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Assistive Technology and Adult Literacy: Access and Benefits

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This chapter focuses on the role that assistive technology (AT) can play in improving the literacy acquisition and motivation of struggling adult students who have mild reading disabilities. Mild reading disabilities may be the result of learning, attention, memory, cognitive, or sensory impairments, and these categories often overlap. For example, Schulte, Conners, and Osborne (1999) found that attention deficits (AD) and learning disabilities (LD) co-occur at rates greater than can be predicted by chance. Although the main difficulties associated with the two disorders are distinct (LD is associated with language-based disorders and AD with executive-function disorders), the combination of the two disabilities often contributes to poor school performance and achievement.

Providing access to assistive technologies to supplement classroom instruction can address students' needs for additional tutoring and small-group instruction, as well as support their literacy learning by making studying and reading easier. Students could then begin to engage in more effective self-study activities, thus boosting their learning, classroom performance, and sense of competence and motivation.

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The range of AT is vast and addresses many different types of functional limitations, but in this chapter I focus on only a few categories of computer-based AT that support literacy development. I first review services provided for adults with LD in the adult basic and literacy education (ABLE) field, followed by a brief overview of the elements of adult literacy learning. Then I present specific AT tools and their functions and uses, followed by two case studies of how literacy learners benefited from supplemental instruction with AT. In the fourth section, I look at the research and discuss the use of computer-based technologies to support youth and adult engagement with literacy tasks. Finally, I explore the practice, policy, and research implications of integrating these technologies into services for adult literacy students with mild reading disabilities.

PROVIDING SERVICES

As young people leave the K–12 educational system when they graduate, reach the maximum age (22) for special-education services, or drop out, they leave behind the entitlement program and legal mandates of the special education system, which is governed by the Individuals with Disabilities Education Improvement Act (IDEA, 2004). They enter abruptly into the legal standing of individuals with the right to claim disability protection under the Americans with Disabilities Act (ADA) and Section 504 of the Vocational Rehabilitation Act of 1973. However, most youth and adults with disabilities do not understand this right, or how to claim it (Mull & Sitlington, 2003; Stodden & Conway, 2002).

The ABLE field must comply with legal mandates to accommodate students with disabilities and to provide appropriate services to benefit students with disabilities. The policies and effective practices associated with such services, however, are less than clear-cut. The capacity to provide such services—among practitioners, programs, and communities—is still sorely lacking (Corley & Taymans, 2002).

Postsecondary institutions and employers are required to maintain physical environments that are universally accessible, provide nondiscriminatory services, and respond to an individual's self-disclosed disability. Postsecondary institutions and employers must provide "reasonable" accommodations when requested. The government does not mandate universally accessible services and products. Rather, these must be provided in nondiscriminatory formats in a manner that is timely, accurate, and appropriate to the material accommodated, as well as to the individual

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with the disability (Grossman, 2001). For example, scheduling information for a program should be available in multiple formats (large print, online or on disks for those who use computer readers, or recorded); a "discriminatory" format would be a complicated printed schedule, with the only arrangements made for accommodation being a receptionist reading the schedule aloud to a student in a lobby.

The Bridges to Practice initiative funded by the National Institute for Literacy from 1993 to 1999 provided guidance to the ABLE field. Through professional development and technical assistance, the project provided resources and training to practitioners and program managers to evaluate whether curriculum and policies effectively met the needs of adults with LD. Programs were urged to adopt screening policies and instruments to identify students at risk for LD and forge community coalitions for obtaining appropriate diagnoses. Five years after the publication of Bridges materials (National Adult Literacy and Learning Disabilities Center [NALLDC], 1999), Corley and Taymans (2002) suggested the field still has a way to go to realize improved outcomes for students with learning disabilities.

Although the research base on teaching students with mild disabilities within adult education is exceedingly slim, there is a substantial database of research addressing the instructional needs of elementary and secondary students with LD. In a review of several meta-analyses and syntheses of research on intervention strategies for K–12 students with LD, Vaughn, Gersten, and Chard (2000) identified several guiding principles. Their review found that effective instruction requires the following:

- Visible and explicit components (expectations and examples demonstrated clearly and through multiple sensory channels).
- Managed task difficulty and sequence (complex tasks taught in logical steps and sequence).
- Interactive dialogue and thinking aloud (lots of teacher–student conversation and probing questions).
- Opportunities for guided practice and directed feedback (practice activities completed in class with immediate and focused feedback).
- Small-group settings (either for practice or differentiated instruction based on group needs).
- Peer-mediated activities (peer tutoring or cooperative-learning activities).
- Both a skill- and strategy-level focus (building and practicing skills, as well as learning how to problem solve in a discipline).

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These findings were consistent across elementary and secondary studies reviewed over a 30-year period representing the research on LD. The authors concluded that although the findings are not revolutionary, the practices are not widespread in U.S. classrooms, leaving students with LD to languish due to ineffective instruction.

In fact, students with mild disabilities are resisting this ineffective instruction and curriculum. In 2000, an estimated 3.8 million youth and young adults (ages 16–24) were high school noncompleters, a full 10% of their age group (Kaufman, Alt, & Chapman, 2001). As is true historically, students from low-income families drop out in greater numbers—28.9% in October 2000 as compared to the national average of 10.9% (Kaufman et al., 2001). Statistics on special-education students' dropout rates include recent rates as high as 29.4% (Office of Special Education Programs, 2000). Leading the trend are students diagnosed with serious emotional disturbance (51.4%), specific LD (27.6%), mental retardation (26%), speech or language impairments (24.6%), and other health impairments (22.4%).

For youth and adults with mild disabilities in search of educational improvements, ABLE and family literacy programs are some of the few places they can turn to for affordable services. Yet the programs are not prepared to serve them well. Scanlon and Lenz (2002), in a national survey of adult education completed by program directors and practitioners from 34 states, sought open-ended responses to questions about literacy areas emphasized in interventions for adults with LD, and specific interventions and materials used in programs. The survey findings demonstrate the eclectic nature of ABLE practice and the gaps in research conducted with adult literacy students with LD. Notably, respondents did not cite any common practices or materials representing any field-based knowledge of best practice. What respondents did cite was a range of practices and materials that reflected a skills-based, functional literacy curriculum and a philosophy of LD as a set of deficits. Whereas skills-based practices may be appropriate as a component of a curriculum for youth and adults with LD, adult LD researchers (Scanlon & Lenz, 2002; Sturomski, Lenz, Scanlon, & Catts, 1998) caution that adults in ABLE settings may resist skills-based or functional pedagogies and deficit-model philosophies.

Furthermore, adult education programs that focus solely on functional literacy and skill development may be missing some of the higher order thinking and problem-solving strategy instruction strongly recommended for youth and adults with LD in ABLE programs (Corley & Taymans, 2002; NALLDC, 1999). This type of strategic instruction is also documented as

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best practice for youth with LD through encompassing reviews (Swanson & Hoskyn, 1998; Vaughn et al., 2000) and without LD (Hinchman, Alvermann, Boyd, Brozo, & Vacca, 2003–2004; National Institute of Child Health and Human Development, 2000).

Adult literacy practitioners should choose pedagogies based on research, but most research takes place in secondary or postsecondary schools. Nevertheless, research representing secondary and college students with mild disabilities may be the closest body of knowledge from which to make inferences for our practice. In the next section, I explore adult literacy development from two perspectives: LD research and new literacies theory.

ADULT LITERACY DEVELOPMENT

Adult reading research (Kruidenier, 2002) sees literacy development as the improvement of a set of component skills. Learners with LD struggle with basic phonological awareness (the ability to hear and manipulate individual sounds and clusters of sounds within words) and with how sound and visual patterns comprise the foundational blocks of learning English literacy (phonics). Many learners with LD struggle with visual perception, finding the two-dimensional, black-on-white presentation of text difficult to keep in focus or discern, causing fatigue, frustration, and an inability to concentrate on text. Attention deficits may also interfere with the level of attention, persistence, and memory learners are able to bring to literacy learning. Readers who have difficulty with any of these basic skills are bound to struggle with fluency (the ability to do these tasks smoothly and quickly; Kruidenier, 2002). Slow, laborious decoding, guessing at unknown words based on superficial clues, and fatigue from the reading process are hallmarks of the reading efforts of adults with low literacy.

How adults with LD acquire vocabulary is also a concern. Their phonologic and orthographic difficulties make teaching and learning vocabulary a complex challenge that interferes with success on the general equivalency diploma (GED), in further education, and in employment. Readers' acquisition of, or even exposure to, interesting and content-appropriate reading instruction or materials can be blocked by these difficulties, in varying combinations and prominence. Higher order and critical comprehension strategies are often left off the instructional, and even research, agenda with adult new readers with mild disabilities.

