter and scanning or reading lists of possible items can sometimes outweigh the benefit of reduced keystrokes (Koester & Levine, 1994; Treviranus & Norris, 1987; Venkatagiri).

Especially when the vocabulary size is large, word prediction systems based on a database of word frequencies and inter-word correlations, have a hard time predicting the word that the user actually intended. To address this issue, Lesher and Rinkus (2001) proposed that domain-specific vocabularies may help to constrain the predicted item list. They measured the average keystroke savings of an n-gram prediction model with and without the use of domain-specific vocabularies derived from the Switchboard corpus of telephone transcripts. They demonstrated that endowing the system with domain-specific knowledge can afford keystroke savings between 53-58% relative to models that do not incorporate such information. Constraining the word prediction to offer situationaly-appropriate vocabulary items may decrease the cognitive dissonance associated with searching lists of unrelated and unnecessary words (Renaud, 2002; Venkatagiri, 1994). Since situational vocabulary can potentially be enormous, it requires new ways to thinking about how to make it available to AAC users such that their interactions can be timely and relevant to the topic and setting of conversation.

The idea of using domain-specific vocabulary has made it into some AAC products (e.g., SOLO™ by Don-Johnston, Inc.); however, context is predetermined and vocabulary is predefined by the user or his/her clinician. Balandin and Iacono (1998) showed that even trained professionals have difficulty predicting vocabulary usage. They asked ten professionals (five speech pathologists, three rehabilitation counselors and two teachers) to predict topics and vocabulary of meal break conversations at work. While the professionals accurately predicted some conversational topics, approximately 33% of the key words predicted by the participants did not occur in the conversational sample at all. Thus predicted and actual usage patterns may not always be aligned. Moreover, within a given setting, conversational topics can be diverse. Balandin and Iacono (1998) collected meal break conversational samples from 34 non-disabled participants across four work sites and found that the participants referenced 73 different topics some of which were associated with the day of the week. Upon further analysis of the conversational sample, Balandin, Iacono, and Crews (1999) reported that a small stable core vocabulary of approximately 350 words accounted for 78% of the conversational sample. Fluent AAC communicators may have equally diverse conversations and thus the challenge is to offer the user an appropriate vocabulary set as s/he encounters the various conversation topics, partners, and settings throughout the day. As a first step toward this goal, the present study sought to determine whether vocabulary usage does in fact cluster by geographic location and if so, how effective are these vocabulary clusters for predicting future use in similar contexts? This initial exploration, considers the vocabulary usage patterns of one able-bodied user in various geographically distinct locations. The geographic locations are sensed using a global positioning system (GPS) and the vocabulary usage patterns are mined to extract items that the user may be likely to use in future interactions in those settings.

Figure 1. A screenshot of the iconCHAT interface. © 2007, Rupal Patel. Used with permission.



Our Approach

In this paper we focus on the use of geographic context to accelerate access to situational vocabulary and demonstrate how this may be implemented in an icon-based electronic communication aid. Given that adaptive interfaces which change too often or in unpredictable ways can pose additional challenges, we chose to display the results of the prediction algorithm on our prototype communication system called iconCHAT. This system was chosen for illustration purposes since it provided a test-bed for discussions about the competing trade-offs between vocabulary size and organization and novel visual navigation schemes. For example, given that fringe vocabulary makes up only a fraction (approximately 15%) of the vocabulary used, its was essential that users always had access to core vocabulary items and that only the appropriate fringe vocabulary would be made accessible based on context cues. The general principles discussed, however, are applicable to iconic AAC systems as a whole.

The iconCHAT system is aimed at enhancing communication ease and efficiency by offering a semantically organized method of message construction and a context-driven method of vocabulary organization and prediction (see Figure 1). Vocabulary is organized in three panels: semantic frames, lexical categories, and lexical items. Semantic frames consist of action words or verbs that provide the user with the scaffolding to construct a message [based on case grammars in Fillmore (1968); see also scripts in Schank (1973)]. The frame slots (displayed in the semantic schema), can be filled with lexical items that are classified in their respective lexical categories. Once a message is constructed, the user can generate spoken output using the text-to-speech synthesizer through the control panel. A set of message parameters allow the user to directly control the contents and expression of his/her message. Context parameters inform the user of the system's sensed location, time, and conversational partner [a detailed account of iconCHAT is provided in Patel, Pilato, and Roy (2004)].

We propose using location context to filter and organize vocabulary based on previous usage patterns. Location has been identified as one of the most definitive elements of context in ubiquitous computing (Beigl, Zimmer, & Decker, 2002). It is possible to determine the location of a person with significant accuracy using the GPS in outdoor environments. With the emergence of the E911 directive (Federal Communications Commission, 2005), Assistive-GPS (AGPS) technology will allow location detection in indoor environments in the near future. Endowing an AAC system with location-dependant, user-specific vocabulary may enhance access to situational vocabulary and thereby support timely and appropriate message constructions.

Method

Data Collection

An able-bodied, adult male native English speaker collected a corpus of spoken data over the course of 5 weeks in various geographical locations. Approximately 2.7 hours of audio was recorded on a daily basis for a total of 20.4 hours of silence-removed speech collected over the 5 week period. It is important to note that we began with an able-bodied individual rather than an AAC user in order to collect a sufficiently large corpus of data necessary for building location-dependant vocabulary models. Future plans include gathering location-sensitive expressive output from a group of AAC users.

We captured the location information using the Garmin GPS receiver (Garmin model 35 LVS wearable) and the Geostats GeoLogger (Geostats, Inc. Model DL-04, Version 3.4). The data logger was configured to record latitude, longitude, date and time at five second intervals. Since currently available GPS does not work in indoor spaces, the subject was advised to place the receiver near a window or any such opening with a clear view of the sky.

Spoken utterances were captured on the HP iPAQ h2215 personal digital assistant (PDA) using voice recording software (Resco, sro., 2007). The on-board microphone of the PDA was used with automatic gain control (AGC) disabled to minimize ambient noise. The software was configured to record date and time stamped voice recordings at an encoding rate of 16 bits sampled at 22050 Hz. PDA time and GPS time were synchronized using the U.S. Naval Observatory Master Clock.

The participant was instructed to record conversational speech in his everyday routines. The participant identified certain locations that he felt comfortable recording in and was asked to frequent these locations for several minutes over the course of the week. For reasons of privacy and practicality, not all conversational contexts were sampled. Location clustering revealed eight locations types within his spoken corpus: the campus bookstore, a research lab, various classrooms, clothing stores, electronic stores, grocery stores, the user's kitchen, and his lab meetings.

Subsequent to data collection, each audio file was manually transcribed and coded by location. While we attempted to transcribe the audio files using automatic speech recognition (Nuance Communications, Inc., 2007), we found poor accuracy rates due to the level of ambient noise in the various natural environments. For each of the eight locations, a random sample of 20% of the data was transcribed by two listeners in order to establish inter-rater reliability. Across all locations, the average inter-rater reliability was 98.4%. For words that were not in agreement, an additional pass of the transcription was completed to resolve any discrepancies.

Table 1
Number of Words and Sentences Per Location

Location	*N* of Words	*N* of Sentences
Bookstore	7161	656
Research Lab	5666	474
Classrooms	2962	409
Clothing Store	12256	1122
Electronics Store	8205	687
Grocery Stores	9898	1375
Kitchen	8885	1085
Lab Meetings	5761	493
Total	60794	6301

Transcribed text and location data were integrated into a synchronized representation for the data mining and clustering phase. Table 1 provides a summary of the collected corpus in terms of the number of words and sentences per geographic location.

Generating Location-Dependant Frequent Vocabulary Patterns

An association rule-based data mining algorithm was used to implement location-dependant vocabulary prediction. A pattern is a set of items, or sequence of items that reoccur within a database. The probability that a transaction contains a pattern is referred to as its support. A pattern is said to be frequent if its support is greater than a predetermined minimum threshold and is said to be maximal if it has no other frequent super-pattern (Han & Kamber, 2000).

We used Borgelt's adaptation (Borgelt, 2003) of the Equivalence Class Transformation (Eclat) algorithm (Zaki, Parthasarathy, & Li, 1997), a parallel frequent pattern mining algorithm. The algorithm reduces the number of passes over the database and is highly efficient in generating maximal frequent patterns. In our implementation, the algorithm considers a sentential unit (i.e., a phrase, a sentence, or a fragment) as a transaction in order to generate frequent patterns.

Prior to further processing we implemented stop-word removal to eliminate core vocabulary items. Stop-words include words such as the, is, and, or, if, to, I, you, this, that, etc. which are thought to carry little semantic content. In addition to using stop-word lists widely used in natural language processing, such as the DVL/Verity Stop Word List (Defense Virtual Information Architecture, 2000) and the University of Glasgow Stop Word List (van Rijsbergen, 1979) we generated a speaker-dependant stop-word list containing colloquialisms and words such as like, you know, and wow that occurred often in the present corpus. These words and phrases were used across locations and carried little, if any, semantic content.

Following stop-word removal, we ran the algorithm using different invocation parameters and minimum support thresholds. These parameters included the frequent pattern size (i.e., one word, two word, etc.) and an option for generating only maximal frequent patterns.

Classifying Frequent Patterns into Discrete Levels of Predictiveness

Each lexical category in iconCHAT contains a one-layer deep lexical item set. For example, 'jeans' is contained in the category 'clothes' and similarly 'pizza' in the category 'food'. We have implemented a three-level differential shading scheme to help users scan and select the most appropriate vocabulary given their geographic context and current stage in message construction.

Decisions on differential shading of lexical items and semantic frames are based on frequency statistics observed within each location. The algorithm generates a rank ordered list of size-one (i.e., one word) frequent patterns. The support value of each frequent item is used to sort the list into one of three discrete levels: highly probable, probable, and neutral, conditioned on the user's current location and his/her current state in message construction. These discrete levels are visually represented using an arbitrarily defined grayscale shading scheme where the lightest items are those from the highly probable category to facilitate easy access. For example, 'coke,' 'fries,' 'drink,' 'hamburger,' and 'small' may be the top five (size-one) frequent times in a restaurant. Each item would have an associated support value that is used to determine whether the item should be categorized as highly probable, probable, or neutral.

Generating Quick Access Vocabulary Based on Frequent Patterns and Semantic Relatedness

To further improve vocabulary access we employed frequent patterns and semantic relatedness measures to populate a quick access vocabulary panel. Semantic relatedness is a quantitative measure of the degree to which two words are related. We used this measure to select closely related lexical items from the frequent pattern inventory. Several measures have been proposed to assess the semantic relatedness using WordNet (Fellbaum, 1998). WordNet is an online database in which lexical items are represented as a synonym sets. Lexical items in the database are linked to one another by approximately 30 semantic relations. Budanitsky and Hirst (2001) compared five methods of implementing relatedness using WordNet and found that the Jiang and Conrath (JCN; 1997) measure was most suited for natural language processing tasks such as ours.

1. We implemented a multi-step algorithm to populate the 3 x 8 icon quick access panel:
2. Select all size-one frequent patterns that have support values higher than the threshold.
3. For maximal frequent patterns of size two or greater, select all remaining items.
4. Given that the quick access panel can only accommodate a maximum of 24 icons, calculate the number of vacant icon slots after steps 1 and 2.
5. Calculate semantic closeness using the JCN measure (Pedersen, Patwardhan, & Michelizzi, 2004) for all pairs of size-two patterns that contain at least one element from step 1.

For each item in step 1, calculate the number of vacant slots that it can contribute to the panel based on its support. Fill these slots with item(s) that are most semantically related to it.

