Research Synthesis on Assistive Technology use by People with Learning Disabilities and
Difficulties

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Abstract: In this article, we provide a synthesis of the literature available on the use of assistive technology (AT) by elementary through postsecondary education students with learning disabilities and/or difficulties. The synthesis addresses the following questions: 1. What types of AT are being used in educational and workplace settings? 2. What are the outcomes for students with learning disabilities and difficulties who use AT? 3. What types of AT, as used by students with learning disabilities and difficulties, necessitate additional research, and 4. Does the use of AT improve performance and retention rates? Answers to these questions are based upon analysis of seven articles found through an extensive literature search based upon the following criteria: (a) Empirical studies on AT; (b) Studies published in refereed journals; (c) Study participants attending elementary through postsecondary educational institutions; (d) Non-mainstreamed technologies (i.e. technology not used regularly by people without disabilities such as spell checkers, grammar checkers, word processing software, educational software); (e) Technology that is used to compensate for learning difficulties and not used to remediate, and (f) Study participants identified as having a learning disability or learning difficulty. Overall, the use of AT as a compensatory strategy by students with learning disabilities and/or difficulties was shown to be effective.

Key Words: assistive technology, learning disabilities or difficulties, voice recognition software

Introduction

The United States Office of Education (1977) defines "specific learning disability" as: "A disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or do mathematical calculations. The term includes such conditions as perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia. The term does not include children who have learning problems that are primarily the result of visual, hearing, or motor impairments; mental retardation; emotional disturbance; or environmental, cultural, or economic conditions." For purposes of this literature review the terms learning disabled and learning difficulties were both used in the search process as current research indicates that it is virtually impossible to differentiate between those labeled slow learners and those labeled learning disabled based on tests of cognitive functioning (Lyon et al., 2000).

It is estimated that 15% of all school-aged children have one or more type of learning disability (Johnson & Blalock, 1987). Research indicates that the academic difficulties experienced by these children in elementary and secondary school persist into adulthood (Gerber, Ginsberg, & Reiff, 1992; Johnson & Blalock, 1987; White, 1985). Yet, an increasing number of secondary students are choosing to continue their education (Higgins & Zvi, 1995). In 1991, 8.8% of full-time college freshmen reported having some form of disability, compared

with 2.6% in 1978. Of the types of disabilities reported, learning disabilities were the fastest growing group, increasing from 15% to 25% of all students with disabilities over the 13-year period (Henderson, 1992). These data demonstrate an increase in the number of people with learning disabilities attending college, but they do not show the number of students graduating. Vogel and Adelman (1992) indicate that young adults with learning disabilities have low postsecondary graduation rates and tend to take longer to complete their program of study compared to their peers without disabilities.

Even though people with learning disabilities often form their own compensatory strategies (ways to circumvent deficits) through "trial and error" or via "training," which then helps them to counterbalance their learning disabilities (Schumaker, Deshler, & Ellis, 1986), there may still be persistent areas of difficulty. Estimates of the number of adults with learning disabilities who exhibit written language disorders range from 80% to 90%. Eighty percent of people with learning disabilities are estimated to have a reading disability (Blalock, 1981).

For persons with learning disabilities and or learning difficulties, AT may provide a new compensatory strategy for reading and writing (The Alliance for Technology Access, 1994). Raskind (1993) indicated that although remedial and compensatory strategies are beneficial foadults with learning disabilities, the compensatory approach "may offer the most expeditious means of addressing specific difficulties within particular contexts" (p. 159). Raskind (1993) also points to the frustration and burnout adults with learning disabilities experience as a result of years of remedial instruction that yielded little benefit, and the appeal of immediate solutions to particular problems as reasons to support the use of AT.