Critical literacy or new literacies theorists (Lankshear & Knobel, 2003; Luke, 2000; Luke & Freebody, 1997) would likely cast most of this research as woefully and unhelpfully individualistic. Reading, they maintain, is a social, transactional act that cannot adequately be understood by studying a single person or classroom, but rather requires a social context and critique to be understood adequately. The New Literacy Studies model shares much with the Freirian model of literacy that embeds literacy learning and use in praxis of naming powers and working openly toward social justice. This model also includes a strong critique of the assumption that facility with print literacy is central to identity and personal development, an essential assumption underpinning skills-based and literacy-practice theory. New and critical literacy theories remind us to question the materials and approaches we employ and the outcomes we watch and measure in adult literacy instruction. The questions raised by critical literacies help us frame questions such as "Access to what, for what, and for whom?"

Adult reading instructors and researchers must keep these multiple and overlapping theories in mind when working with students and when designing research and instruction, and remember that theories show us the same phenomenon—literacy—from various perspectives (Leu, Kinzer, Coiro, & Cammack, 2004). None of the perspectives alone can provide a full understanding. Balancing perspectives and goals for literacy learning is a challenge that can only be met by involving the adult learner in setting goals, identifying his or her developing needs and hopes, and exploring—and more important—creating options and access to new materials.

The use of AT to create options for literacy learners requires a creative and strategic approach that pairs the functions of the technology with the needs of the student and the demands of the literacy task. The next section explores types of AT in more detail.

CATEGORIES OF ASSISTIVE TECHNOLOGIES

AT is a subfield of educational technology, and for youth and adults, it is associated with rehabilitation practice and research (Watts, O'Brian, & Wojcik, 2004). AT was defined in the 1988 Technology-Related Assistance Act as "any item, piece of equipment, or product system acquired commercially off-the-shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of individuals with disabilities"

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(Technology-Related Assistance for Individuals With Disabilities Act of 1988). This definition was used in the 1997 reauthorization of the IDEA, which mandates pre-K through 12th-grade special education services. Although this definition has proven to be too broad to guide educational practice (Edyburn, 2000), it remained unchanged in the 2004 reauthorization of IDEA (H.R. 1350) and of the AT Act of 2004 (H.R. 4278).

Special educators have used several applications of computer-based technologies effectively to meet the literacy needs of students with mild disabilities, such as learning, attention, memory, or mild sensory impairments. Although the research base is still small, it is growing; new studies with sophisticated designs and outcome measures are emerging. There is a complementary growing database of practical knowledge, which explains how technologies are used and modified to meet needs in instructional, employment, and daily-living situations.

Drawing on this emerging knowledge base for secondary and postsecondary students with mild disabilities, in this section I examine three of the most readily available categories of software: text readers, voice recognition, and predictive word processors. The functions, range of applications, and demands on the user are discussed, as well as how the software–user interactions may meet literacy development needs. How these technologies can supplement adult education instruction for learners with disabilities will be shared in two brief anecdotes.

Text Readers

Text-to-speech (TTS), or speech-synthesis technology, refers to the conversion of digital information into synthesized speech. In other words, the computer reads the text aloud. TTS engines[15] can be an optional feature combined with other software programs or configured as stand-alone specialized text readers.

Functions, Applications, and Demands. Speech engines vary in the quality of the "voices" they use to read aloud and the range of customizable features they offer, such as text and background colors and contrast, reading rate, or highlighting and masking. Dynamic highlighting—a feature that colors a single word or phrase—emphasizes the text being

[15]Two free TTS engines are ReadPlease (http://www.readplease.com) and Microsoft Reader (http://www.microsoft.com).

read. Dual highlighting is a related software feature, sometimes called masking, in which the context (sentence or paragraph) is highlighted in one color while the spoken word is highlighted in a second color, making it easier for readers to stay in sync with the spoken text.

These features are digital versions of the window cards (index cards with a slot cut out of the middle) teachers have relied on to assist struggling readers to keep their place on a line of text. The dynamic digital version brings the reader's attention to a word and its placement on the line without a loss of peripheral vision of the rest of the text (a drawback of index cards, rulers, and blank paper used to track reading). TTS with dynamic highlighting, therefore, offers simultaneous auditory and visual input. When users read along, or even subvocalize (lip sync), their speech muscles add proprioceptive (mouth and throat muscle) input to the experience, making it truly multisensory.

There are specialized tools that read only some files, such as talking Web browsers[16] or a program that reads Adobe Acrobat files.[17] Other TTS engines read text from multiple software applications (word processors, spreadsheets, database, Web pages, e-mail, etc.).

Comprehensive software programs designed to help learners with disabilities combine TTS with other powerful capabilities—such as optical character recognition (OCR), embedded resources, and word processors—include programs such as several versions of the Kurzweil readers,[18] WYNN readers,[19] programs from the Premier Assistive Suite,[20] and Read and Write Gold.[21] According to a national survey of postsecondary institutions (Michaels, Prezant, Morabito, & Jackson, 2002), these AT devices are some of the most commonly provided, available on 78% of campuses, and considered by survey respondents to be among the top five most useful AT devices[22] for college students with disabilities.

[16]Such as Web Talkster (http://www.code-it.com), or BrowseAloud (http://www.browsealoud.com)—both are free TTS engines that navigate Internet Web pages.

[17]Such as PDF Aloud (http://www.texthelp.com/PDFaloud.asp?q1=products&q2=PDFaloud).

[18]See http://www.kurzweiledu.com/.

[19]See http://www.freedomscientific.com/LSG/index.asp.

[20]See http://www.premier-programming.com/.

[21]See http://www.texthelp.com/home.asp.

[22]Other useful devices identified in the survey include recorded textbooks, real-time captioning, screen magnification software, and specialized tape recorders.

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OCR is scanning software that digitizes print from a piece of paper and converts scanned images into document files. These scanners do not simply make a picture or image of a page of scanned text, but actually decode the print and turn it into an electronic document, which can then be read aloud by the TTS. OCR can recognize standard text fonts, but accuracy depends on clear, crisp print and high-quality scanners. Proprietary scanners preserve the layout of the scanned page on the computer screen and are capable of reading text that continues across multiple columns, reading tagged graphics (those with a linked description), and preserving navigational markers such as chapter breaks. This can be an advantage if a student is using an OCR program in a classroom in which instruction often references textbook features.

All of these comprehensive programs (Kurzweil, WYNN, the Premier Assistive Suite, Read and Write Gold) are highly customizable. The programs have elaborate TTS engines, often with a wide variety of voices of differing pitches, tones, and even accents. Readers can select preferences such as reading rate, the amount of text visible at a time on the screen, the size of the font, the colors of the presentation (background, text, highlighting), the text segment that is highlighted or masked (sentence, phrase, or word), the toolbar icons visible, and so on. These preferences can be set as defaults for a particular learner (as a user profile), eliminating the need to reset them at each session.

These top-of-the-line programs offer many resources and features to enhance studying, such as multiple dictionaries, syllabication and pronunciation guides, thesauruses, text highlighters (static highlighters that replicate highlighting on a paper text), and annotation options such as digital sticky notes or margin notes into which the reader can copy and paste definitions from the dictionary or glossary, type comments, or (in the Kurzweil 3000) speak a voice note (saved as an audio file). These annotations attach to a line or word in the text, but are not visible until opened. Most programs allow users to extract (copy) the text annotations. For example, a learner could extract all of her annotations of definitions to a word processor and create a personal glossary for later use.

Literacy Supports and Learning Opportunities. OCR software and TTS engines have opened the world of print to users with mild visual disabilities. Sophisticated TTS engines that navigate the Web have done the same for Web-based materials. Comprehensive programs create a working environment modeled after master students' habits, with tools and resources at the ready. However, OCR and TTS are not perfect tools. TTS

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engines often mispronounce homographs (words that are spelled the same but pronounced differently, such as *read* as a past- or present-tense verb). Not all Web pages are designed to be compatible with TTS engines, rendering them incomprehensible. Print scanned into OCR often needs to be edited to clean up any misrecognitions caused by poor print copies, unusual fonts, or scanner software glitches.

The imperfections in the tools, however, are opportunities to examine how the tools function. When literacy learners notice incorrect pronunciation and are coached to spend time exploring them, they have an opportunity to compare what they had expected with what was pronounced. Looking for the cause of the mispronunciation of the verb *to read,* for example, can lead to a minilesson on verb tense, homographs in general, or quality of scanned print and how to correct misrecognitions. When literacy learners are given supported access to AT (in the form of a literacy coach or tutor), the novelty of the tools and the situation create an environment in which literacy is made visible and open for exploration, analysis, and mastery.