This algorithm yielded a list of lexical items that were used to populate the quick access panel for each unique geographic location.

Results and Discussion

In this section, we present the results of the algorithms described above and elaborate on how the findings can be leveraged to improve vocabulary access in an iconic AAC system. Interface adaptations are discussed in terms of the iconCHAT system to provide concrete examples of possible implementations. The general principles discussed, however, are applicable to AAC systems as a whole. We discuss issues of visual organization and navigation speed that influence message construction and their implications on human versus machine generated vocabulary selection.

Frequent Items in Each Location

A partial list of the 20 most frequent size-one patterns in the spoken corpus in each of the eight locations is presented in Table 2. Note that for some locations, the most frequent pattern has a relatively high support value (i.e., in bookstore, book has a support value of 69) while in other locations the most frequent pattern has a lower support value (i.e., in the kitchen, onion has a support value of only 39.5). This indicates that in locations such as the bookstore, the word *book* is likely to be part of a greater number of sentences, while *onion* may appear in fewer sentences produced in the kitchen. Recall that high support values influence the contribution weight of the item in the quick access panel.

Additionally the range of support values in the frequent patterns also differed by location (e.g., for Table 1, the bookstore support value range = 55.2; kitchen support value range =18.4). This range influenced the cutoff values for classifying items into the three discrete likelihood levels for differential shading. Frequent patterns that occur across multiple locations were typically core vocabulary items such as predicates (want, look, etc.), modifiers

Table 2
Size-One Frequent Patterns in Each Location and Their Support Measures

Bookstore	Research Lab	Classrooms	Clothing Stores	Electronics Stores	Grocery Stores	Kitchen	Lab Meetings
book-69.0	thing-47.7	time-50.0	Look-56.9	look-55.7	need-63.0	onion-39.5	time-44.1
look-41.4	people-45.5	thing-42.9	Nice-52.0	nice-28.6	look-40.7	cut-36.8	way-38.2
class-39.7	time-43.2	motor-35.7	Shirt-46.1	thing-28.6	make-37.0	use-36.8	try-38.2
stuff-34.5	work-34.1	way-35.7	color-36.3	stuff-24.3	want-37.0	carrot-34.2	little_bit-35.3
need-32.8	say-31.8	people-35.7	jacket-31.4	probably-24.3	thing-33.3	soup-31.6	different-32.4
thing-31.0	class-31.8	little_bit-28.6	stripe-30.4	little-24.3	Cheese-31.5	water-31.6	say-32.4
time-31.0	sort-29.5	stuff-28.6	Wear-29.4	small-22.9	ones-29.6	chop-28.9	class-29.4
read-25.9	speech-27.3	better-21.4	Stuff-26.5	work-20.0	stuff-27.8	little-28.9	record-26.5
use -24.1	little_bit-27.3	play-21.4	Blue-26.5	sort-17.1	use-25.9	need-28.9	minute-29.4
buy-20.7	use-25.0	oral-21.4	pants-25.5	different-17.1	cream-24.1	parsley-26.3	able-26.5
different-19.0	person-22.7	facial-21.4	Ones-24.5	speaker-17.1	chicken-22.2	add-26.3	easy-23.5
probably-19.0	different-22.7	sure-21.4	sale-24.5	want-15.7	probably-20.4	little_bit-23.7	recording-23.5
speech-19.0	disorder-20.5	disorder-21.4	different-24.5	sure-14.3	better-18.5	garlic-23.7	want-23.5
way-17.2	language-20.5	talking-21.4	white-23.5	little_bit-14.3	sure-16.7	pepper-23.7	data-23.5
sort-17.2	want-20.5	day-21.4	sort-22.5	player-14.3	ginger-16.7	boil-23.7	thing-23.5
sure-15.5	talk-20.5	couple-21.4	Light-22.5	big-12.9	little_bit-14.8	thing-21.1	file-23.5
actually-15.5	semester-20.5	want-21.4	probably-21.6	digital-12.9	plantains-14.8	fresh-21.1	sort-20.6
a_lot-15.5	lab-18.2	prepare-14.3	black-21.6	watch-12.9	list-14.8	way-21.1	make-20.6
funny-13.8	start-18.2	words-14.3	Thing-18.6	use-12.9	feel-13.0	vegetable-21.1	work-20.6
textbook-13.8	difficult-18.2	read-14.3	Little_bit-18.6	regular-12.9	eat-14.8	celery-21.1	maybe-20.6

Table 3
Impact of User-Dependant Stop-Word Pruning on Frequent Patterns in the Clothing Store Context

Pruned Frequent Patterns	
Generic Stop-Word	User-Dependent Stop-Word
like - 83.7%	look - 56.9%
kind – 69.6%	nice - 52.0%
know - 47.4%	shirt - 46.1%
look – 45.9%	color - 36.3%
yeah – 45.9%	jacket - 31.4%
nice - 43.7%	stripe - 30.4%
oh - 38.5%	wear - 29.4%
just - 37.0%	stuff - 26.5%
shirt - 34.8%	blue - 26.5%
color - 29.6%	pants - 25.5%

(a little bit, a lot), or generic nouns (thing, stuff). Perhaps these items should be made accessible in a different part of the interface such as in a context-independent panel of scroll buttons.

Factors that Influenced Algorithm Performance

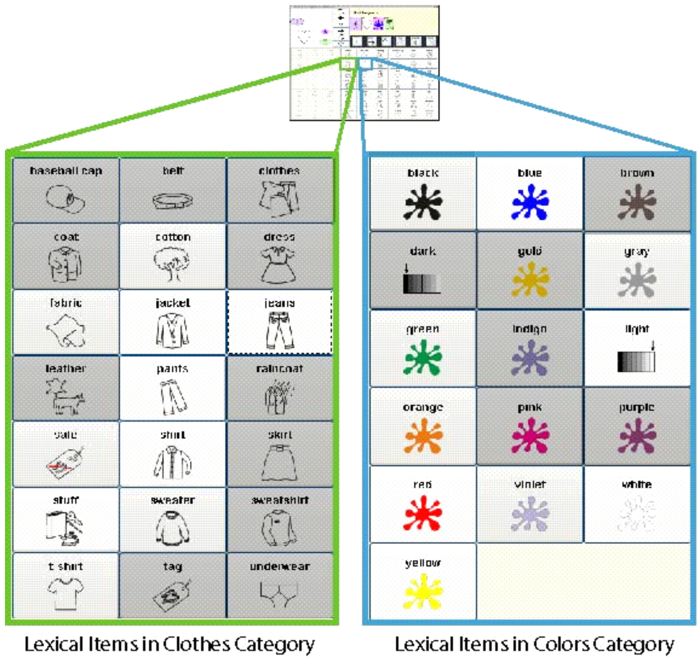
Given that stop-words occur often in spoken dialogue, they may alias as frequent patterns. As a result, other more content-laden vocabulary items may be pushed lower in the frequent pattern ranking or lost completely. In addition to using conventional stop-word lists, we found that a speaker-dependent list greatly enhanced performance (see Table 3 for a truncated list of size-one frequent items in the clothing store generated with and without user-dependant stop-words). An effective stop-word removal phase is especially important for iconCHAT since the natural language generation module attempts to minimize keystrokes by allowing the user to only select content words, leaving out function words such as *of*, *to*, and *the* during message construction.

Transaction size also had a significant impact on algorithm performance. Conversational speech typically contains less formal structure than written text. Incomplete grammatical constructions, fragments, lengthy trains of thought and backchannel exchanges often characterize typical spoken conversations. In contrast, communicative exchanges using iconCHAT fall somewhere between conversational dialogue and written discourse. Keeping these factors in mind, we experimented with varying lengths of sequential units to arrive at an ideal transaction size.

Leveraging Frequent Patterns to Provide Visual Selection Cues

For each location, size-one frequent patterns were classified into three discrete predictive levels within each lexical category. Predictive shading of category items enables the user to rapidly scan and sift through the most likely lexical items within each category. Figure 2 illustrates this feature in the *clothes* and *colors* categories for the clothing store context.

Figure 2. Location-dependant predictive shading for clothes and colors categories. © 2007, Rupal Patel. Used with permission.

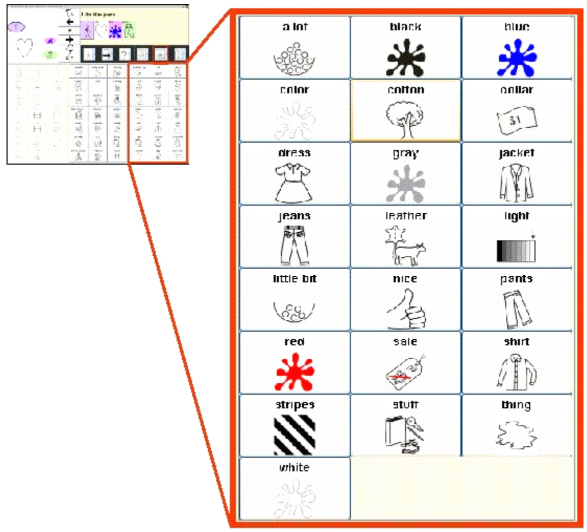


In the clothes category, the algorithm ranked *jacket* and *pants* to be among the most probable items and were thus represented at the brightest, most accessible level. Conversely, words such as *belt* and *dress* appear darkest and least accessible since they were judged to be neutral items for this user. Note that within each category, lexical items are alphabetically arranged as an attempt to assist in symbol search and promote early literacy skills.

Location-Dependant Quick Access Vocabulary

The quick access panel is aimed at further improving message construction ease. In other words, it helps reduce the number of clicks required to create a message by providing the most likely lexical items for a given context within a single panel (see Figure 3). Closer examination of the lexical items reveals their diversity with respect to their category and part of speech roles. In addition, an item such as 'dress', which was ranked 47 in the size-one frequent patterns, is promoted to the quick access panel containing only 22 members because support values and semantic closeness measures were considered together in this stage of analysis. Just as with differential shading, we anticipate that after repeated exposure, the user may gain insights into his/her own vocabulary usage patterns. The contents of the quick access panel may gradually change over time. For example, in the clothing store context, frequent items may change over the seasons. These changes occur over extended periods of time (e.g. weeks, months) such that the user is not confronted with a continual changing interface. Also note that the user still has access to all vocabulary items through the lexical category panel if the contents of the quick access panel do not meet his/her needs. Perhaps these seamless changes in the vocabulary content will promote receptive language and categorization skills.

Figure 3. Quick access panel for the clothing store location. © 2007, Rupal Patel. Used with permission.



Quick Access for Clothing Store

Correlating Human and Algorithmic Rankings of Predictive Vocabulary

The Spearman ranked correlation measure was used to compare algorithm-generated vocabulary usage patterns with the user's perception of his patterns. Rankings were requested for the 10 most frequent size-one items in each location (see Table 4). Rankings for only nouns and modifiers were requested given our interest in assessing the effectiveness of predictive shading and quick access.

Inspection of the correlations across locations indicated that in general, locations with a large support value range in frequent patterns (i.e., bookstore) had higher correlations than those with a reduced support range (i.e., kitchen). From the user's perspective, it seems intuitive that a distribution of support values over a large range would allow more precise ordering. Conversely, a smaller range in support value distribution would make it difficult for the user to discern the importance of one item over another resulting in low or negative correlations. These discrepancies between user and algorithm rankings provide evidence that actual versus perceived frequency statistics often differ.