The purpose of this synthesis is to examine articles on the use of AT as a compensatory strategy by persons with learning disabilities and learning difficulties in elementary through postsecondary settings, thus answering the following questions:

1. What types of AT are being used in educational and workplace settings?
2. What are the outcomes for students with learning disabilities and difficulties who use AT?
3. What types of AT, as used by students with learning disabilities and difficulties, necessitate additional research?
4. Does the use of AT improve performance and retention rates?

Overview of Assistive Technology

AT is defined as any item, piece of equipment, or product system, whether acquired commercially off-the-shelf, modified, or customized, that is used to increase, maintain or improve the functional capabilities of individuals with disabilities (The Technology Related Assistance for Individuals with Disabilities Act of 1988).

In reviewing the literature on AT for people with learning disabilities no articles included empirical data on any types of learning disabilities other than those related to reading and writing. Three forms of AT seem to be particularly suited to advancement of the reading and writing process for individuals with learning disabilities and/or learning difficulties. These

include (a) optical character recognition (OCR), (b) speech synthesis (SS), also known as screen readers, and (c) voice recognition software (VRS), also referred to as speech recognition.

OCR software is used with a scanner to convert images (i.e., text material such as chapters from books, newspaper articles, and other printed material) to text and create documents, which can be "read" back to the user, using SS. SS provides auditory feedback via the computer. Some SS programs actually highlight the text, word for word, as it is being "spoken." The premise is that persons with learning disabilities often have phonetic awareness problems that negatively influence their ability to decode words, thus affecting their ability to comprehend written text (Stanovich, Cunningham, & Freeman, 1984; Adams, 1990). Having text read out loud should increase comprehension.

VRS allows the user to operate the computer by speaking rather than using the keyboard and mouse. Using VRS, the user speaks into a headset-mounted microphone; the system then converts the spoken words to electronic text displayed on the computer screen and entered into a word processing document (Riviere, 1996). The document can be saved and edited. It can also be read back using a speech synthesizer. For persons with learning disabilities and/or learning difficulties, who often face difficulties with written language and spelling, voice recognition allows them to use their oral language abilities, which frequently precede and exceed their written performance (King & Rentel, 1981).

To best employ these forms of AT as compensatory strategies for persons with learning disabilities and/or learning difficulties in multiple settings, an understanding of the research and strategies applied to date is imperative. What has and has not been effective in the past needs to be evaluated so effective strategies and AT devices can be implemented to a greater degree and ineffective strategies eliminated or revised.

Method

This literature synthesis reviews six studies from peer reviewed journals. The criteria used for article selection was that they be (a) empirical studies on AT, (b) published in refereed journals, (c) based on study participants who are in postsecondary educational institutions and workplace settings, (d) focused on non-mainstreamed technologies (i.e. technology not used regularly by people without disabilities, such as spell checkers, grammar checkers, word processing software, educational software), (e) focused on technology that is used to compensate for learning difficulties and not used to remediate, and (f) based on study participants identified as having a learning disability or learning difficulty. Originally, the intent was to review articles on the use of AT by persons with learning disabilities in postsecondary education and in the workforce. Due to the limited number of articles that met the criteria, however, the synthesis was expanded to include three articles that investigated the use of AT by students in grades 4 through 12 (Leong, 1992; Leong, 1995; Wetzel, 1996). Two of these articles (Leong, 1992; Leong, 1995) also investigated students with learning difficulties rather than diagnosed learning disabilities. Because there are questions as to whether there are psychometric differences between the two groups (Ysseldyke, et al. 1983) these studies were deemed acceptable for inclusion in this synthesis.