Voice Recognition

The converse of text readers is speech or voice recognition software, which can process spoken language into digital text.[23] Industry increasingly uses such software as a front-line service option for over-the-telephone reservations, requests, and routing. This technology has a long history of intense research and is still receiving research and development attention from companies such as AT&T, Microsoft, and IBM (Kanellos, 2003; Kelly, 2004) in an effort to improve accuracy of recognition, range of recognized speech-pattern variations (tone, pitch, rate, volume, dialect, idioms, specialized vocabularies, etc.), and ease of training. Improvements in any one of these areas involve trade-offs in other areas of the program. For example, accuracy for a single user can be greatly enhanced, but for a commercial software package to be programmed to recognize an unknown buyer, software companies have to maximize the range of voices that can be recognized. Portability of voice files that would allow a user to dictate and word process on multiple machines and with multiple microphones, for example, is an urgent area for future development so that users can use the

[23]Such as IBM ViaVoice (http://www.scansoft.com/viavoice/), Dragon Naturally Speaking (http://www.scansoft.com/naturallyspeaking/), and SpeakQ (http://www.wordq.com/speakqenglish.html).

program on more than one computer. Cross-disciplinary research, including linguistics, speech and hearing sciences, the science of sound and microphones, artificial intelligence, and computer science, is contributing improvements as well, and the next generation of these products promises great improvements in usability.

Functions, Applications, and Demands. These programs are widely utilized by individuals with motor and physical impairments that make using a keyboard difficult or impossible. Individuals who struggle with spelling and handwriting are now using voice recognition to bypass those tasks.

Voice recognition can be included with software programs performing other functions (e.g., in the Apple and Microsoft operating systems), or it can be the central feature of a software application, such as Dragon Naturally Speaking. Even dedicated software programs, however, now combine several functions into a seamless user interface (both programs working simultaneously in one "window") so that the voice recognition capabilities are available for multiple applications. With Naturally Speaking, for example, users can dictate into a variety of word processing programs, database programs, spreadsheets, e-mail, and operating systems.

Accuracy is a still a major hurdle. The software requires a quiet location and a high-quality microphone dedicated to a powerful and fast computer. Users must train the computer to recognize their voice and, although initial training can now take as little as 10 minutes, for literacy learners, reading scripts aloud for voice training is a process that requires support and patience. Some voices are more easily recognized by the technology than others, and other voices require additional and sometimes extensive training. SpeakQ is a new program that is dedicated to improving accuracy for users with voices that are difficult to recognize, users who stutter, and students with literacy difficulties. As users train and dictate to the program, their "voice file," or what the program knows about recognizing the user's voice and pronunciation as well as specialized vocabulary, continues to grow, thus improving accuracy.

Users need to tell the computer how to format what they dictate. Therefore, they must learn the formatting commands (here referenced to Naturally Speaking commands) such as Indent, New Paragraph, Flush Left, and so on, and the vocabulary of punctuation. They must command the program with these exact phrases, or, instead, format their composition using the keyboard and mouse.

Dictation must be performed with clear enunciation and an even rhythm, volume, intonation, and conventional phrasing. Users must discipline

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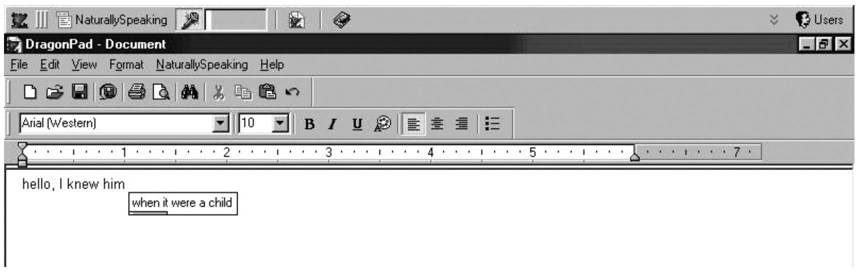

FIG. 4.1. Dragon Naturally Speaking. Note that the Results Box is processing the second phrase dictated and errors are appearing (“it” for “I” and “were” for “was”).

themselves not to add extraneous verbal input that will distort the recognition process, such as “uhms,” sighs, tongue clicks, throat clearing, and so on. As a user dictates, the Results Box on the screen displays the way the program recognizes the speech. The Results Box is a window into the workings of the linguistic and artificial intelligence predictions the program makes based on context clues and the user’s voice file data (see Fig. 4.1).

Even under the best conditions, perfect accuracy is not possible, and users must expect recognition errors (*I scream*/*ice cream*). A user must decide how to handle misrecognitions, such as whether to pay attention to accuracy or to continue dictating and work on revisions, edits, and corrections later. Alternatively, a user can decide to pay attention to accuracy during the dictation process, starting with reading the text as it appears in the Results Box. Writers can correct recognition errors through multiple means, each with advantages and disadvantages. For example, by keyboard or voice command (Scratch That), they can delete dictated phrases that contain errors and then redictate. None of these actions “teaches” the program about the error or improves the voice file.

A third option is for users to correct errors through a process that actually improves the accuracy of their voice file, with correction procedures and further training on each misrecognition. When the user chooses a word or phrase for a Correct That process, a box appears on the screen with several choices based on semantic context or alternative formatting (e.g., a variety of ways to represent dates). If the correct recognition is on the list, a user can simply choose the correction by commanding, “Choose #,” or by entering the shortcut key. Programs that pair with TTS engines can read these choices aloud. Naturally Speaking also includes a Train That option, a further word-by-word or short-phrase dictation that will train the voice file to recognize a user's particular pronunciation of a word. Each correction, whether done during the dictation process or later during editing, then, requires strategic planning and a high level of engagement with the print.

Literacy Supports and Learning Opportunities. In education and employment settings, voice recognition has provided computing access to individuals with physical impairments that limit their ability to use a keyboard. With the vast improvements in accuracy and cost reductions in the past decade, voice recognition has gained a growing user base among individuals with LD.

For students for whom writing is slow, laborious, or torturous due to their spelling, handwriting, and composition difficulties, voice recognition software opens new opportunities to express themselves and complete writing assignments. Voice recognition software employs a user's oral vocabulary and expression strengths to capture the intended message while bypassing many of the most common barriers to writing.

Voice recognition, however, does not do all the work. The cognitive demands when using voice recognition are high for users with language disabilities and LD, limited literacy, or AD. Using voice recognition software requires writers to constantly engage and monitor the text produced. Users must compare the actual results with their expected results to determine accuracy. They must determine the most strategic response to correct any errors (e.g., delete the mistake and redictate the phrase with more attention to enunciation, go through a correction procedure, ignore the mistake and edit later, incorporate the unexpected words into the flow of the text), command the program to format the text, and simultaneously maintain their train of thought to continue composing.

Several features support users in their efforts to utilize voice recognition software successfully. TTS engines included with the software read the dictated text and the text given as correction alternatives. Dictating into a word processor that has embedded tools, such as a spelling and grammar checker, alerts users when an incorrect word or sentence has been accepted. Automatic formatting tools in word processors also perform some basic formatting tasks, such as indentations, capitalization, or aligning and numbering lists. Writers can use predefined templates to minimize formatting, and, for enterprising users and instructors, customized templates and macros (abbreviation expanders) can be created to structure users' interaction with the software.

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For example, a user could program his or her address to be automatically finished after typing only a few starter letters.

Word Prediction

Word prediction programs and phonetic spell checkers[24] have opened access to word processing and composing for those with severe spelling disabilities. Like many other forms of AT, word prediction technology was originally designed for a specific category of disabled students (in this case, those with physical disabilities for whom typing was highly problematic), but has since become a crossover technology for the larger population of students with spelling difficulties. Research from linguistics was used in the design of the word prediction tools, providing the writer a practical set of words, in a choice box similar to a spell-checker box, that logically completes a phrase, a sentence, or word that the writer started. For example, if a writer types, *I need to buy milk at the st. . .* , the prediction box would likely include nouns such as *store* and *street* as alternatives, and if one of these were chosen by shortcut key or mouse, the program would automatically finish typing the word into the sentence.

Phonetic spell checkers, a similar technology, are designed to accommodate the common errors made by dyslexic writers. Instead of providing options of words with sequences of letters similar to the incorrect entry (as a typical spell-checking program does), these spell checkers are built based on research on the actual spelling attempts made by writers with dyslexia. For example, if a writer types *dragon* as *jragun*, ordinary spell checkers will suggest or autocorrect to the word *jargon*, but phonetic spell checkers would include *dragon* as an alternative.

Functions, Applications, and Demands. There are stand-alone word prediction and phonetic spell checker software programs that work with a user's word processor, simply displaying a second or an alternative results box and small toolbar in the open program window. Other word prediction and phonetic spell checker functions are included with word processing applications, such as those available in the comprehensive text reader packages of Kurzweil, WYNN, and Read and Write Gold. The word prediction

[24]Such as WordSmith (http://www.texthelp.com/wordsmith.asp?q1=products&q2=wordsmith), Co:Writer (http://www.donjohnston.com/catalog/cow 4000d.htm), and WordQ (http://www.wordq.com/products.html).