Trained clinicians, such as speech language pathologists, often make vocabulary choice decisions when programming AAC devices based on their own experiences and intuitions about a user's needs. Using an algorithmic approach to make these decisions based on actual frequency statistics along with clinical insights may improve communication efficiency and effectiveness. The algorithm may identify subtle, idiosyncratic patterns that are specific to that user thereby improving device customization. Since many users prefer a certain degree of control over their system rather than delegating decision making to the system (or to a clinician), a hybrid approach may balance these tradeoffs.

Outcomes and Benefits

This paper described an initial effort aimed at leveraging situational context for vocabulary prediction. The methodology

Table 4
Correlation Between User and Algorithm-Generated Rankings Size-One Frequent Patterns

Locations	Spearman Rank Correlation Measure
Bookstore	0.733
Research Lab	0.479
Classrooms	0.491
Clothing Stores	0.418
Electronics Stores	0.346
Grocery Stores	0.079
Kitchen	-0.369
Lab Meetings	-0.212

described mined vocabulary usage patterns of one able-bodied male user in various geographic contexts. The resulting context-dependant vocabulary patterns were implemented on the iconCHAT prototype system to illustrate how vocabulary access may be enhanced. While we began with an able-bodied user to ensure sufficient data on which to implement and assess the data mining algorithm, this open-set corpus had its drawbacks. The conversational topics, types of message constructions, and vocabulary choices were diverse and complex. Given that sentence constructions, conversational topics and frequent locations will vary on an individual basis additional algorithm tuning will be required in future implementations that operate on usage patterns of a typical AAC user. For some AAC users, the vocabulary set on their device may restrict the type and number of unique messages that can be created. These constraints may in fact improve algorithm performance.

Correlations between the user and algorithm-generated frequent pattern rankings suggest that decisions about vocabulary sets may benefit from a hybrid approach. In some locations the user's perception of frequent patterns were highly correlated with the actual statistics while in other locations the correlation was poor. A hybrid approach would entail the algorithm suggesting a vocabulary set (based on past usage patterns) from which the user or trained professional could choose the relevant items. Selecting the appropriate vocabulary is key to achieving improved communication success.

Another area that can significantly impact vocabulary access and thereby communication effectiveness is the user's understanding of his/her own usage patterns. Thus, if a user knew that frequent lexical items which are represented at the most accessible grayscale level were also likely to be in the quick access panel, s/he may be able to efficiently navigate to the desired item. In other words, knowing where to find a particular vocabulary item may accelerate access by reducing the number of keystrokes for message construction. Usability studies that assess the impact of situational vocabulary prediction on keystrokes savings, cognitive load and message construction accuracy and complexity are warranted.

Limitations and Future Directions

We plan to extend this work by collecting a more extensive corpus of message constructions produced by a group of able-bodied users as well as a group of AAC users within varied geographic contexts. Particular attention will be given to collecting sample utterances in a variety of conversational settings with multiple communication partners. This corpus will then be used to generate context-dependant vocabulary patterns for each user. Subsequently, we will evaluate the usability of discrete predictive levels of shading and the quick access panel.

We plan to broaden the methodology by building user-specific predictive vocabulary networks. Such networks would provide insight into organizational and navigational features that are beneficial across users. These insights can then be incorporated into future iterations of the interface design.

While this paper focused on the use of geographic context for vocabulary prediction, we are currently working toward harnessing other contextual cues such as time of day and conversational partner and topic. A significant challenge will be to integrate and visually represent vocabulary prediction using these varied contextual cues. Additionally, it will be important to monitor the use and effectiveness of situational vocabulary prediction.

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Achieving Systemic Change with Universal Design for Learning and Digital Content

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Abstract: Systemic change may be achieved through a combination of the Universal Design for Learning (UDL) principles in instructional delivery, the integration of accessible digital materials, and the use of state-of-the-art technology tools. To demonstrate this premise, the Kentucky Department of Education (KDE) partnered with the University of Louisville to develop a statewide initiative that addresses the implementation of UDL. This initiative included accessibility to statewide accountability testing (CATS), digitized text system, and UDL model schools. The Kentucky Model demonstrates how systemic change can be achieved through the combination of several parts. After consideration of all factors, the authors conclude that there was an overall positive systemic change for the majority of the model schools included in the project.

Key Words: Accessible digital content, Universal design for learning, Systemic change

The lack of access to curricula is often cited as a primary reason for unacceptable educational outcomes for children with disabilities. In viewing the current types of materials used in education, one finds that the textbook is the primary conveyer of the curriculum (Rose & Meyer, 2000). Essentially, the print whether it is found in a book, handouts, or a variety of other formats has created a barrier for some individuals with disabilities. With the current practices, children with disabilities are falling far behind in comparison to their peers who are non-disabled. In addition, students in special education have lower school completion rates than do their peers who are non-disabled (Benz, Lindstrom, & Yovanoff, 2000; Blackorby & Wagner, 1996; Flexer, Luft, Baer, & Simmons, 2007). Therefore, these practices in the education of children with disabilities must change in order to provide greater opportunities as adults to be productive members in their communities.

Warger (1999) reports that in the Individuals with Disabilities Act of 1997 (IDEA '97), there was a move to ensure that children with disabilities have access to the general curriculum. The rationale behind this move was one of providing better education opportunities and higher expectations of the education of children with disabilities. This has appeared to be a daunting challenge for educators, administrators, and parents as they reconsider how children with disabilities are educated while ensuring access to the general curriculum. Furthermore, the determination of what constitutes access, and more specifically, how to provide children with disabilities meaningful access to instruction that is aligned with high-level standards and supported by research based interventions is a major concern (President's Commission on Excellence in Special Education, 2002; U.S. Department of Education, 2002; Wehmeyer, Lattin, & Agran, 2001).

To ensure meaningful access, there is the challenge to provide the curriculum with supports, modifications, and accommodations that can guarantee that curriculum goals are achievable (Pugach & Warger, 2001; Stahl, 2004). Furthermore, in the greater scheme of instruction, IDEA '97 demands that educational supports and services provided to students with disabilities "lead to clear and measurable outcomes in adulthood" (Dymond & Orelove, 2001).

In light of the emphasis placed on access to the general curriculum, it is imperative for regular and special educators to work together to serve all students including those with disabilities in the regular education program. A way this can be accomplished is by providing equal access to knowledge through adjusted or altered curriculum and instruction. One approach to curriculum alteration is through the application of Universal Design for Learning (UDL) principles (Rose & Meyer, 2000). This approach to curriculum and instruction emphasizes the methods for teaching that are compatible with how the brain works and the importance of flexible materials and curriculum to allow access for all students (Rose & Meyer). The goal to implement these ideals should be school wide to promote access to the curriculum for every student. In order to be successful, systemic change needs to be planned, acted upon by the school personnel, and evaluated through student outcomes.

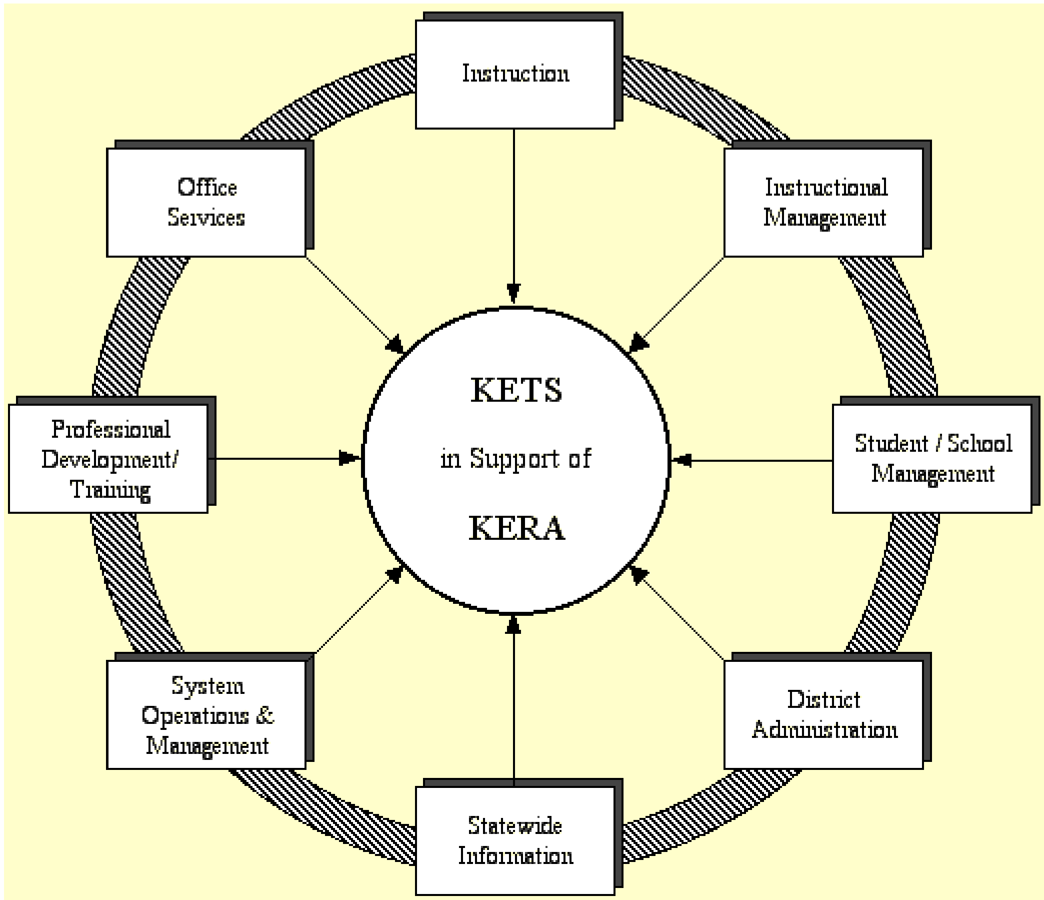
One avenue for systemic change to be successfully achieved in addressing access to the general curriculum is through a combination of the UDL principles in instructional delivery, the integration of accessible digital materials, and the use of state of the art technology tools. The Kentucky Department of Education (KDE) partnered with the University of Louisville (UofL) to provide three year grants at $30,000 annually to six schools. The ultimate goal of these grants was to develop a unique school wide model program utilizing best practices of UDL principles across the curriculum.

In order to understand how Kentucky arrived at the premise under consideration for the grants, it is important to look at some of our state history within the area of education and technology. The Master Plan for Education Technology 1992 (Kentucky Department of Education, 1992) was enacted two years after the Kentucky Education Reform Act of 1990 (KERA, House Bill 940). The 1992 Master Plan addressed "the need to ensure equitable access to education technology by establishing a state standard for the level and type of technology within each school…provide financial and technical assistance to each and every school until the school attains the standard." In addition, the legislative assembly clearly understood this would be an ongoing process and not a one time event and sought to provide the finances for the endeavor (Kentucky Department of Education).

Kentucky Educational Technology System (KETS)

The main objective for the KETS was to (a) develop an integrated process for both the instructional and administrative aspects of all levels of the public school system, (b) enact equitable and efficient use of technology in instruction and administration, (c) improve teaching and learning, (d) improve instructional outcomes for children, and (e) enhance operation of the public school system. The 1992 Master Plan called for a system of educational technology that would encompass both the instructional and administrative aspects of all levels of the public school system so they would be in sync

Figure 1. Schema of the KETS Support System. Source: Kentucky Department of Education. (1992). Master plan for education technology. Frankfort, KY: Author. Used with permission.



as one system (Kentucky Department of Education, 1992; see Figure 1).