For this literature synthesis four databases were searched: Educational Resources Information Center (ERIC), PubMed (MEDLINE), Info Trac (Expanded Academic Index ASAP), and PsyInfo. Ancestral and hand searches were also performed. The timelines specified did not include a beginning or end date. Ancestral searches were performed by reviewing the reference lists of articles that met the criteria as well as articles that reported anecdotally on the effectiveness of AT. Hand searches of the *Journal of Learning Disabilities*, *Exceptional Children*, and *Learning Disabilities Quarterly* were performed for the years 1999 to 2003 and yielded no additional articles. Search terms included "learning disabilities", "assistive technology," "learning difficulties," "postsecondary education," "adults," "workplace," "workforce," "employment," "technology," "speech recognition," "university," "voice recognition," "reading," "text-to-speech," "dictation," and "college." These terms were searched for individually and in combination. A total of 53,753 articles were found with a search in ERIC using the keyword "technology." Due to this high number, "technology" was combined with "learning disabilities" and 427 articles were found. Many of these articles appeared in search results from all four databases. There were no articles found when the keywords "technology" and "learning disabilities" were used that did not appear in the search when the keywords "assistive technology" and "learning disabilities" were used. When the terms "learning disabilities" and "assistive technology" were used, ERIC yielded 49 articles, PSY INFO found 13, ASAP found 11, and PubMed found 53. Fewer articles were found with a keyword search using "assistive technology" and "learning difficulties," with all articles found under this search included in the keyword search for "learning disabilities" and "assistive technology." Ancestral and hand searches did not yield any articles that were not included in the database searches. After reviewing the articles found by the database, ancestral, and hand searches, six articles met the criteria for inclusion in the synthesis. While there were numerous articles that reported on the use of AT as a remedial tool the intent of this synthesis was to investigate AT used as a means to compensate for learning disabilities and difficulties.

Results

This section reports on the results of the literature synthesis including demographics, study variables, and literature review questions.

Demographics

Table 1 shows the demographics of the participants in each study reviewed. The number of participants in each study ranged from 1 to 192. In the studies that indicated gender there were more males than females with a ratio of approximately 3 to 2. Age and grade ranges were from age 9 to 37 and grade 4 to graduate school respectively. Disability categories were learning disabled with two studies (Leong, 1992; Leong, 1995) identifying students as having learning difficulties. IQ's ranged from 74 to 137. Ethnicity was varied. Achievement scores were reported from a range of tests. In general the reported achievement levels were average. In the studies that indicated socioeconomic status (Higgins & Raskind, 1995; Higgins & Raskind, 1997; Raskind & Higgins, 1995) the majority of participants self-identified as middle class.

Study Variables

Table 2 shows the various types of interventions used, the methods of selecting subjects, study design and analysis, study variables, and the findings for the six studies reviewed. Two studies investigated the use of VRS (Higgins & Raskind, 1995; Wetzel, 1996) and four studies researched the use of SS and OCR software (Higgins & Raskind, 1997; Leong, 1992; Leong, 1995; Raskind & Higgins, 1995). The duration and quantity of intervention ranged from three essays being written over an unspecified time to 18 weeks of intervention. Selection of subjects was not indicated in the six studies. Design and analysis of the studies varied with one study using a post-test only (Higgins & Raskind, 1995), two using ANOVA (Higgins & Raskind, 1997; Leong, 1992), one using ANCOVA (Leong, 1995), one using z-scores (Raskind & Higgins, 1995), and one not indicating a method of analysis (Wetzel, 1996).

Dependent Variables

Dependent variables in the articles reviewed were; composition performance, reading comprehension, spelling, word recognition, proofreading, long-term effects on academics, behavior, attitudes and retention, and written language difficulties. The most frequently reported dependent variables were reading comprehension, which was investigated in three studies (Higgins & Raskind, 1997; Leong, 1992; Leong, 1995), and written language/composition performance, which was investigated in two studies (Higgins & Raskind, 1995; Wetzel, 1996). The sixth study investigated proofreading (Raskind & Higgins, 1995).