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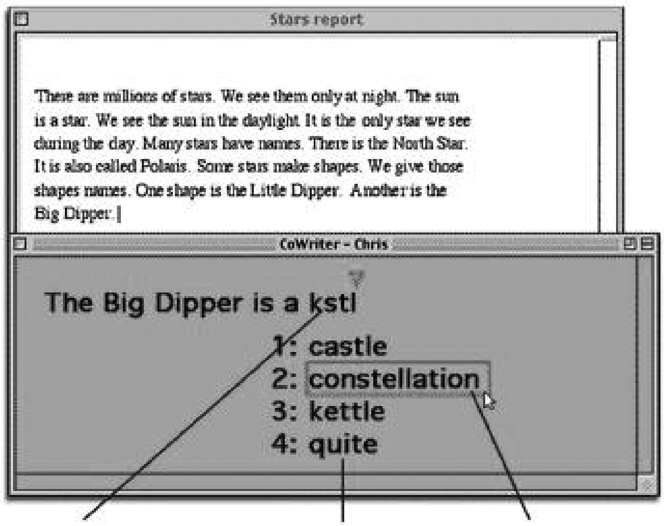

FIG. 4.2. Co:Writer Word Prediction with Word Processor Also Open. Note the student spelling attempt, the alternatives suggested, and the shortcut keys that will auto-type the choice.

program Co:Writer can be paired with Write:OutLoud[25] to create a seamless application, in which all functions appear in one workspace or window. WordQ is a program designed to work within Microsoft Windows. Most word processors are paired with a TTS engine to read aloud the alternatives as well as the composed text. TTS support can be set to read each letter as it is typed, each word, or a sentence once it is completed. Users can choose from the suggestion list by either typing the word or simply pressing the shortcut key (see Fig. 4.2). The choice then appears in the document, finishing a word that was only partially typed, replacing a word that was misspelled, or adding a new word or phrase to a text. Shortcut keys reduce the number of keystrokes necessary to type a word or phrase and the amount of typing and spelling necessary for composition.

Most word prediction programs also build in homophone (e.g., pair–pear) and homonym (there–their) checkers, which prompt (through TTS) the user to choose a correct option based on a quick definition. For example, if a user types *their,* the program can alert him that "This is the

[25]See http://www.donjohnston.com/catalog/writecover/writecoverfrm.htm.

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their that is possessive." Similarly, if a user types *pair,* the alert could be "This is the pair that means two of the same thing." (See Fig. 4.2 for an example of a word processor with the prediction tool activated.)

Literacy Supports and Learning Opportunities. Word prediction software, like voice recognition, imposes a heavy cognitive demand on a user. The ever-changing results box, offering alternative word choices for each typed word, can be a distraction. Programs such as WordQ, which can be customized to appear continuously on screen or only when called up with a shortcut key, can help a user manage this distraction. TTS engines in the word processors also help students listen to their own writing as they compose, edit, and proofread. Nevertheless, word prediction requires a strategic approach to composing, spelling, and editing. Learning and applying such a strategic approach to writing for most students requires coaching and practice. Students with severe spelling difficulties, however, can benefit by being able to produce writing assignments that are legible and more complete than those they are able to produce without the technology.

Word prediction is particularly appropriate for students who have good keyboarding skills. Such students may choose to work with word prediction software rather than voice recognition and make use of a more thorough and helpful spell checker without overtly changing the way they interact with the computer.

CASE STUDIES

ABLE instructors have long supported students' literacy development by being scribes to students' dictation or assisting comprehension by reading aloud in class and digressing to define words, demonstrate annotations, consult resources, and model monitoring strategies. When students are empowered to do these activities themselves during class or self-study time, the responsibility for understanding the literacy process is transferred to them. The equipment does not replace instruction; rather, it provides an enriched environment so that students can engage in their own study and practice. The two cases shared here are taken from a participatory action research project conducted with adult students with mild disabilities at an adult education program (discussed later). This project investigated the role small group or peer-assisted access to AT could play in supplementing regular class instruction.

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Case 1: How Voice Recognition Works as a Language-Experience Activity

One older African-American man, John (a pseudonym), recently retired from a career as a city employee, was returning to reading classes determined to finally learn how to read and spell. He was attracted immediately to voice recognition and found that the process of dictating to the computer gave him new insight, "new light," into the literacy learning process:

> I'm more enthusiastic in trying to pronounce my words and understand them. Because if we learn how to pronounce them, and read them, eventually we should learn how to write them. You know, 'cause if . . . the writing and reading goes side by side so you're like, you know, if you don't know how to read, you really don't know how to write. So but if you conquer both of them, you got your reading and your writing there . . . [Dictation is] opening up some new light, you know, in my vision. And . . . makes you want to strive a little farther and see how much . . . how far you can go.

John's use of the software helped him understand the connections between speech and writing. He watched as his spoken words were recognized or misrecognized and discovered that the accuracy of the program improved when he paid attention to enunciating his words more distinctly. He learned to use the Mute button on the microphone to manually filter out extraneous utterances, such as sighs and self-talk ("Let me see . . ."), which was easier than changing his natural speech patterns. He learned about writing mechanics by watching the word processor (Microsoft Word) automatically format his document (e.g., with capital letters) or prompt him with underlining to include ending punctuation. Because he used a casual, African-American dialect that was not recognized well by the software, he naturally explored the differences between oral and written language conventions. He used the capacity of the built-in TTS feature to command the program to Read That, as well as the digital recording feature (which captures a brief segment of a user's dictation) to Play That Back. By listening to two auditory models and comparing them to the recognition results, he could determine where errors had occurred and strategically decide how best to fix them.

At the end of each dictation session, which lasted approximately 1 hour, John saved his voice file and the document, and printed out the document

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for reading practice. He improved the document in later sessions. These are the elements of a classic language experience activity lesson: dictation, production, reading, and revising. The intervention of the software, however, demanded much more from the student. No longer was the "scribe" an already literate and compassionate tutor, responsible for correct spelling, legible handwriting, determining word boundaries, and disregarding misarticulations. The student and the computer now shared these literacy component tasks, with the student assuming responsibility to monitor the developing document.

Case 2: Reading With Embedded Resources

From the same study, Emma (a pseudonym), a Hispanic young woman with LD and attention deficit disorder (ADD) made use of supported access to a computer equipped with the comprehensive text-reading program Kurzweil 3000. She was attending a fast-track GED class, which met for 4 hours a day, covered one subject every 2 weeks, and expected students to complete copious amounts of reading and homework. Despite her commitment, drive, and persistence, she struggled with limited vocabulary skills that hindered her reading comprehension, had difficulty organizing and spelling writing assignments, was distractible, and had extreme test anxiety.

Emma identified reading comprehension, concentration, and anxiety as her immediate struggles. She talked a great deal about the visceral feelings of being overwhelmed by the volume of text and homework, and by her test anxiety. She said that as soon as her eyes touched a page of text, her stomach knotted, her shoulders clenched, and her spirits flagged. "If it's like a big passage, I get overwhelmed and I get more focused on how big it is than on reading each step," she said in her initial interview.

By working on assignments scanned into the Kurzweil 3000 program from her GED book, Emma was able to read along with the TTS, use the dictionary, learn the definitions, make annotations, and highlight the words and phrases necessary to her assignment. She could print out personal glossaries, built from her extracted annotations and definitional notes. She no longer felt overwhelmed by volume. She realized that her listening vocabulary was much greater than her reading vocabulary (she often said, "Oh, is *that* what that word is?!"), and felt empowered to deal with that disparity by using electronic dictionaries that eliminated frustrating and time-consuming searches through paper dictionaries.

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Additionally, Emma talked about how the auditory input allowed her to visualize what she was reading, and that even listening once would help when she took the printed passage home:

> Yes, I think for me there is [transfer of learning], because like last night, I reread the story [on paper] and I was actually visualizing it! Usually I'm like, "Oh my goodness" [sigh] [rolling her eyes]. . . . But it actually worked for me, I was actually in there [the story], visualizing them walking on the beach or talking on the rock, things like that, and I finished it . . .

The responsibility for learning was transferred to Emma, and she gladly accepted it. She was empowered by access to the equipment that made her efforts at self-study effective. Supported access to OCR helped her better understand the content of her class and reference materials. She maintained her motivation and persisted, passing her GED tests and entering community college where she sought disability support services, such as access to AT and testing accommodations.

RESEARCH AND PRACTICE ON ASSISTIVE TECHNOLOGY FOR STUDENTS WITH MILD DISABILITIES

Disability advocates and technology researchers have touted AT as the "fix" for disabilities through the explosion of computerized technologies over the past decade. Networks and newsletters, such as Closing the Gap (http://www.closingthegap.com) and Quality Indicators for Assistive Technology (http://www.qiat.org), have sprung up to discuss the benefits of AT for those with functional limitations, offering practical and technical advice on how to match needs with applications. For all of the "wow" factor of what AT can help people achieve, however, there is a strikingly small research base on how or whether these devices and the integration of AT into education improves learning or participation outcomes (Edyburn, 2004).

Reviewed here are findings about what is assistive about AT for literacy learning and independent studying for secondary and postsecondary students with mild disabilities. This review focuses on the literature published on secondary and postsecondary students with LD. Strategic use of these tools in the ABLE curriculum requires understanding how these technologies support information processing and learning needs.