KETS consists of two major infrastructure components: the (a) Education Communication Network (ECN), the highway over which the users will interface with each other and the information will flow; and (b) Education Information System (EIS), the application tools that assist students in learning, help teachers to teach and provide the entire local education community access to information and communications. Approximately $346 million in one-time costs were estimated as the shared cost between the state and local districts on a 50/50 matching funds basis. This was prescribed in HB 698 enacted on April 2, 1992, for the first stage of implementation. Specific objectives were proposed for five phases of implementation in two-year increments through 2000 (Kentucky Department of Education, 1992).

The Master Plan of 1992 was updated in 1996 and 1998. Changes to the 1992 Master Plan enabled the expenditure of state technology funds on assistive and adaptive technology. (Cody, Kimbrough, & Coffman, 1998). Being able to purchase assistive and adaptive technology with state technology funds helped ensure that all schools were fully aware of their responsibility to provide an equal educational opportunity for students with disabilities as the schools obtained technology hardware and software for learning. The Kentucky Department of Education routinely provides for an update of a matrix of proven assistive/adaptive technologies which schools may procure with state funds to provide equitable access to the instructional network (Cody et al.).

By 1998, the goals of the original 1992 plan had been incorporated into most of the technology plans for school districts in Kentucky (Cody et al., 1998). By 1998, it was necessary to address new issues arising from experiences gained during the previous five years implementation. It was recognized that federal programs and other external factors were having an impact upon Master Plan implementation. There was renewed emphasis on the preparation of teachers to be able to use technology effectively, which included the issue of program evaluation. As stated in the updated plan (Cody et al.), the primary objectives for equity and equitable access for Kentucky for the next stage of implementation were listed as: (a) one high-performance, networked computer for every six students; (b) one high-performance, networked computer for every teacher and an ability to access the network from home; (c) all teachers will have training and support; (d) every school will have a building-wide, full-function local area network; (e) every classroom with at least four to six active network drops capable of delivering data services, Internet and email; (f) a cordless phone and video in every classroom; (g) instructional software available to every desktop from the network; (h) every school directly connected to the wide area network; (i) every district office with complete local and wide area networking; and (j) every district using a standard, fund-based accounting system (Cody et al.).

The infrastructure of support personnel throughout the state includes two full-time KETS professionals (an instructional technology specialist and a network engineer) are assigned to each of the eight 8 Regional Service Centers. Each district has a District Technology Coordinator (DTC) and each school a School Technology Coordinator (STC). The roles and responsibilities of the DTC includes leading the integration of technology into the curriculum, creating and implementing a vision for improved student learning through technology, and planning for the effective preparation of all teachers to use technology well. The STC performs a similar function at the local school level.

Kentucky is making a significant investment of time and money to prepare teachers to integrate technology into daily instruction for every child. KERA "makes it clear that the preparation of teachers to use technologies effectively is a long-term, recurring obligation shared by state, district, and school leadership. The preparation and support of teachers is critical. As noted by Cody et al. (1998), "the enlightened and appropriate use of technology in every classroom, in every area of the curriculum, and with every age level is not an option but a responsibility" (p. 24).

In 1994, the Student Technology Leadership State Advisory Council created the Student Technology Leadership Program (STLP) with the objective of empowering all students in all grade levels to use technology to learn and to achieve. It is a project-based program with four categories: instructional, community, technical, and entrepreneurial. Approximately 1,100 schools with more than 5,000 students participate in all 176 school districts in Kentucky (Harrison, 2005).

Some students take leadership roles in providing technical services as Junior Engineers. Individuals selected as Junior Systems Engineers participate in a competitive application process and become part of a cadre which receive advanced training in such things as installation and maintenance of local area networks, support for wide area networks, installation of software, and troubleshooting highly-technical problems. Throughout the year they provide support at special events and are treated as contracted professionals.

Less technical programs provide a focus on service to communities and projects for these communities. Such projects include leading basic computer skills courses for groups who may not otherwise be engaged with the school; constructing and supporting web sites for their schools and communities; and serving as technology mentors for student groups in lower grade levels.

As schools advance in their ability to engage in technical and instructional projects, STLP students may take on projects that encourage entrepreneurial aspects. By taking an idea, or providing a product or service, they can turn it into a business which can provide financial support for some of their STLP events or activities. Regional and state showcases are appropriate staging arenas to display all four categories of projects (Harrison, 2005).

With the development of an online assessment program, the Commonwealth Accountability Testing System (CATS), acquisition of accessible curriculum materials was an important element when considering flexible instructional materials for all students (Lewis, 2005). The need for access to digital content was legislated in 2002. At this time, Senator Casebier sponsored Senate Bill 243 of Kentucky Revised Statutes, providing the legal basis for acquiring student ready accessible digital curriculum through the amended textbook adoption law. This state mandate provided an opportunity to strongly encourage publishers to provide such materials offered for adoption within the state (Abell, Bauder, & Simmons, 2005; Casebier, 2002).

The Kentucky Accessible Materials Consortium (KAMC) was formed in partnership with the Department of Education and the University of Louisville to provide a number of services to schools and publishers. The Kentucky Accessible Materials Database (KAMD) was developed as a repository for the accessible digital content available to qualified students from participating publishers.

Now, Kentucky had an integrated technology structure for instructional and administrative needs, a vibrant student leadership program, an extensive network of district and local technology coordinators in place, instructional practices, online assessment, and availability to accessible digital content. The importance of expecting teachers and staff to have a basic level of technology competence was addressed in hiring practices and teacher/staff professional development (Cody et al., 1998).

Yet, there still was an inconsistent ability to integrate technology with learning across all districts into effective classroom instruction. The Kentucky Department of Education investigated current research looking for the best way to achieve the objective of effective instruction. The answer appeared to be found in the principles of UDL. Dolan and Hall (2001) explained that the concept of universal design was first used in the area of architecture as a way to design structures so that they can be used by anyone. Therefore, it is better to anticipate the needs of all possible users before building something than to try and retrofit the same structure at a later date. An unexpected benefit arose when other populations benefited from those same considerations. Dolan and Hall noted that curb cuts and wheelchair ramps are classic examples of universal design. The curb cut was originally designed for individuals in wheelchairs to be able to handle the obstacle that curbs presented, but is widely used by individuals with strollers, skateboards, skaters, a delivery person with a rolling cart or those individuals who prefer a graded approach over a step up or down.

This approach toward design on a universal basis for all individuals was adapted for instructional use in the classroom. By acknowledging the diverse ways that individuals learn and how the brain handles input of information in the process of learning, the opportunity exists to devise a learning atmosphere in which all learners will be effective.

Burgstahler (2007) describes the work of Ron Mace who coined the term "universal design" in 1997 along with his group of architects, product designers, engineers and environmental design researchers, who developed the seven principles of universal design at the Center for Universal Design at North Carolina State University. These seven principles are: (a) equitable use, (b) flexibility in use, (c) simple and intuitive, (d) perceptible information, (e) tolerance for error, (f) low physical effort, and (g) size and space for approach and use.

Dolan and Hall (2001) examined Vygotsky's (1962) work which identified the areas of recognition of information to be learned, application of strategies to process the information and engagement with the learning task as important elements in the process of learning. They recognized that Vyogtsky's work reflected the three principles of UDL commonly expressed as multiple means of recognition, multiple means of expression, and multiple means of engagement. By combining the previous seven principles of universal design with the three principles of UDL, Burgstahler (2007) developed eight performance categories that portray a good universally designed classroom of instruction. They are:

1. *Class Climate*. Adopt practices that reflect high values with respect to both diversity and inclusiveness.
2. *Physical Access, Usability, and Safety*. Assure [sic] that activities, materials, and equipment are physically accessible to and useable by all students and that all potential student characteristics are addressed in safety considerations.
3. *Delivery Methods*. Use multiple accessible instructional methods.
4. *Information Resources*. *Assure* [sic] that course materials, notes, and other information resources are flexible and accessible to all students.
5. *Interaction*. *Encourage* effective interaction between students and the instructor. Assure [sic] that communication methods are accessible to all participants.
6. *Feedback*. Provide specific feedback on a regular basis.
7. *Assessment*. Regularly assess student progress using multiple, accessible methods and tools and adjust instruction accordingly.
8. *Accommodation*. Plan for accommodations for students for whom the instructional design fails to meet their needs.

It is important to realize that utilizing universal design principles does not negate a school's responsibility of providing specific accommodations for individuals with disabilities.

Kentucky took the position that UDL is the process of designing and delivering curricula, materials and environments in a manner that makes them flexible, accessible and useable to all students. UDL has its roots in differentiated instruction. A key difference though, is that UDL is about leveraging the use of technology to achieve effective instruction. The digital tools and materials used in the application of curriculum and in the delivery of content are critical. Students are empowered to differentiate their own instruction to support personal learning styles. The burden is no longer solely on the teacher because the curriculum is innately flexible by its design (Lewis, 2006).

UDL Model School Project in Kentucky

Currently, UDL in Kentucky is supported by a number of stakeholders including the KAMC, the KAMD, text reader and text-to-speech software, Commonwealth Accountability Testing System (CATS) Online assessment, and UDL Model Schools. The UDL Model Schools are financed through the State Improvement Grant.

In 2004, the University of Louisville partnered with the Kentucky Department of Education to offer three-year grants to three K-12 public schools throughout Kentucky. The goal of these grants was to develop a best practices model of how UDL can be integrated and implemented throughout the school population and across the curriculum.

Twenty-nine counties responded and 34 grant applications were received from a wide variety of school settings – elementary, middle and high; urban and rural; large student population; and small student population. All applications were reviewed and scored by personnel at both the University of Louisville and the Department of Education based on the following criteria: the (a) importance of the project's impact on access to the general curriculum; (b) quality of the project as it relates to the use of accessible curriculum materials; the integration of technology into instruction; the involvement of low incidence students and parents; the development of professional development and training; and the dissemination plan; (c) quality of the project personnel and overall administrative support; (d) quality of the management and evaluation plans; and (e) adequacy of resources.

Even though the original plan was to fund only three schools, the Kentucky Department of Education decided to fund an additional three schools for a total of six Model Schools, each receiving $30,000 annually. Although the Kentucky Department of Education chose to fund the six schools which scored the highest during the review process, it was a pleasant surprise to find that we had funded across a continuum which included at least one elementary, one middle, one high school, both rural and urban schools with both large and small student populations.

UDL Project Roadmap

Year 1. The grant ran from January through September, 2005. The primary objectives and activities in Year 1 revolved around getting the UDL team oriented to the project and to begin purchasing hardware and software.

Year 2. The grant ran from October, 2005, through June, 2006. The primary objective and activities of Year Two revolved around training and professional development of faculty and staff at the respective schools as well as an initial implementation process.

Year 3. The grant began in July, 2006, and ended in June, 2007. Year 3 was designated as the dissemination year in which each school was expected to present its project to other schools on a local, state and national level. They were also expected to assist other schools in designing and implementing their own projects.

Technology Tools – Hardware

Although each school plan was unique, there were common elements which included the selection of hardware and software. Presented in Table 1 is a list of technology tools being utilized by Model Schools.

At this point, it should be pointed out that there is a range of costs presented in this

Table 1
Technology Tools Utilized by Model Schools

Keyboard/Digital Devices	Auditory Devices	Productivity Tools	Interactive/Wireless Devices	Visual Response Devices
Laptop Alternative (e.g. Alphasmart™ Keyboard) Laptop Personal Digital Assistant (PDA; e.g., Palm Handheld® Blackberry®)	Listening Devices (e.g., Telex Scholar, Digital Talking Book Player, Mp3 Player, Daisy Player)	Scanner Projector CD/DVD Duplicator Digital Document Camera Digital Still/Video Camera	InteractiveWireless Graphic Tablet (e.g., InterWriteSchool Pad™) Interactive White Boards (e.g., SMARTBoard™, Promethean Board™) Wireless Mouse and Keyboard	Personal Response System

partial list of technology tool, ranging from a simple MP3 player to an Interactive White Board. Although UDL means leveraging technology, it does not necessarily require an enormous outlay of money or financial resources by a school. There is a low to high range in both cost and sophistication of devices.