Independent Variables

Independent variables included the three major AT's used; VRS, OCR, and SS. Other compensations used included a human transcriber (Higgins & Raskind, 1995), text read aloud (Higgins & Raskind, 1997), on-line reading (Leong, 1995), explanation of difficult words (Leong, 1992), and meta-cognitive activities (Leong, 1995). Pre-training was provided in five of the six studies with three using OCR/SS (Higgins & Raskind, 1997; Leong 1992; Raskind & Higgins, 1995) and two using VRS (Higgins & Raskind, 1995; Wetzel, 1996). The pre-training provided instruction and training on the use of the OCR, SS, and VRS before the research began. Researcher and/or assistant involvement was indicated in all but one study (Raskind & Higgins, 1995). When indicated the researchers and assistants were mostly involved in providing training and instruction.

Literature Review Questions

The questions posed previously, and the answers, as determined from the literature reviewed, are answered in the following text.

What types of AT are being used in educational and workplace settings? Based upon the applied literature search procedures and articles reviewed the types of AT's used in educational settings for persons with learning disabilities and difficulties were VRS, OCR, and SS. The purpose of these applications of AT was to improve reading and writing. No research studies were found that met the criteria and were conducted with individuals in the work place.

What are the outcomes for individuals with learning disabilities and difficulties who use AT? Outcomes were positive for most participants in the studies reviewed. Two of the studies (Leong, 1992; Wetzel, 1996) found that the AT intervention did not improve the reading and writing performance of the subjects. In the remaining four articles, the AT intervention was reported as positively influencing the reading, writing, and proofreading performance of the participants.

What types of AT used by individuals with learning disabilities and difficulties need more research? Additional research is needed on all forms of AT for use by persons with learning disabilities and difficulties. The findings from the six studies reviewed are not definitive, leaving room for additional research.

Does the use of AT improve performance and retention rates? Higgins and Zvi (1995) reported on the findings from the three intervention studies with postsecondary education students (Higgins & Raskind, 1995, 1997; Raskind and Higgins, 1995) reviewed in this paper. In this overall review Higgins and Zvi (1995) reported that retention rates for participants in the studies increased significantly. Higgins and Zvi (1995) also reported that the grade point averages (GPA) for courses with heavy reading and or composition requirements improved significantly with a pre-study GPA of 2.20 and post study GPA of 2.63 (one-tailed $t = 1.76 < .05$). In the same review Higgins and Zvi (1995) also reported that the dropout rate for persons in the studies dropped to 1.4% compared to 34% for the match control group and 48% for the non-disabled population. No studies reported workplace outcomes.

Overall Findings

Study results (see Table 2) were consistent with all except Wetzel's (1996) indicating positive outcomes for AT use. The studies by Higgins and Raskind (1995 & 1997), and Raskind and Higgins (1995) are the most extensive studies reviewed. They researched the use of OCR, SS, and VRS by university students. Over a period of three years they researched reading comprehension, proofreading and written composition, long-term effects on academic success and retention, and behavior and attitudes. All forms of AT were found to be effective compensatory strategies.

Raskind and Higgins (1995) also found VRS to be an effective tool for improving holistic written scores. They found that when learning disabled students used voice recognition their written performance was not significantly different from their non-disabled peers whereas without the VRS their written performance was significantly lower. Higgins and Raskind, (1997) also found a significant correlation between silent reading scores and improvement under the technology conditions such that the greater the difficulty the more the technology enhanced performance.

Of the four studies (Higgins & Raskind, 1997; Leong, 1992, 1995; Raskind & Higgins, 1995) that investigated the effectiveness of OCR and SS three of them (Higgins & Raskind, 1997; Leong, 1992, 1995) explored its use and its effects on reading comprehension. In all three cases it was found to be effective. In the fourth study (Raskind & Higgins, 1995) SS was used to research proofreading ability. Raskind and Higgins (1995) indicated that the study participants

found more errors when using the SS compared to having the material read to them, or when reading it themselves. Leong, in her 1995 study with younger children, obtained similar results when investigating the use of SS for increasing comprehension. This result was different from Leong's 1992 findings where SS did not prove statistically significant but where it still indicated positive results in 10 of the 12 passages read.