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This section presents five themes from the research demonstrating the promising practices of AT:

1. Pairing text with speech.
2. Text enhancements.
3. Writing supports.
4. Motivation and persistence.
5. Integration into a well-designed curriculum.

Each section explains the theme, provides the evidence and pedagogies that support the practice, describes how the practice adapts to a digital environment, and presents available research documenting effectiveness for students with mild disabilities.

Pairing Text With Speech

Highlighting words and sentences as the computer reads them aloud is a powerful updating of a proven approach to presenting information to two senses: hearing and vision. When students read aloud or even subvocalize, they add a third sense: proprioceptive, or speech muscles. The simultaneous presentation of auditory and visual supports taps into longstanding teaching methods for students with LD (Fernald, 1943; Orton, 1932/1966), which emphasize multisensory input and expression. Two reading methods that enact this principle are repeated reading (RR) and the neurologic impress method (NIM). RR is an effective instructional strategy for students with reading disabilities. It develops reading fluency and increased comprehension (Allinder, Dunse, Brunken, & Obermiller-Krolikowski, 2001; Meyer & Felton, 1999). When teachers guide students through rereading the same passage, the number of word recognition errors decreases, reading speed increases, and oral reading fluency and expression improve (Dowhower, 1994; Meyer & Felton, 1999; Reitsma, 1988; Samuels, 2002). NIM is a strategy that presents a fluent reader as a model in very close proximity to the student. Traditionally, this strategy has been used by a teacher–student pair reading in unison, with the teacher sitting behind and to the side (reading in the student's ear), setting the pace and tracking the text with a finger. This multisensory method builds readers' fluency skills and diminishes dysfunctional reading habits while building positive ones (Heckelman, 1986).

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Both of these strategies adapt easily to technological applications to create an individualized, multisensory, and intense experience with print. For example, digital text is available for endless repetitions, dynamic highlighting tracks the text, and TTS (preferably through headphones to mimic the teacher's reading into the student's ear) provides a fluent oral model and elicits proprioceptive input when readers read along aloud or subvocalize.

Several studies report the positive effects of TTS for struggling readers. Dawson, Venn, and Gunter (2000) studied the effects of a fluent model reader for students with mild disabilities in three conditions: no model, a teacher model reading through the passage one time while students followed along, and a TTS model that presented the text on the screen while it was read (without dynamic highlighting). Students' reading performance was measured for rate and accuracy. Students in the teacher model performed best, and the TTS model group outperformed the no-model condition. This study shows that hearing a fluent model read a passage, even one time through, can help orient students with reading difficulties to the vocabulary and rhythm of the passage and set them up to succeed in their own decoding efforts.

Montali and Lewandowski (1996) conducted a detailed investigation on dynamic highlighting with middle school students (Grades 8 and 9). Their study looked at two groups of students (students with LD and normally achieving students) in three conditions: visual only (text on the computer screen), auditory only (listening to recorded text with no text on screen or paper), and bimodal (visual highlighting of text with simultaneous TTS). They found that students with LD who were given text passages with bimodal input performed as well on the comprehension questions as the average reader control group with visual input alone. Additionally, they found that students with LD received no benefits from the auditory-only condition. They relate their findings to the well-established psychology literature that shows the power of multimodal input versus single modal input on attention and memory.

Summary. TTS is now available free of charge to anyone with Internet access. If the reading material can be scanned or is digital, it can be read by a TTS engine. Research studies such as those cited here have demonstrated that the multisensory presentation of text boosts students' subsequent reading efforts. Digital text and a TTS engine not only provide access to content, but to literacy benefits, as students' skills improve with the practice.

Text Enhancements for Vocabulary Development and Comprehension

Enhancements are resources such as digital highlighters, electronic references (e.g., dictionaries, glossaries, or encyclopedias), and annotation options that are embedded within comprehensive literacy software programs.

Although all students need to learn how to use reference resources effectively, for students who struggle with alphabetical listings, distractibility, memory, and persistence, traditional print-based references can present a barrier, not a support (Edyburn, 1991). Similarly, comprehension and study strategy instruction (Nist & Holschuh, 2000) emphasize reader interaction with text through annotations, vocabulary inquiry, question posing, and strategic highlighting. For students who struggle with note taking, spelling, and comprehension, such annotation tasks can also present a barrier.

The relationship between vocabulary and comprehension is reciprocal throughout the literacy acquisition process (Jitendra, Edwards, Sacks, & Jacobson, 2004); reading increases vocabulary, which in turn improves comprehension. Although oral language is a relative-to-self strength (a strength compared to other weaknesses, such as literacy acquisition) for adult literacy learners, their vocabularies are often limited. Moreover, adults with low literacy can have difficulty expanding their vocabularies and recognizing word-family relationships (Greenberg, Ehri, & Perin, 1997).

Recent reviews of the research on teaching vocabulary to youth with LD (Bryant, Goodwin, Bryant, & Higgins, 2003; Jitendra et al., 2004) and developmental college students (Simpson & Randall, 2000) reveal that effective practices for vocabulary instruction include the following:

- Direct instruction, with explicit teaching followed by guided practice.
- Emphasis on both definitional and contextual knowledge.
- Words chosen in clusters related to a discipline or content-area theme.
- Peer learning and peer tutoring activities and practice.
- Language-rich environments and wide reading.
- Activity-based instruction that is intense, multisensory, and hands-on.
- Computer-assisted instruction with a variety of software programs.

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All of these instructional practices elicit deep cognitive processing by students as they make word-family connections and put their growing vocabulary to use. They also require interaction and discussion of the text between teachers and students. When teachers engage students in such interactive learning, their learning demonstrates improved long-term recall of vocabulary and improved reading comprehension (Bos & Anders, 1990).

Adapting these vocabulary and study strategies to a digital learning environment is possible with comprehensive software programs that link digital text with enhancements such as reference materials or annotation features. E-dictionaries, for example, can show and read definitions, syllabication and pronunciation guides, sample sentences, and further definitions of words within a complex definition—all at the click of a mouse or command prompt without having to retype the word or laboriously sort through paper dictionaries. Students can use annotation features of software programs to write questions, margin notes, notes to an instructor or tutor, or to attach definitions to new vocabulary words. Programs that offer extract features enable users to copy their annotations to a word processing document where they are then available for further study, such as the creation of a personal glossary or set of study questions.

The roles of the instructor, tutor, or coach and peers should not be overlooked or underemphasized. Best practices already cited emphasize that the learning environment needs to be dynamic, language-rich, and dialogic to excite the deep processing that enables transfer and recall.

Studies that investigated the impact of digital enhancements have struggled to isolate the impact of the enhancements from the full digital learning environment in which they are embedded. Two projects—at the Center for Electronic Studying (CES) and the Center for Applied Special Technology (CAST)—have created student tracking software with which to monitor students' use of enhancements. CES (http://ces.uoregon.edu/) creates and investigates technological enhancements for instructional materials and activities. CES describes the digital learning environments they create and use with secondary students with and without mild disabilities as "*supported text* to refer to electronic documents in which the text has been enhanced with various types of media for the purposes of expanding or improving student comprehension" (Anderson-Inman & Horney, 1999, p. 129). With software tracking students' interactions or paths through the text and resources, CES researchers have been able to

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document how students access and use enhancements. They have found that students use the embedded resources in purposeful ways that can best be described as "studying the text." They define studying as being "actively engaged in constructing meaning, struggling to comprehend unfamiliar vocabulary, or determinedly trying to assimilate and accommodate new concepts into their cognitive schemas" (p. 163). This documentation shows that students are not passive users of the technology, but utilize collateral resources that boost their comprehension. CES hosts a library of Web-based textbooks and materials that have embedded enhancements to promote comprehension (http://ces.uoregon.edu/intersect/default.html), and although these do not include TTS, they can be read by a TTS engine.

CAST (http://www.cast.org) is a leader in the field of AT and universal design for learning, a set of principles that guide the development of accessible learning materials, environments, and assessments (Rose & Meyer, 2002). CAST has recently developed a product called Thinking Reader (distributed by Tom Snyder, Inc.), developed for middle-school language arts students. This is a set of digitized versions of popular Newbery Award-winning books. The e-books are supported with TTS, have embedded comprehension strategy prompts, e-resources such as glossaries and dictionaries, note-taking and journaling capabilities, and an avatar or animated navigational aide (similar to the "paper clip guy" in Microsoft Word). Thinking Reader software includes student progress monitoring features that track a user's progress as well as alert an instructor to trouble spots. Researchers compared two groups of middle-school students; one group was given paper copies of the books, the other received the enhanced digital books through Thinking Reader. Both groups were taught the same comprehension strategies in whole-class instruction. Struggling students (those performing at or below the 25th percentile) who used the digital versions showed significantly more gains on the reading achievement tests than those who used the paper copies (Dalton, Pisha, Eagleton, Coyne, & Dysher, 2001).