Technology Tools – Web-Based and Software

The use of digital text and textreader software along with the items in Table 2 are examples of software products and web-based technology tools that are being utilized by the UDL Model Schools as they implant their Project Plans on a systemic level.

Importance of Digitized Text

Since technology has become increasingly important for teachers and students (Berhmann & Jerome, 2002; Edyburn, Higgins, & Boone, 2005), it seems reasonable to integrate technology use to promote curriculum access. One approach is use of digitized text. Digital content offers ease of use and flexibility in the delivery of information. The flexibility and ease of use can be demonstrated by the different formats that content can easily be rendered into, such as an audio file played on an MP3 player to an HTML version of text that is readily available and speaking onscreen of a computer. Different text reader software programs will empower the student by allowing (a) personalized voices; (b) speech options; and (c) varying speeds, screen and color choices. There are a number of options in these software programs that aid the student with the use of word selection, word prediction, spellchecking, dictionary for basic and advanced definitions, homophones, standard calculator, scientific calculator, mapping, scanning ability, capturing of facts, text, citation material, identification of foreign words, search engines, and other options.

The use of accessible digital content and its different forms can be tailored to the individual learner. If a student has physical disabilities that require switch access, as long as the material can be accessed with a tab and enter key, it is accessible to that student. This accessible digital content can be formatted to show scaffolded instruction that can serve to individualize instruction for students with cognitive disabilities, but also stay within appropriate age content as required by many State of Education agencies. (See work by Lynn Inman Anderson at http://ces.uoregon.edu/intersect/default.html and http://ces.uoregon.edu/; and Kentucky

Table 2
Software and Web-based Technology Tools Utilized by UDL Model Schools

Software Products	Web-based Technology Tools
Achieve 3000 Differentiation Software Program™	BrainPOP®
Boardmaker®	Compass Learning®
Curriculum Mapper®	Criterion Online Writing Evaluation Service
Geometers Sketch Pad®	Encyclomedia
Inspiration®/Kidspiration®	Quia
Intellitools®	QuizStar
Read, Write & Gold®	Rubistar
STAR Reading	WISE (Web-based Inquiry Science Environment)
Riverdeep DestinationMath®	United Streaming Video – Discovery Education
Riverdeep Destination Reading®	School Center
Piano Suite	Track Star
Thinking Reader™	Think Link Learning ™
Writing With Symbols	Scholastic Reading Inventory™
	Start To Finish Books®
	State Technology Directors Association (SETDA)

examples at http://kysig.louisville.edu/kyschools.htm)

Acquiring Digital Text

While professionals may acknowledge the value of accessible digital content, the more pragmatic concern expressed by many is where to locate such material. If it is copyrighted material and part of the adopted textbooks cycle, then a likely place to locate such materials would be the KAMC (see http://kamc.louisville.edu/kyecontent/). The KAMC works with publishers to supply content that is on the state adoption list to students who qualify for its usage. To qualify, a student must have a current individual education program (IEP) or Section 504 remediation plan that identifies appropriate accommodations. This is a free service to students in Kentucky, K-12 grades if eligibility is met. The KAMC also works to acquire content material that is not on the adopted text list, but is being currently used by students in the Commonwealth.

Another resource is Bookshare.org, a subscription based group that provides access to individuals with (a) print disabilities, including visual impairment; and (b) learning disabilities or mobility impairments to copyrighted/non copyrighted materials (e.g., popular fiction, books and newspapers). In December, 2006, the National Instructional Materials Access Center (NIMAC) began to accept files using the National Instructional Materials Accessibility Standard (NIMAS) format. These files have an .xml format and the package has specific criteria. NIMAS files are not student ready and must be downloaded and converted by an authorized state user into a student ready format. The cost of the service is to be determined by the state. Currently in Kentucky, this service is free.

Non-copyrighted material is no longer protected by copyright and available for use by anyone. It is often used in classrooms for instructional purposes such as book reports or research. Much of this content can be found on Internet sites such as the KAMC, Electronic Text Center at the University of Virginia, and the Gutenburg Library among others. An appropriate individual to consult in this area would be one's local librarian or media specialist.

Developing Accessible Digital Content

There are numerous ways to incorporate content once it is digitized. Teachers routinely develop materials to use within their classrooms for instructional purposes. With a little forethought, this material can be made accessible to all students with a minimum of work using commonly owned software. For example, a unit plan could include all of the important information distilled from the content material within a chapter or group of chapters, along with any quizzes, test questions, and assignments. If the teacher excerpts this information out of copyrighted material and places it in a Microsoft® Word or .PDF format, then it is accessible for use by any student. Any passages that are quoted should be given the proper citation from the text.

Key words and definitions are often used by teachers. Work tasks and assignments can be completed by student groups and posted for everyone in the class. Study questions and study guides can be treated the same way as a Unit Plan. Homework is another example. The questions can be posted and then answered by students in a Microsoft® Word document, printed or sent as an email or attachment. Answers can be submitted online to a Web page set up by the teacher or as an STLP project by students. Students can experiment with Web pages, updating and changing them to reflect their interests. Blogs have become very popular and could be a way to increase writing by the student. Several of the model schools share their unit plans online on school web sites as they are developed as part of their dissemination plan for Year Three.

Evaluation Methods

Each school was required to develop their own evaluation process. Although they varied slightly from school to school, there were common evaluation methods used. At the School Level, there were survey and interviews with faculty, staff and students; classroom observations; monthly or quarterly reports; review of products (e.g., curriculum maps, lesson and unit plans, school/district improvement and teacher growth plans, and student products).

At the Project Level, evaluation methods included (a) Individualized Classroom Environment Questionnaire; (b) review of CATS scores and NCLB Adequate Yearly Progress (AYP) reports; and (c) monthly and year-end reports. The monthly and year-end reports were submitted to the Grant Coordinator for documentation. The CATS scores and AYP reports were monitored for the model schools as well as a group of control schools to provide additional feedback. The Individualized Classroom Environment Questionnaire by Fraser (1990) was chosen and adapted for use as a measure of change in the classroom environment as a result of this project. This questionnaire was administered at the beginning of Year 2 and was re-administered at the conclusion of Year 3.

Outcomes and Benefits

There have been a number of outcomes and benefits that are in common across the participating UDL Model Schools. Although these schools took a variety of paths to achieve similar goals, all of the Model Schools have shown various levels of progress. These areas of progress can be grouped categorically as (a) planning, (b) training, (c) participation, (d) resources, and (e) support.

Planning included the development of a lesson/unit template with a UDL component, embedment of UDL principles in school/district improvement plans, inclusion of UDL instructional strategies in teacher growth plans, and inclusion of UDL on all faculty and site based decision making agendas. Although the planning at each school was unique, planning across the aforementioned areas provided a consistent basis for the project to be implemented. By having all shareholders included in the development and implementation, there was shared ownership of the project, increased collegiality among staff and support from the local and district administration.

Training was paramount. Important common threads were authentic professional development to facilitate understanding of the philosophy and premises of UDL that pertains to education. The actual practice of embedding UDL components and strategies in real lesson plans and learning units provided hands-on practice, training, and mentoring by teacher trainers who were more proficient in understanding UDL. According to interview surveys, it was important for teachers and staff to have a baseline and to start at their functioning levels both in understanding UDL principles as well as training in any new or unfamiliar technologies and software.

Training occurred both during the school day, after school, and during the summer. Substitutes were provided for teachers during in-school training. Financial compensation for out-of-school work was motivating and placed value on the efforts expended by the staff. It was very important that the work environment be one where teachers and staff felt comfortable trying new strategies and technologies and the experiencing real 'possibility' of initial failure.

Participation was also crucial to the successful outcomes and benefits of the project. Expectations were raised by the administration, the staff, and the students. Teachers and staff were expected/required to demonstrate knowledge and skills subsequent to training that had been presented. Students were expected to access and use the equipment, software, and materials that the school and their teachers were providing both at school and home. Special education students were expected to have access to needed equipment and materials and be included in the normal school day and program. Students expected their instruction to be universally designed, flexible, and integrated with technology. Teacher training groups and cadres were expected to provide training and mentorship for their colleagues. Administrators were expected to participate, observe, and provide leadership for their staff.

Of course the allocation and use of resources was one of the most crucial aspects of the project. Without resources, there would be no project. The allocation of finances and in kind support from the district was as important as the financial resources from the grant. Each school determined its unique needs in terms of equipment, software, and professional development for the school. There was no set or fixed list of items for each school, but rather a melding of what was already at the schools and what was needed for each to achieve their particular goals. For example, some schools spent more on equipping classrooms with computers, while another school purchased interactive whiteboards. The purchases were determined by the types of technology integration that the school was pursuing.

Within the schools, equipment and software resources were distributed equitably to those teachers who were actively using them. There was active solicitation for resources such as digital text from the KAMC, and the publishers and from the Internet. The teachers and staff worked together to provide scanned materials and to convert in house content such as teacher made tests, quizzes, study guides, and units to digital form which was shared through an intranet in the schools. Common planning time was important for teachers and staff to effectively manage their time while sharing information, exploring, practicing, training, and mentoring. Increased collaboration across the curriculum was very prevalent in the UDL schools.

Support at both the local and district levels played a large part in determining the success of each school that participated in the project. By providing financial and in-kind resources, the district gave the local schools additional resources to help ensure successful outcomes. At the local level, the administration's support was reflected in varying ways. Establishing a clearly developed management plan gave teachers and staff a sound basis for developing their portions of the project. Strong leadership was needed to facilitate progress, and to smooth out conflicts and disagreements over implementation of the plans. Clear needs for data gathering was articulated and used to identify strengths and weaknesses which were evaluated on a monthly basis. Adjustments were then made to alleviate perceived weaknesses.

Outcomes at the model UDL Model Schools were successful, in part, due to the active participation of parents, student personnel, trainer cadres, support teams, and staff. As the schools publicized their successes at local, regional, and state levels, more requests for information and mentoring came in from other schools.

It must be noted that not all six schools have been successful. One school was terminated at the end of Year 2 based on lack of progress in their designated project. One of the remaining five schools struggled to make progress in Year 2 and continued to experience implementation difficulties in Year 3. Despite the fact that only one of the schools has demonstrated consistent improvement in regard to CATS scores and NCLB reports, we still consider this project a success given that systemic change occurred both in schools and their respective districts. Indeed, two of the model schools were so successful in their endeavors that the local school districts appropriated additional funds to replicate the model classroom for other local schools. In addition, one principal has even committed 10% of his discretionary funds to continue maintenance of the UDL Model within his school.

What Did It Take at the Different Levels of Participation?

Classroom level. A successful project will have a teacher who is a risk taker and willing to put in the time it takes to become comfortable with the concepts and instructional strategies related to UDL as well as the technology involved. The teacher also needs to have a willingness to learn from others and to share knowledge and skills with peers. Being able to learn in context is also critical for a successful project. There needs to be a support person available to teachers at all times for technical support.

School level. For a successful project, the principal will be key player. She or he will need to understand the goals of the project and see the potential value. This principal needs to be one who is willing to commit to being in the classrooms on a regular basis and who is willing to commit personnel and financial resources to the project. The principal will also need to be willing to clarify standards and expectations, allocate resources, direct policy, offer support, and intervene if necessary. There needs to be cohesion among the faculty, with regular collaboration and communication. The school needs to be a safe environment where teachers feel comfortable in taking chances and know that their efforts will be recognized and rewarded. Finally, the project needs to have a pair of co-directors who have good leadership and motivational skills (not to mention, never taking "no" for an answer).

District level. A successful project will have the support of targeted district personnel. As with the principal, these district personnel must understand the goals of the project and be willing to devote personnel and financial resources toward ensuring its success. Another important element is the technology support staff, who must be knowledgeable in both technical and curricular expertise as well as how to integrate both elements.

Replication of Successful Systemic Change – Key Elements

There are five common elements among all of the efforts at systemic change that were also found in our most successful Model Schools. Each of these is described below.

System review. A thorough review needs to be conducted to identify the key weaknesses of individual schools and devise specific strategies to correct each one of them. Then, professionals should monitor the implementation of the school improvement plan and hold regular reviews of the progress. Data should be used to drive decision making. Accountability should be built internally and linked to the accountability externally.

Detailed road map. A detailed road map is needed (i.e., identification of the features of the project and the key stages). Objectives and outcomes, with indicators of progress need to be specified, along with a system and schedule for measuring and monitoring progress. Everyone's role on the team needs to be clarified, as well as the behaviors, tasks, and targets for all members of the team.

Capacity building. The best person should be working on the problem. After identifying specific weaknesses and strategies to deal with the problem/s, the most qualified individual should be appointed to lead that strategy. The team needs to have a shared vision and an ownership of the project. There needs to be a shift in mindset from talking about the project and activities (i.e., from "my" to "our"). Change will never happen until teachers stop thinking "my classroom" and start thinking "our school," until school leaders stop thinking "my school" and start thinking "our school" and so on. The best place to begin will be in assuming that one of the reasons that the identified specific weaknesses exists is either because other people don't know how to change the situation or that they don't think it can be changed. The definition of capacity building is to first change the person and then work on building change within the system.

Change by doing. Often professionals get stuck in endlessly meeting about or discussing a problem. They must realize that change can only happen when action takes place. Making elaborate plans doesn't serve much purpose except to use up time that could be better spent in action.

Sustainability. Last but not least, sustainability is essential. There is no change if it cannot be sustained. The team leaders need to foster and maintain the development of relationships and to build professional learning communities. Establishing conditions that will support the development of positive pressure to change is important. The leaders also need to be thinking in terms of "leaders developing leaders" if the project has a chance for sustainability.

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Evidence-Based Practice and the Consideration of Assistive Technology

Effectiveness and Outcomes

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Abstract: The legislative and policy background for evidence-based practice (EBP) is presented with implications for research on assistive technology (AT) research in general and for the AT consideration process specifically. Requirements for the development of research-based evidence of AT effectiveness are presented as a guide for researchers and developers of AT and for practitioners who use findings of AT effectiveness. EBP as part of decision-making guidelines for AT consideration are presented.

Key Words: Evidence-based practice, AT outcomes, AT decision-making

In today's educational environments, demands for evidence-based practice in assistive technology (AT) decision-making are being articulated with increasing frequency by administrators, policy-makers, researchers, and classroom practitioners (Dugan, Milbourne, Campbell, & Wilcox, 2004; Edyburn, 2003; Hill, 2006; Parette, Peterson-Karlan, & Wojcik, 2005). Owing in large part to legislative influences (i.e., The No Child Left Behind Act of 2001 [NCLB] and the Individuals with Disabilities Education Improvement Act of 2004 [IDEIA 2004]), the term 'evidence-based practice' has become almost ubiquitous in education circles (Detrich, Keyworth, & States, 2007).

NCLB requires that that educational interventions used to improve educational performance are based on scientifically-based research (Odom et al., 2005; U.S. Department of Education, 2003). Education professionals familiar with the legislation are aware that there are more than 100 references to 'research' noted in its text, communicating a clear intent to have school reform efforts focused on educational curricula, instructional strategies, and achievement that are based in research [§1114(B)(ii)]. Similarly, IDEIA 2004 requires that educational interventions with students having disabilities are scientifically-based instructional practices [118 Stat. 2650(B)].

For a decade now, it has been a mandate that AT be 'considered' in the development of the IEP of every student with a disability [20 U.S.C. 1401 § 614(B)(v)], and the use of AT has been implicitly linked to enhanced educational outcomes for students [§616(a)(2)(A)]. Moreover, in school settings, AT is an intervention in that it is applied not only to enhance or improve student access to educational opportunities but also to improve performance in the general education and life skills curricula (Peterson-Karlan & Parette, 2007). Thus, educational law and policy generated from these laws require that AT consideration be based upon evidence of AT effectiveness and that claims of effectiveness arise from scientifically-based research. This, in turn, requires that we understand what evidence-based practice is, what constitutes an acceptable scientifically-based research claim, and how such evidence and research can inform the process of AT consideration and decision-making.

What is Evidence-Based Practice?

While an entire issue of Exceptional Children in 2005 was devoted to evidence-based approaches in special education, there is still no consensus regarding a definition of and guidelines for such practices (Detrich et al., 2007; Odom et al., 2005). As noted by Odom et al., numerous groups have developed standards for evidence-based practice, though there is no agreement across groups regarding the quantity or quality of evidence required. Recent compilations of evidence-based recommendations are observable in the health care industry (HealthLinks, 2007; U.S. Department of Health and Human Services, n.d.), medicine (Wikipedia, 2007a), nursing (Beyea & Slattery, 2006; Malloch & Porter-O'Grady, 2006), counseling (Chwalisz, 2003), psychology (American Psychological Association, 2005), and early childhood special education (Smith et al., 2003; Strain & Dunlap, n.d.). These recommendations reflect both commonalities and differences in thinking about evidence-based practices.

Despite this seeming lack of clarity in what EBP might be conceptually, the U.S. Department of Education (2003) is clear in how evidence-based practice works. NCLB calls upon educational practitioners to use "scientifically-based research to guide their decisions about which interventions to implement" (U.S. Department of Education). Interventions are broadly conceptualized to include such things as reading and math curricula, school-wide reform programs, after-

Table 1
Characteristics of Scientific Research from the Education Sciences Reform Act (P.L. 107-279)

Scientific research studies:

- Employ systematic, empirical methods that draw on observation or experiment;
- Involve data analyses that are adequate to support the general findings;
- Rely on measurements or observational methods that provide reliable data;
- **Make claims of causal relationships only in random assignment experiments** [emphasis added] or other designs (to the extent such designs substantially eliminate plausible competing explanations or competing results);
- Ensure that studies and methods are presented in sufficient detail and clarity to allow for replication, or at a minimum, to offer the opportunity to build systematically on the findings of the research;
- Use research designs and methods appropriate to the research question posed; and
- Obtain acceptance by a peer-reviewed journal or approval by a panel of experts through a comparably rigorous, objective, and scientific review.

school programs, and technologies and are criticized for having claims to effectiveness that, while being supported by evidence, is based upon "poorly designed or advocacy-driven studies (U.S. Department of Education, 2003). While NCLB allows flexibility in the type of "reliable evidence of effectiveness" presented [115 Stat. 1597, §1502(B)], there is an emphasis on "rigorous" scientific evidence (U.S. Department of Education).

What Is Scientifically-Based Evidence?

Given its explicit connection to EBP, knowledge of the characteristics of scientifically-based research and methodologies used to produce it are needed by AT developers, researchers who investigate AT effectiveness, and practitioners who must now use EBP. The Education Sciences Reform Act of 2002 established standards for scientifically-based research that include (a) applying rigorous, systematic, and objective methodologies to obtain reliable and valid knowledge to education activities and programs; and (b) presenting findings and making claims that are appropriate to and supported by the methods that have been employed. Table 1 details the seven characteristics of research that would be considered to be rigorous, systematic, objective, and reliable. Noted in Table 1 (with emphasis added) is what has been referred to as the 'gold standard' for research design: the 'random assignment experiment,' also referred to as the 'randomized controlled trial' (RCT). The randomized controlled trial has been cited as being the highest standard for research in medicine, welfare, employment, and psychology (Odom et al., 2005; U.S. Department of Education, 2003). While "other designs" which "substantially eliminate plausible competing explanations for the obtained results" are permissible, the RCT has been emphatically promoted as one of two key indicators of "strong evidence" of effectiveness with the second being trials showing effectiveness in two or more typical school settings, including a "setting similar to that of your schools/classrooms"(U.S. Department of Education) Randomized controlled trials are studies "that randomly assign individuals to an intervention group or to a control group, in order to measure the effects of the intervention" (U.S. Department of Education) This would mean, for example, that to determine the effectiveness of a text-to-speech (TTS) digital reader on text passage comprehension, a developer or researcher would need to (a) identify a large number of students with reading impairments at a particular grade level, and (b) randomly assign some in the same class to an intervention using the TTS technology, while others are might be assigned to an intervention in which someone reads the text to the student. This would be repeated across all the classes at that grade level having impaired readers. A lesser claim of "possible evidence of effectiveness" is also permitted when closely matched comparison groups are used in lieu of randomized assignment. A closely matched comparison group is created, for example, in the TTS technology study when students who have reading deficits from one or two classrooms, perhaps at one school, are assigned to the TTS intervention while others having the same degree of reading deficit from other classrooms, perhaps in another school, are assigned to the adult reader intervention.

Developing Claims for AT Outcomes and Benefits

It is obvious that these standards for scientifically-based research and claims of effectiveness have great impact upon what AT may be considered to be effective, how the evidence is a claim of AT effectiveness, and what would be included in AT decision-making consideration. There has not, however, been total acceptance among special education researchers of one 'gold standard' research methodology (Odom et al., 2005). RCT addresses only one of three possible questions that can be addressed by research: (a) What is happening? (description); (b) Is there a systematic effect? (cause); and (c) Why or how is it happening? (process or mechanism; Odom, et al.). RCT is a method for determining effectiveness. The Council for Exceptional Children (CEC) Division for Research (as cited in Odom et al.) identified four different types of methodologies are needed to address these questions when developing and evaluating the effectiveness of intervention practices: (a) experimental group (of which RCT is a part); (b) correlational; (c) single-subject; and (d) qualitative. Subsequent work has established rationale, characteristics and standards for group and quasi-experimental (Gersten et al., 2005); single-subject (Horner et al., 2005); correlational (Thompson, Diamond, McWilliam, Snyder, & Snyder, 2005); and qualitative (Brantlinger, Jimenez, Klingner, Pugach, & Richardson, 2005) research methods. Space does not permit a full examination of the purpose served by each approach or the quality indicators associated with each; for further information the reader is referred to the individual articles cited here.

Multiple methodologies are needed, not just because there are multiple questions to be answered but also because research in special education, including AT development and research, is complex (Odom et al., 2005). Additionally, different types of research are needed as a field, such as AT, emerges and develops (Odom et al.).

Complexity of AT Research

Special education research has been characterized as the "hardest to do science given the local conditions that often limit generalization and theory building" (Berliner, 2002, p. 18). As with special education research in general, AT research is inherently complex including the (a) variability of participants (i.e., both types and severity of disabilities) in service settings [20 U.S.C. 1401; §602(3)]; and (b) educational contexts where interventions are to be provided [i.e., for whom an intervention is designed and in what context; Odom et al.; 118 Stat. 2657(29)]. The educational context issue is particularly problematic given that randomization and stratification (critical elements for RCT; Gersten et al., 2005; Mosteller & Boruch, 2002; U.S. Department of Education, 2003) may be difficult, if not impossible, due to heterogeneity of the student makeup in many special education classrooms. Also problematic are issues related to low prevalence rates for certain groups of students (e.g., physical, sensory, severe cognitive or multiple disabilities), and clustering of students in groups (i.e., classrooms may become the units for assignments vs. students; Detrich, 2006; Odom et al.).