Elkind and colleagues (Elkind, 1998; Elkind, Black, & Murray, 1996; Elkind, Cohen, & Murray, 1993; Hecker, Burns, Elkind, Elkind, & Katz, 2002) have reported several studies over the past decade on the use of computer readers' effects on reading comprehension for youth and post-secondary students with mild disabilities. Findings from their work emphasize the importance of matching student profiles of strengths and weaknesses to strategic uses of the software. For example, OCR programs (specifically, Kurzweil 3000) provided to college students with LD and

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attention deficit hyperactivity disorder (ADHD) were found to help students decrease distractibility, complete assignments with less stress and fatigue, and persist longer on reading tasks. Comprehension measures reveal greater improvement for students with weaker decoding skills, but much less improvement for students who were more proficient readers already (Hecker et al., 2002).

Summary. Readers cannot comprehend text they cannot decode, or text that has too much unfamiliar vocabulary. At the same time, struggling readers need explicit instruction on and prompting to develop effective comprehension strategies. Providing text with embedded resources to support readers' acquisition of vocabulary and strategies is a transformative use of technology, facilitating contextualized learning and providing access to more complex materials.

Writing Supports

In this section I describe the research on effective practices for improving the writing performance of struggling students. Youth and adults with LD struggle with "the physical demand and conventions of writing and . . . have difficulty coordinating the complex cognitive processes of setting goals, generating content, organizing their writing, and evaluating and revising their text" (MacArthur, Ferretti, Okolo, & Cavalier, 2001, p. 345). Add difficulties with spelling and vocabulary (discussed throughout the chapter), and writing assignments can present major barriers for students with mild disabilities. Engaging adult students who struggle with the acquisition of writing skills and confidence requires a well-designed instructional model that supports their literacy learning—reading and writing—in strategic ways.

A "gradual release model" recommended for secondary students struggling and at risk for dropping out (Fisher & Frey, 2003) will sound familiar to adult educators. Beginning with language experience activities, students see their oral language transformed into print. Groups or tutor–student pairs can then move into an interactive writing activity, during which they share the pen and compose a text together, making literacy "visible" (Luke, 2000); risks and mistakes are used as teachable moments. Teachers can then provide writing models, such as sentence starters or poetry models ("I am . . ." or "Somewhere in the world today . . ."), to structure and elicit students' responses. Generative sentences, taken either from students' work or from literature, can provide material to analyze

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and teach mechanics and grammar concepts. Power writing, also known as free writing, is a fluency activity that encourages students to write as much as they can (without editing) in a short, intense burst. Independent writing is, of course, the ultimate goal. This will be facilitated most effectively for students with mild disabilities if they are taught strategies to use when writing. For example, when students face a blank page and an essay question, they can call on an internalized strategy to talk themselves through creating a model or sentence starter out of the words in the essay question.

There are many ways mainstream technologies and AT can support a gradual release model of writing development for students who struggle with the many aspects of writing. The first case study shared earlier demonstrates how speech recognition can help students bridge their oral language to digital print, which is inherently flexible and modifiable. Digital text can then be edited, revised, read aloud, printed out, and so on. Small groups, or pairs of students with a tutor or coach, can "share the pen"—or in this case, the keyboard—and participate in interactive writing and writing models. Sentences are easily available for analysis in a generative sentence activity. Power writing could be done either on voice recognition or with keyboarding. (Keyboarding skills are obviously a great asset to working on word processors and using these technologies. Adult literacy students should be encouraged to work on typing tutorial software programs[26] to gain facility with keyboarding and formatting.)

The research on supporting the writing of students with mild disabilities with technology has a fairly long history. MacArthur and his colleagues conducted several studies investigating the use of mainstream technologies to support the writing processes and products of middle school and high school students with LD (see review in MacArthur, 2000). Their early work investigated the introduction of the current technologies (word processors, spell checkers) for students with LD receiving standard (nonexperimental) instruction. The bulk of these short-term, technology-focused studies found little significant advantage for students with LD. Later, more sophisticated studies matched specific strategy instruction taught explicitly in whole-group settings with particular technology features. For example, Graham and MacArthur

[26]Tutorials include commercial programs such as Mavis Beacon Teaches Typing (http://www.mavisbeacon.com/), and free Web sites that offer drills such as Learn2Type (http://www.learn2type.com/) and Touch Typing (http://www.senselang.com/).

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(1988) found significant positive impact on students' writing from providing both instruction on revising strategies and on word processing revision strategies in the same class, in effect doubling the instructional intervention. They found that the number of revisions, the length and quality of compositions, and students' self-efficacy were positively affected.

Spell checkers, similarly, have been shown to be more effective when paired with strategy instruction on their uses. Although MacArthur, Graham, Haynes, and De La Paz (1996) found that middle school students with LD improved their error finding rate from 9% to 37% with the assistance of a spell checker, the compositions still had many errors not caught by the spell checker or the student (e.g., real—but incorrect—words). McNaughton, Hughes, and Ofiesh (1997), however, explicitly taught strategies to secondary students with LD to back up the spell checker, such as trying a phonetic typing of a misspelled word, proofreading a paper copy, or asking a peer to edit the paper copy. They found students were able to catch as many errors as their nondisabled peers. Lewis (1998) reported similar benefits of a "SpellCHECK" strategy for secondary students with LD. This set of strategies includes (a) check the beginning sound of the word, (b) hunt for correct consonants, (c) examine the vowels, (d) consult changes in the word list for hints, and (e) keep repeating each of the steps. Paper dictionaries, a word list, a peer, and a teacher were consulted as last resorts.

Other studies have focused on the impact of more specialized AT such as voice recognition programs. In an article called "Speaking to Read," Raskind and Higgins (1999) reported on their investigations of the effects of voice recognition software (Dragon Dictate, a "discrete" or word-by-word dictation version) to enhance basic reading skills for youth with LD. They found that students who used speech recognition software showed significantly more improvement than their control peers (taking a computer basics class) on word recognition, spelling, and reading comprehension. Additionally, their analysis found that improved phonological processing was associated with significant differences in all of the academic measures: word recognition, spelling, and reading comprehension.

Higgins and Raskind (2000) found that correction procedures in the voice recognition software were one of the most powerful learning experiences in their original study and were the focus of a follow-up extension study (Higgins & Raskind, 2000) that added an experimental group who used a then newly released continuous speech recognition program that allows more natural spoken input in phrases (Naturally Speaking). These students also showed significant gains in word recognition and reading

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comprehension, although the word-by-word dictation group showed stronger gains in spelling and phonological awareness measures. The continuous dictation group showed greater gains in working memory, discussed as a possible effect of dictating longer utterances. Correction procedures, wherein users are intensely comparing similar words (both on orthographic and phonologic features) to determine and train the program about their intended choice, are posited as key to the boost in literacy skills. They suggest, following Ehri (1984), Leong (1991), and Olson and Wise (1992), that multisensory print exposure, in this case provided by the visual, auditory, proprioceptive, and kinesthetic experience of using voice recognition, can enhance phonological awareness growth. Their work highlights the reciprocal relationship between reading and writing development.

Voice recognition software was recently studied as a viable accommodation on standardized tests for high school students. Traditionally, students who cannot write tests due to physical or writing disabilities are provided scribes, either a human scribe or a tape recorder into which the student speaks his or her text. MacArthur and Cavalier's (2004) investigation looked at how secondary students with (n = 21) and without LD (n = 10) performed on assigned writing prompts under three conditions (all students tried each option): handwriting, dictation to a human scribe, and use of voice recognition software. All students received 8 hours of training on the use of the software and voice training, as well as strategic use of graphic organizers and planning strategies for writing a persuasive essay. All but three students achieved recognition accuracy levels above 80%. Essays dictated to a human scribe were scored as being the highest in quality of composition, followed by those completed with the software, and then the handwritten essays. Dictation to a human was also considerably faster than either of the other two conditions; it was concluded that the time gained by avoiding spelling and handwriting with the software was balanced out by time spent on correction procedures. Overall, the students responded very positively to the voice recognition software and judged it to be helpful and worth using for future assignments. MacArthur and Cavalier concluded that the software can indeed be a valid accommodation, if—as is recommended for any accommodation to a test—students have trained to a level of comfort with the software and equipment prior to taking the test.

Summary. Identifying the roles technology can play in supporting struggling writers is an ongoing process because technology is quickly changing the nature of writing tasks, expectations, and practices for youth

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and adults; for example, correct spelling or mechanics in text messages in which the goal is to send as few characters or digits as possible and still be understood is quite different from standard writing. The research is clear, however, that technological features must be taught as part of a strategic, supported approach to writing for struggling students and those with mild disabilities. Adopting a gradual release model (Fisher & Frey, 2003), supplemented with technology, offers real promise.

Motivation and Persistence

Motivation is a crucial element for students who must work hard to succeed at literacy tasks. Such students have no (more) time to waste (Allington, 2000) and energizing their motivation and persistence early in their reentry into education is critical to their persistence in literacy programs (Quigley, 1998).