Research examining AT development and effectiveness shares the complexities cited above. Methodology other than RCT may better address AT research needs. Carefully constructed single-subject designs employing individuals as their own controls and systematically replicating AT interventions across individuals and/or settings within the same experiment may be more feasible in producing systematic, objective, and reliable data regarding outcomes and benefits than RCT methodology. Designs including multiple baselines across individuals, activities, and settings; alternating treatment designs; and multiple probe designs among others have had a long history in special education research (Horner et al., 2005). Concurrent time series probe designs can produce objective and reliable data concerning long-term effectiveness of AT in supporting student educational progress (Smith, 2000). Such single-subject research designs have been instruments of rigorous, scientific methodology for over 40 years (Horner et al., 2005) and conform to the characteristics of scientific research outlined in Table 1, with the single exception of RCT design.

Evidence-Based Practice and the Emergence of AT Research

AT development and research have developed over time; technologies, applications of technologies, and their implementation in service settings emerge over time in a logical progression from basic to small-scale applied research to large-scale demonstrations. And as noted above, not all research appropriately addresses the same questions. Descriptions of what is happening often precede demonstrations of (a) whether specific elements cause effects, and (b) how or why these effects occur, and (c) different methods for obtaining this evidence. Emerging fields such as AT use in the school settings may not be able to transition from case study to RCT research without intervening steps. Using science to improve educational or AT outcomes may actually be a continuum of research activities (Odom et al., 2005) which begins with preliminary ideas, hypotheses, observations, or descriptions, and then moves through classroom-based demonstration and design research, and finally culminates in RCT studies. None of these activities is sufficient in the absence of others; all may be necessary for a research-based knowledge base to develop that informs educational practice. In the early stage of description and exploration of specific AT technologies, qualitative research, for example, can be used to describe what is happening when individuals with disabilities, their families, or their educational professionals (a) select and use AT; (b) examine attitudes, opinions, and beliefs about AT consideration, selection and use of AT; or (c) examine personal reactions to types of AT and AT-supported interventions (Thompson et al., 2005). Single-subject research, as described above, especially systematic replications of AT-supported interventions, can provide evidence of AT effectiveness or efficiency in school and community applications while replications across disabilities which differ in important ways (e.g., autism spectrum disorders, cognitive impairments, learning disabilities) provide evidence of the generalizability of AT outcomes.

In summary, it is argued here that, while scientifically-based research is certainly requisite to the development of evidence-based practice, there are methods other than RCT that can provide reliable, valid descriptions of AT (or AT-supported) interventions, examinations of effectiveness, and consideration of how they are effective. For AT developers and researchers, reliable, replicable qualitative, single-subject, or quasi-experimental research with carefully determined dependent variables and consistency of intervention should be used to generate evidence-based practice that is published in peer-reviewed journals such as ATOB. Case studies and building- or district-based evaluations of AT effectiveness lacking these characteristics, while initially serving a helpful purpose, cannot be used as standard for evidence-based practice in a maturing field. For educational professionals and families, awareness of the need for evidence-based practice, knowledge of the characteristics of appropriate evidence-based practice, and application of scientifically-based research to AT consideration, selection, and implementation are important goals for professional development and family education.

Evidence-Based Practice and AT Decision-Making Practices: Outcomes and Benefits

Though special education practitioners express interest in evidence-based practices (CEC, 2007), such interventions are used relatively infrequently in classroom settings (Kratochill, Albers, & Shernoff, 2004; Odom et al., 2005) with little guidance being provided to assist families and professionals in choosing among available interventions (Detrich, 2006). Admittedly, the complexity of such guidance is laden with a plethora of embedded issues discussed above regarding the variability of participants and educational contexts

While the debate about evidence-based practice continues, there are still glaring issues about the implementation of such practices by education professionals. Detrich et al. (2007) suggested that there are four pressing EBP implementation issues. These include (a) effective and accessible dissemination of interventions, (b) selection of interventions, (c) initial implementation, and (d) sustainability. Each of these issues is discussed briefly in the following section.

Effective and Accessible Dissemination of Interventions

Given that many researchers in the field of AT are often aligned with university settings, publication in peer-reviewed journals is viewed as a valued and primary venue for the dissemination of knowledge, particularly evidence-based findings. However, these venues may not be an effective dissemination strategy for decision makers (Detrich et al., 2007). Unfortunately, the very nature of the research process is so intensive that findings from a body of work are frequently distributed across multiple journals. Sometimes these journals are in related discipline databases such that searches in one source (e.g., Psych Info or Academic Search Premier) do not necessarily identify citations of archived peer-reviewed publications archived in other databases (e.g., Social Sciences Abstracts, ERIC EBSCO). Even more perplexing is that the lack of accessibility of peer-reviewed publications is constrained by subscriptions to online journals (i.e., one cannot access the article without subscription or payment for the article). This is complicated even further by the lack of training in conducting searches of varying databases where evidence-based publications may be archived, coupled with lack of training in how to evaluate primary source data reported in the articles (Detrich et al.). Finally, time constraints on the part of decision-makers in intervention settings may be such that reading professional journals is a low priority activity.

To meet the needs of the practitioner for accessible evidence-based practice, a number of Web-based resources have emerged. Table 2 provides a listing of sites and their URLs which provide professionals, consumers, and students with organized information regarding evidence-based practices. Users of such sites must still be aware of and knowledgeable about the difference between summaries of areas of research and summaries of the research itself and the differences in research which has been peer-reviewed and that which has not. For example, LD OnLine (http://www.ldonline.org/) contains both summaries of articles which have undergone expert examination (peer review) and those that have not. Peer review assures that there has been evaluation of the reliability of the evidence, the integrity of the treatments or interventions, and the validity of the research claims.

Table 2
Web-Based Resources Disseminating Information on Research-Based Practices

Site	URL
What Works Clearinghouse	http://ies.ed.gov/ncee/wwc
Center for Implementing Technology in Education (CITEd)	http://www.cited.org
National Center for Technology Innovation (NCTI)	http://www.nationaltechcenter.org
Tech Matrix	http://www.techmatreix.org
Center for Evidence-Based Practice: Young Children with Challenging Behavior	http://challengingbehavior.fmhi.usf.edu/resources.html
National Early Childhood Technical Assistance Center	http://www.nectac.org/topics/evbased/evbased.asp

Selection of Interventions

Researchers have noted that systems influences impact assistive technology decision making (Parette, 1991; Parette, Brotherson, & Huer, 2000; Parette, Huer, & Brotherson, 2001). Such influences as cost, expert opinion, individual preferences (based on experiences with particular devices), and the effort associated with systems change exert powerful influences on decisions regarding selections of specific interventions. While these influences are indeed practical reality, they are valid criteria only to the extent that they are applied to a range of possible AT solutions for which evidence of effectiveness has been established through scientifically-based research. One might correctly question a decision to provide a student with a preferred, less costly, or readily available AT tool (for which little valid research information is available) in lieu of one that is less preferred, more costly, or which must be obtained (but for which evidence of AT benefit has been established by an even small body of research studies). Thus, professionals and families must become consumers of evidence of effectiveness when selecting AT during a consideration process and either seek this information themselves or require vendors to provide such information upon request.

Initial Implementation

In making decisions regarding a particular intervention, the question must be asked, "What is necessary to gain practitioner support?" (Detrich et al., 2007). This may present a dilemma in the decision-making process since one's previous training and experiences may suggest a particular choice of intervention, though pragmatics of implementing the decision with practitioners may result in a very different choice. Decision-makers are often confronted with the challenging issue of how to effectively train practitioners. It has been recognized that a broad base of competently trained AT practitioners is needed in the field (Parette et al., 2005; Parette, Peterson-Karlan, Smith, Gray, & Silver-Pacuilla, 2006). However, developing such a broad base of effectively trained practitioners is more problematic as there is little guidance for the field. An especially thorny concern is ensuring the fidelity of implementation of evidence-based findings (Odom et al., 2005). If fidelity of implementation is absent (i.e., the specific procedures reported in an evidence-based report of an AT-supported intervention are not followed), unknown effects may be anticipated from what becomes, in essence, an unknown intervention (Detrich et al.).

All too often, decision makers must examine available evidence-based practice reports and decide if the reported intervention can be adapted to meet local circumstances. Detrich et al. (2007) described two inherent dangers when such decisions are to be made. First, if the intervention is changed too much, what is implemented is a different intervention for which there are no data. Second, if the intervention is not modified to accommodate local circumstances, it may not be implemented at all.

Sustainability

Sustainability is defined as "a characteristic of a process or state that can be maintained at a certain level indefinitely" (Wikipedia, 2007b). Detrich et al. (2007) suggest that sustainable programs (a) maintain over time, (b) maintain across generations of practitioners, and (c) are supported with existing resources of system. Wikipedia also notes that sustainability "focuses on providing the *best outcomes* [emphasis added] for both the human and natural environments now, and into the indefinite future." Unfortunately, evidence-based interventions that are not sustainable run the risk of being replaced with alternative, ineffective practices. A corollary, then, is that the larger the scale of implementation required of a particular system, the more complex and potentially unsustainable these issues become (Detrich et al.).

Summary

As CEC (2007b) has noted, evidence-based practice, while wanted and needed, is hard to find. In the absence of randomized controlled trials with large numbers of students with disabilities of AT-supported interventions, the consideration, selection, and implementation of AT in school and community settings will need to depend upon AT developers and researchers providing systematic, objective, and reliable data regarding outcomes and benefits based upon research methods appropriate to the participant, context, and evaluation questions. AT developers and researchers will, in turn, depend upon educational professionals and families of students with disabilities who have been informed of the characteristics of valid research and are committed to asking for and using it in AT decision-making. Finally, information technologies will need to be developed and/or sustained to insure access to such information by educational and family consumers.

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CALL FOR PAPERS

Assistive Technology Outcomes and Benefits

Fall, 2008
Submission deadline: March 31, 2008

Assistive Technology Outcomes and Benefits is a peer-reviewed, cross-disability, transdisciplinary journal that publishes articles related to the *outcomes* and *benefits* of assistive technology (AT) across the lifespan. The journal's purposes are to (a) foster communication among vendors, AT Specialists, AT Consultants, and other professionals that work in the field of AT, family members, and consumers with disabilities; (b) facilitate dialogue regarding effective AT practices; and (c) help practitioners, consumers, and family members advocate for effective AT practices.

Call for Papers for Volume 5

Assistive Technology Outcomes and Benefits invites submissions of original manuscripts for publication consideration. Only papers that address *outcomes* or *benefits* related to assistive technology devices and services will be accepted. These may include (a) findings of original scientific research, including group studies and single subject designs; (b) marketing research conducted relevant to specific devices having broad interest across disciplines and disabilities; (c) technical notes regarding AT product development findings; (d) qualitative studies, such as focus group and structured interview findings with consumers and their families regarding AT service delivery and associated outcomes and benefits; and (e) project/program descriptions in which AT outcomes and benefits have been documented.

This peer-reviewed journal will include a broad spectrum of papers on topics specifically dealing with AT outcomes and benefits issues, in (but NOT limited to) the following areas:

- Transitions
- Employment
- Outcomes Research
- Innovative Program Descriptions
- Government Policy
- Research and Development
- Low Incidence Populations

For information on how to submit manuscripts see the *Guidelines for Authors* at http://atobjournal.org

Guidelines for Authors

Assistive Technology Outcomes and Benefits
Submission deadline for *Volume 5*: March 31, 2008

Submission Categories

Articles may be submitted under two categories—*Voices from the Field* and *Voices from the Industry*.

Voices from the Field. Articles submitted under this category should come from professionals who are involved in some aspect of assistive technology service delivery with persons having disabilities, or from family members and/or consumers with disabilities.

Voices from the Industry. Articles submitted under this category should come from professionals involved in developing and marketing specific assistive technology devices and services.

Within each of these two categories, authors have a range of options for the type of manuscript submitted. Regardless of the type of article submitted, primary consideration will be given by the journal to work that has *quantifiable results*.

Types of articles that are appropriate include:

- **Applied/Clinical Research.** Original work presented with careful attention to experimental design, objective data analysis, and reference to the literature.
- **Case Studies.** Studies that involve only one or a few subjects or an informal protocol. Publication is justified if the results are potentially significant and have broad appeal to a cross-disciplinary audience.
- **Design.** Conceptual or physical design of new assistive technology models, techniques, or devices.
- **Marketing Research**. Industry-based research related to specific AT devices and/or services.
- **Project/Program Description.** Grant projects, private foundation activities, institutes, and centers having specific goals and objectives related to AT outcomes and benefits.

In all categories, authors MUST include a section titled ‘Outcomes and Benefits’ in which a discussion is provided related to outcomes and benefits of the assistive technology devices/services addressed in the article.

Manuscript Preparation Guidelines for Submission to

Assistive Technology Outcomes and Benefits

All articles submitted will be refereed by the Editorial Review Board. Recommendations on suitability for publication will be taken as final by the Editor.

All other items would not be reviewed, but the editors reserve the right to refuse or (with the approval of contributors) to edit copy.

1. Each manuscript must reflect style guidelines of the *Publication Manual of the American Psychological Association* (5th edition, 2001).
2. Manuscripts should be **no more** than 25 pages in length (**double-spaced**), *including* references, tables, and figures. Due to the electronic format of the journal, all submissions should be submitted as email attachments in a Microsoft® Word format. The following information should be provided on the cover page of each manuscript:

    - Author'(s') full name(s) and title(s)
    - Name of corresponding author
    - Job title(s)
    - Organization(s)
    - Full contact information of the corresponding author, including email address, postal address, telephone and fax numbers
    - Each manuscript should have at least the following components:
        - Title (up to 10 words)
        - Abstract (75 to 150 words) presenting the main points of the paper and the contributor's/s' conclusions regarding outcomes and benefits
        - 3-4 keywords
        - Main body of paper
        - **Outcomes and Benefits section**
        - References

3. Submissions should be double-spaced.
4. Articles should be subdivided into unnumbered sections, using short, meaningful headings according to *Publication Manual of the American Psychological Association* (5th edition, 2001).
5. Footnotes and endnotes are **not** accepted; all such information should be included in main text.
6. The keywords (just after the abstract) should be separated by **commas**, and each keyword phrase should have initial caps (e.g., Communication devices, Families).
7. Authors should not use underline to emphasize text, but use *italics* instead.
8. For figures, **.tiff, .eps,** and **.jpg** are preferred formats. Figures should be embedded in the text narrative at appropriate places and centered horizontally. Captions (maximum 6 to 8 words each) must be provided for every figure (below the figure) and must be referenced in the text. If scanned images are used as figures, authors are responsible for insuring that they are crisp images (i.e., no pixilation, fuzziness, or shading artifacts).

In the event that the file(s) can't be opened, the Editor will contact the corresponding author by email and request that the appropriate format be provided. Figures should NOT have text captions embedded in them. Text captions should be contained in the narrative. Figures that are copyrighted or adapted from copyrighted figures must have approval for use. Notation of this approval is included in the figure caption along with a letter from the copyright holder indicating approval for use or adaptation (see p. 174 of APA Manual for guidelines).

Sample

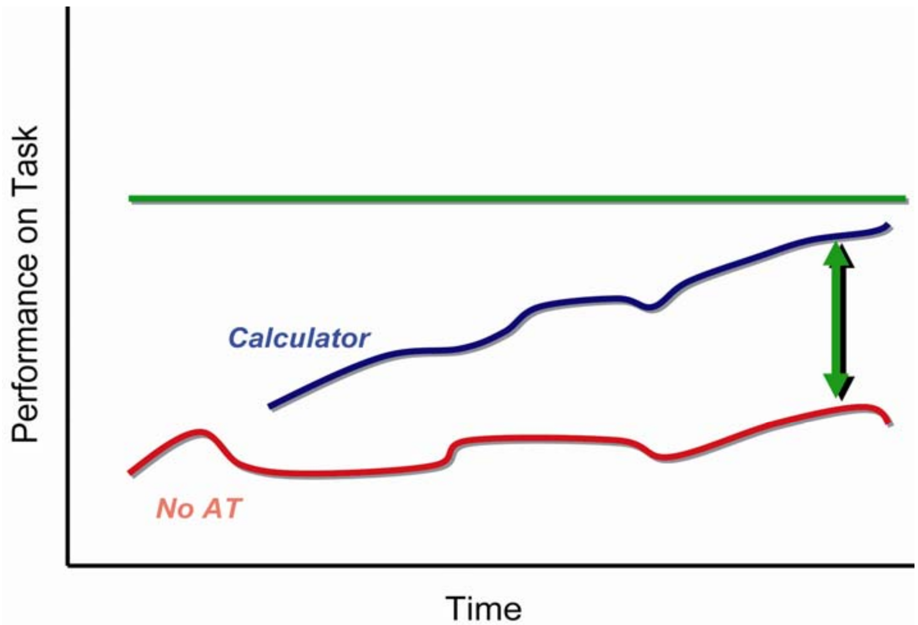

Figure 1. Comparison of direct teaching vs. use of calculator on functional performance. Source: ©2007, SEAT Center. Used with permission.

If the figure is excerpted or adapted from a previously published source:

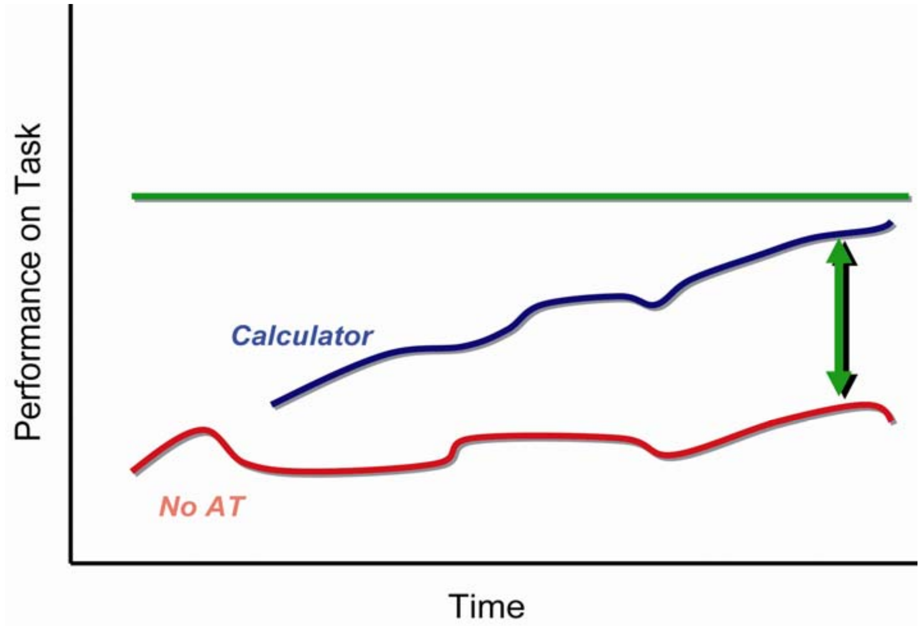

Figure 1. Comparison of direct teaching vs. use of calculator on functional performance. Source: Parette, H. P., Peterson-Karlan, G. R., Wojcik, B. W., & Bardi, N. (2007). Monitor that progress! Interpreting data trends for AT decision-making. *Teaching Exceptional Children, 39*(7), p. 6. Used with permission.

9. Tables should be included in the text at appropriate places and centered horizontally. Captions (maximum 6 to 8 words each) must be provided for every table (above the table) and must be referenced in the text. Tables should not be graphic images, but should be original tables created using the Table feature of Microsoft® Word (see pp. 147-176 of APA Manual for table preparation guidelines).

   Example:

   Table 1

   Focus Group Participant Demographics

Professional	Gender	Degree	Yrs. Education	Role	Classroom
Sam	M	BS	16	Teacher	Pre-K
Joan	F	BS	17	Aide	Pre-K
Deborah	F	BS	16	Aide	Pre-K
Makela	F	HS	12	Aide	ECE
Tom	M	BS	14	Aide	ECE

10. The References section should contain appropriate citations noted in the APA Manual (5th ed.)

   Sample citations

Journal article

James, P., & Tatem, J. J. (2003). Assistive technology benefits. *American Journal of Occupational Therapy*, *39*, 336-337.

Paper presentation

Stuart, S. K., & Kemp, L. M. (2003, January). *Native Americans and AAC issues*. Paper presented to the Annual Meeting of the Assistive Technology Industry Association, New Orleans, LA.

Book

Kalyanpur, M., & Harry, B. (1999). *Culture in special education. Building reciprocal family-professional relationships*. Baltimore: Brookes.

Book chapter

Soto, G., Huer, M., & Taylor, O. (1997). Multicultural issues in augmentative and alternative communication. In L. Lloyd, D. Fuller, & H. Arvidson (Eds.), *Augmentative and alternative communication* (pp. 406-413). Boston: Allyn and Bacon.

Legislation (Any law that is described in the manuscript narrative must be included in the Reference List; see p. 404 of APA Manual)

Individuals with Disabilities Education Act Amendments, 20 U.S.C. § 1400 *et seq* (1997).

No Child Left Behind Act, 20 U.S.C. 6301 *et seq*. (2001)

Electronic Resources

Use of electronic sources has become increasingly common, though many authors are unfamiliar with appropriate citation and referencing formats when using such sources. For any electronic citation, please refer to pp. 268-281 in the *APA Manual* for appropriate formats. Please be sure that the most current link to the file is presented in the reference (Note: Authors often use older Web citations that are no longer accessible or that are archived on other sites. Check the link to all electronic citations to ensure that it is still active; if not, be sure to locate the current link and include that in the reference.)

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11. All statistical symbols should be in italics.
12. The Editor will acknowledge receipt of a submitted article immediately.
13. Authors are encouraged to write in the third person and use “person-first” language, i.e., the individual *precedes* the disability. For example, phrases such as “persons with disabilities,” “students with mental retardation,” “and “adults with cognitive impairments” are more appropriate than such phrases as “the disabled,” “learning disabled students,” or “mentally retarded adults.” Consumers and family members who submit manuscripts describing specific practices may use the first person.
14. A cover statement in the submission should indicate that the manuscript has not been published in whole or substantial part by another publisher and that it is not currently under review by another journal.

All submissions for the third volume of ***Assistive Technology Outcomes and Benefits*** **are due by March 31, 2008.**

After a manuscript has been accepted for publication and subsequent to making all changes recommended by the editorial review board, authors must send a copy of the revised manuscript and a computer file to the Editor via email to: **hpparet@ilstu.edu** or via mail to: Dr. Phil Parette, Special Education Assistive Technology (SEAT) Center, Illinois State University, Campus Box 5910fa, Normal, IL 61790-5910