Although motivation is difficult to quantify, it is an important factor to study. Regardless of the literacy skill benefits found in the research, there is nearly unanimous enthusiasm among researchers about the potential of AT to affect the motivation of students with mild disabilities. Across age groups and settings, researchers and practitioners document the positive motivation generated among students with mild disabilities using technology. Features of the technological learning environment that students report enjoying include the novelty, the customizable interface (the unique way each person can use the technology), interactive features that allow them to explore and follow their own interests, newfound avenues for self-expression, the nonjudgmental nature of the interaction, the sense of boundless challenges, and the sense of independence and self-determined engagement.

The NCSALL Persistence Study (Comings, Parella, & Soricone, 1999) defines persistence among adult students as "staying in programs for as long as they can, engaging in self-directed study when they must drop out of their program, and returning to programs as soon as the demands of their lives allow" (p. 3). This definition recognizes the critical role motivation plays for adult literacy learners who might find the need to "stop out" of programs when their lives make regular classroom attendance difficult. Motivation is the force we draw on to persist and to surmount barriers that might interfere with achieving our goals. We need more research about the role access to technology can play in an adult's self-study.

Persistence on a particular task is important as well. Students who struggle and find literacy study stressful and exhausting are less likely to

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complete assignments or persist in class. As mentioned earlier, Elkind (1998) and others have found TTS and OCR technologies can provide a tremendous boost in speed (fluency), accuracy, and persistence or endurance for secondary and postsecondary students whose decoding skills are weak, thereby making it possible for them to keep up with reading requirements.

The participatory action research study from which the preceding case studies are drawn (Silver-Pacuilla, 2004) indicates that small group tutoring with AT for students with mild disabilities can be an enabling and empowering learning environment. Data are reported on 10 native English-speaking students who participated in the full project, representing wide ranges on many factors:

- Age: 19 to 62 years old.
- Time in the adult education program: 3 months to more than 10 years, with an average of 2 years.
- Ethnicity: 2 African American, 3 Hispanic, 5 White.
- Gender: 8 women, 2 men.
- Literacy levels: Preliteracy skills to GED test takers.
- Computer literacy: Complete novice to quite experienced (using e-mail and word processors daily).
- Time in formal schooling: 1 had not attended high school at all, 5 had completed 10 or 11 years of school, 4 were high school graduates.
- Cooccurrence of disabilities: 8 were diagnosed with LD, 7 of these had at least one other diagnosis including depression, bipolar disorder, ADHD, ADD, and epilepsy.

Assessments were given pre- and postparticipation, including the Test of Adult Basic Education, as well as standardized assessments of phonological awareness—Lindamood Auditory Conceptualization Test (LAC; Lindamood & Lindamood, 1979)—decoding, and spelling—Wide Range Achievement Test-3 (Wilkinson, 1993).

Participants attended 90-minute sessions with AT and a literacy coach once or twice a week while they were enrolled in a class at the adult education program, averaging 16 hours per semester with the AT and coach. Like Reder and Strawn's (2001) survey findings, the participants in this study recognized the necessity of self-study in addition to their classroom instruction. The participants began early in the investigation to talk about the benefit of study time in the AT lab. They related home environments

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that were noisy and interruptive and literacy skills and strategies that were unproductive. “I just read it and read it and read it,” one woman said, “I just can’t get anywhere with it by myself.” When they came to the AT lab, they were able to study as the serious and motivated students they wanted to be. They were able to work through their class assignments or personal literacy tasks in an organized and strategic manner, effectively using the technology, electronic references, and resources. They relied on the coach equally as a “frustration buffer” for technology glitches and as a tutor to explain and demonstrate computer and software features as well as literacy tasks and assignments.

Even students with the lowest literacy skills were able, with coaching, to learn how to access personally motivating and relevant materials. They demonstrated this learning by making use of their new skills and confidence on home or library computers, away from the coaching support. One woman pursued an interest in classical art, visiting museums online and listening to the descriptions of the art and biographies of the artist through a TTS engine. Another woman began journaling with voice recognition software, fulfilling a desire to write about her parenting experiences with an emotionally challenged child. After one session, she held the printed paper in her hand in amazement, marveling at how professional it looked, and reflected:

> I feel really good because it’s . . . I mean I could not have done this on my own . . . I’m like looking at it and it’s like . . . I’m still not sure [about] commas and where you have to have your periods and stuff. I’m still a little confused on that. But other than that I think I really did a really good job on it . . . I definitely have learned that you could go back and fix it and then it teaches you how to say it right. And it fixes the mistakes I’ve done. But you know, without any of this, I would not be able to write this the way I did, you know, and . . . So like with this, I could actually show my son and it’s spelled right.

She was proud to be able to take this paper home and show her son, who often sneered at her spelling and handwriting. As she looked at the printed text, she commented that it felt as if it was and it wasn’t her work: “I mean, it’s like my own words, but the bad . . . like, the bad is not in there.” She gestured shaking a sieve, as if she had filtered out her spelling difficulties or her learning disabilities. “It just . . . I don’t know, makes me feel like I do have intelligence.”

Students’ posttest results showed that, by increasing their active engagement with print, they had improved their fundamental understanding of

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oral-to-print connections so crucial to future literacy learning. Phonological awareness and spelling abilities showed the most significant growth, increasing by an average of more than three grade levels for phonological awareness (on the LAC) and an average of one grade level in spelling (on the WRAT-3). This jump in phonological awareness represents students' change from preschool-equivalent levels of ability to articulate whatever phonological awareness they had, to being able to segment, blend, and identify sounds within words on an assessment that uses colored blocks to represent sounds.

Moreover, these participants reported that the supported access to mainstream technology and AT helped them envision even greater goals and means of achieving them, and enhanced their sense of self-determination through promoting feelings of competence and self-efficacy. Dormant dreams of college and careers were reignited, and students reported feeling more empowered in their roles as parents and workers. They even reported that their new technology-supported study habits seeped into the fabric of their family life with children, spouses, and extended family members who became intrigued with what the technology could do to support learning and inquiry.

Summary. Self-determination is a critical element for adult education students with mild disabilities (Corley & Taymans, 2002). Because they have experienced years of school failure or discouragement, is it important to engage them early in practices that can nurture both literacy learning and self-determination. Mainstream technology and AT provide a new avenue for literacy practitioners and researchers to study persistence, motivation, self-determination, and the role of self-study in adult literacy learning.

Integration Into a Well-Designed Curriculum

Research indicates that AT does not reach its full potential as an add-on or literacy patch. Technology must be integrated into a well-designed instructional effort and transformed curriculum (Leu et al., 2004; MacArthur et al., 2001; Maccini, Gagnon, & Hughes, 2002). Several themes emerge from these reviews:

- The use of the AT tool or application must be presented through effective teaching strategies for adults with LD, which include explicit and multisensory guided practice, interactive small group and peer group settings, and a focus both on skills and strategies.

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- The particular tool or application and the features it offers must be thoughtfully matched with the individual's cognitive profile and the specific literacy task; for example, a student with fairly strong keyboarding skills may prefer word prediction over voice recognition to support composition efforts.
- AT tools and applications have the potential to "collapse" the levels and stages of literacy inherent in learning to read print-based text (McKenna, 1998); for example, TTS supports decoding and fluency processes simultaneously.
- The full potential of the AT and the features embedded within programs cannot be realized unless the standard or traditional instruction and curriculum is transformed; that is, the program should not just add on time for activities using technology but must specifically integrate them throughout the lesson and through all instructional activities.

An instructive example of technology used to supplement a full curriculum comes from developmental education programs in community colleges. Developmental education programs at community colleges focus on retaining students who are underprepared for college-level classes and provide wraparound student support services (e.g., tutoring, child care referrals, transportation vouchers, etc.; Casazza, 1998). These programs increasingly share much of the content and many of the same students as adult education programs (Morest, 2004; Reder, 1999). According to *What Works* (Boylan, 2002), the summative evaluation of a national network on developmental education, and a literature review of the use of technology in college reading programs (Caverly & Peterson, 2000), technology is best used as a supplement to course instruction.

Supplemental instruction, in fact, is a cornerstone of effective developmental education. Supplemental instruction provides a content-knowledgeable coach along with alternative means to explore the course content, such as related Internet resources or course materials, and allows the student to engage in effective study sessions. Accessible technologies and peer learning opportunities are posited as the keys to participants' success in these supplemental classes.

Unfortunately, a great number of developmental education advisors and faculty remain uninformed about the instructional and institutional ramifications of the Americans with Disabilities Act, technology uses and innovations, and the disability rights movement (Doña & Edmister, 2001; Leyser, Vogel, Wyland, & Brulle, 1998; Roessler & Kirk, 1998), thereby limiting the full potential of supplemental education.

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Summary. A reevaluation of the curriculum and teaching methods must accompany supplemental access to technology to realize significant benefits for students. Access must be accompanied by strategic instruction in the use of the features and tools. Teaching the features within the curriculum of the class deepens the learning of both and shifts the responsibilities to students for their own studying. Creative scheduling and community partnering as well as the use of peer and near-peer tutors and coaches can open opportunities to provide supplemental instruction that meets these needs.

IMPLICATIONS FOR PRACTICE, POLICY, AND RESEARCH

AT can play many roles in literacy development for adult students. However, this chapter is not a definitive review of all of those roles: There are other types of software and devices for literacy development; other ways that technology can be used to support content areas such as English as a second language, mathematics, science, social studies, and so on; and there will be new technologies and improved versions by the time this volume reaches readers. However, this chapter joins a growing dialogue (Askov, Johnston, Petty, & Young, 2003; Ginsburg, 2004; Stites, 2003) on the use of mainstream technology and AT in adult education as a part of a transformed and transformative literacy pedagogy. The following are some suggestions and implications for practice, policy, and research.

Practice

Just as Freire (1970), Purcell-Gates, Degener, Jacobson, and Soler (2002), and Purcell-Gates and Waterman (2000) emphasized in their literacy work, this review demonstrates that there is no “lower limit” on literacy levels, both for traditional print and computer literacy, for those who can benefit from increased access to literacy. There is no doubt that the level of incoming literacy and computer literacy affects how easily and confidently students approach learning to use computer-based AT and how quickly they are able to assimilate the technologies into their understanding of literacy practices, but students at even the lowest levels of literacy can benefit. As emphasized earlier, the role of the coach, instructor, tutor, or peer remains crucial in the success of students with mild disabilities.

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A two-pronged approach is necessary to address the "performance gap" for students with disabilities; they need to develop learning strategies for independence as well as build their foundational skills (Deshler et al., 2001). Such an approach requires us as adult educators and researchers to shift our perspectives beyond scrambling to provide accommodations to poorly designed curriculum materials or methods, or insisting that learners with low-level skills master ABE materials before allowing them access to GED and college preparatory content. Instead, we must imagine, demand, and create materials and learning environments that provide access and benefits to students at multiple levels and for multiple purposes. Supplemental instruction, including supported access to mainstream technology and AT for struggling students, holds tremendous potential to be an enabling and empowering learning environment.

Participants in the action research study (Silver-Pacuilla, 2004) encourage instructors and tutors to "try it"—engage with students as colearners of the technology. The free TTS engines ReadPlease[27] and Microsoft Reader[28] require only Internet access, patience, and curiosity to download and explore with students. Free e-books to download into Reader can be found through the University of Virginia's e-library,[29] Project Gutenberg,[30] and increasingly through a simple Internet search. Subscribing to a free, online journal that addresses educational technology practice (see several listed in the Appendix) can help teachers and tutors learn more about how to integrate technology into the teaching and learning environment. Sharing these journals and explorations with colleagues can help bridge the gap from research to practice as teachers work to relate the practices to their particular situations.

Policy

Students with disabilities have the right to accessible learning environments and experiences. Programs are mandated to provide accommodations. Too often, the traditional adult education classroom, teaching, and materials do not meet the needs of students with disabilities, even when basic accommodations are provided. Reconceptualizing literacy practices and services for students with mild disabilities includes examining the roles and benefits mainstream technology and AT can bring to their learning.

[27]See http://www.readplease.com.

[28]See http://www.microsoft.com/reader/default.asp.

[29]See http://etext.lib.virginia.edu/.

[30]See http://www.gutenberg.org/.

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Programs grapple with resource issues related to technology integration such as hardware and software costs, maintenance, and upgrading. Physical spaces are not always prepared or appropriate for the installation of technology. Teachers and tutors need professional development to gain confidence to integrate technology into their instruction strategically. Addressing these concerns and realities will require creativity, funds, and collaboration.

Program administrators and policymakers can reach out to other programs in the community that serve adults with disabilities. Vocational rehabilitation agencies are important partners for adult education programs. Their mission is to assist adults with disabilities to gain employment and independence and they have a vast network of support and resources—including AT—that can be made available to eligible students. AT centers in communities across the country are available for information, demonstrations, and referrals (check local directories and a national association of AT centers at http://www.ataccess.org). Starting a community conversation can lead to a sharing of resources, knowledge, and commitment. As always, involvement of students in the process leads to more collaborative planning, service, and evaluation.

Federal- and state-level leadership and funds should address this issue. Legislation for federally funded programs needs to include language that recognizes the importance of AT for adults with LD, and the government should provide funds for specialized equipment, software, and professional development. Additionally, the need for more flexibility and availability of accommodations on standardized tests and the GED should be a strong point of advocacy. As more research is published validating the use of accommodations on standardized assessments for secondary and postsecondary students, pressure should be applied to the government to make similar policy adjustments to the provision of accommodations for GED test takers.

Research

A research base documenting the impact of AT in adult education is sparse. Therefore, we need a research agenda that builds on what is currently known about both adult learning and the effectiveness of AT for secondary and postsecondary students with mild disabilities.

The adult education field should outline a research agenda to learn how students benefit from electronic and supported text, how the features of computer-based technologies help users—both native and nonnative

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speakers of English—learn about language, and how education programs can best integrate their teaching with technology. Furthermore, this agenda needs to investigate how AT can assist youth and adults with mild disabilities to become more self-determined and persistent in their studying, learning, and goal setting. This agenda most likely needs to start with more participatory action research and situated case study analyses of the integration of technology into literacy instruction, designs that can capture incidental and hidden effects and "offer signposts" (Miller & Olson, 1998, p. 357) of the complexities and the possibilities to other educators and researchers. Such signposts could help practitioners apply and generalize research findings from other postsecondary and community settings.

At the same time, the evaluation of technology integration needs to heed the tenets of adult learning principles and include the voices and reflections of adult learners (Kasworm & Londoner, 2000; Stites, 2003). Students need to be empowered to participate in, conduct, and report research on their own learning, including how technologies affect their literacy practices in and out of the classroom.

Summary. Much more work needs to be done to understand how students benefit from electronic and supported text, how the features of computer-based technologies help users teach themselves about language, and how adult education instructors and programs can best integrate their teaching with technology. The reality that many adult education students with mild disabilities are not succeeding in existing programs and that programs report they are not prepared to teach them raises difficult questions of access and accommodations. If "who we are and how we act is as much a function of what is at hand as of what is in head" (Lemke, 1998, p. 286), then a key concern should be to get more appropriate materials, tools, and learning environments in place for students. Accessible mainstream technology and AT represent an opportunity to transform our literacy instruction in ways that put much more creative control in the hands—and heads—of the students with mild disabilities.

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APPENDIX

RESOURCES

Information on Learning Disabilities

LDOnLine: http://www.ldonline.org
and
SchwabLearning.org: http://www.schwablearning.org/index.asp

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Both sites contain articles (new and archived, some in Spanish), chat rooms, book reviews, artwork, experts on call, and free monthly e-newsletters. Both sites pay attention to common cooccurring difficulties, such as ADHD. The focus is on children, but both sites cover adult issues well.

Dyslexic Adult Link (DAL): http://www.dyslexia-adults.com/index.htm
DAL features articles (new and archived), links to news articles, book reviews, and areas of interest e-bulletin boards. It focuses on adults with dyslexia.

The National Organization on Disability (NOD): http://www.nod.org/
The NOD Web site offers articles, news, and advocacy for adults and children with disabilities. It includes updated statistics, surveys, legislation, and so on.

The National Association for Adults with Special Learning Needs (NAASLN): http://www.naasln.org/
This is a site for advocates, educators, and adult learners.

Technology and Teaching

Contemporary Issues in Technology and Teacher Education (CITE): http://www.citejournal.org/
This journal covers many areas of technology and teacher education. It is a refereed, free online journal.

International Society for Technology in Education (ISTE): http://www.iste.org/
The ISTE publication *Learning and Leading With Technology* features articles on curriculum studies, equity in technology, telecommunications, computer science, and multimedia. It is an editor-reviewed journal.

T.H.E. Journal: http://www.thejournal.com/
This journal reports on curriculum studies, education management and administration, and educational technology systems.

The Center for Applied Research in Educational Technology (CARET): http://caret.iste.org/
CARET provides online articles, frequently asked questions, resources, an annual conference, and more.

Adult Literacy and Technology Network (ALTN): http://www.altn.org
ALTN is an association of adult educators dedicated to improving adult education through technology. It holds workshops and preconference sessions at major adult education conferences.

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Assistive Technology

ABLEDATA: http://www.abledata.com/
ABLEDATA is a clearinghouse of AT information, links, and products.
Assistive Technology Industry Association (ATIA): http:// www.atia.org/
The ATIA Web site features links to member businesses and offers an online journal.
The Alliance for Technology Access (ATA): http://www.ataccess.org
The ATA is a member organization of community or statewide AT training and information centers. The Web site features the Hub—a search engine of AT devices, manufacturers, and product information, including many online demonstrations or video tours of products.