Discussion

The following section will discuss the literature synthesis findings as they relate to the search procedures, demographic variables, and study variables. In addition to these areas the overall findings, limitations, and direction for future research will also be discussed.

Demographics

As seen in Table 1 the known demographics of the study participants indicated that there were more males, Caucasians, and individuals from middle income levels. In the field of learning disabilities there are more males than females diagnosed (Murray, et al., 2000), which is a likely reason for why there are more males in the studies reviewed. IQ's and achievement scores, when indicated, varied. This is typical of persons with learning disabilities (Lyon et al., 2000).

Mean IQ scores were average to low average with a range of 74 to 137. A range of IQ's from 74 to 137 is large but does align with the current literature on learning disabilities (Lyon, et al., 2000; Murray, et al., 2000) that indicates persons are being identified as learning disabled when they may actually be slow learners. For example, a person with an IQ of 74 is functioning in the low range as the average range of IQ scores is from 85 to 115 (American Association on Mental Retardation, 2002). If a person has an IQ of 74 they could possibly be considered borderline mentally retarded depending upon their functional abilities (Diagnostic and Statistical Manual of Mental Disorders-DSM-IV, 2000), which implies that they are a slow learner.

Study Variables

None of the six studies reviewed indicated subject selection procedures, but based on the information provided it is likely that the selection of subjects was convenience sampling. For example, Leong (1995) indicates the sample consisted of 64 grade 4 students, 68 grade 5 students, and 60 grade 6 students. It is possible that these numbers represent students with learning difficulties from two classes at each grade level who were selected because they were members of the class.

The design and analysis procedures varied from study to study, which posed difficulty in performing statistical comparisons of the results. Thus, overall outcomes, rather than specific outcomes, are presented. The lack of continuity in the findings leaves room for future replication studies that may validate the findings in the studies reviewed.

Each article analyzed presented a range of characteristics and variables. Because of this, the data are difficult to categorize yet provide insight into the previously posed questions, as discussed in the following text.

The dependent variables were similar across studies with two investigating written language difficulties (Higgins & Raskind, 1995; Wetzel, 1996), three investigating reading comprehension (Higgins & Raskind, 1997; Leong, 1992; Leong, 1995), and one investigating proofreading (Raskind & Higgins, 1995). It is clear that the AT currently being used by persons with learning disabilities is of the three types mentioned previously. VRS is being used to compensate for written language difficulties while OCR and SS are being used to compensate for reading comprehension and proofreading difficulties.

Overall Findings

Overall, the results indicated that the types of AT investigated (i.e., OCR, SS, and VRS) are effective compensatory tools for persons with learning disabilities and or learning difficulties. The difficulty most frequently experienced by people with learning disabilities is phonetic awareness (Stanovich, Cunningham, & Freeman, 1984; Adams, 1990). With a lack of phonetic awareness the ability of individuals to comprehend written material is reduced. By using OCR and SS electronic text can be "read" to an individual. This appears to minimize the required decoding while improving comprehension. Speech synthesis was also found to improve proofreading abilities when compared to reading alone or having text read by a human reader to an individual (Higgins & Raskind, 1997). This again is not unexpected, as people with learning disabilities have difficulty reading and are so focused on the words that they often do not comprehend the larger meaning. Speech synthesis was found to be more effective than reading alone or using a human reader for proofreading text (Raskind & Higgins, 1995). This may be due to the independence provided by the use of AT as the person doing the proofreading does not have to be concerned with bothering the reader. The individuals using the software can replay the text as many times as they like, thus possibly catching more errors.

Higgins and Raskind, (1997) found a significant correlation between silent reading scores and improvement under the technology conditions such that the greater the difficulty the more the technology enhanced performance. This implies that students with the most severe learning disabilities and/or learning difficulties will benefit the most from the use of AT. This finding is supported by Raskind's (1993) statement that although both remedial and compensatory strategies are beneficial for adults with learning disabilities, the compensatory approach "may offer the most expeditious means of addressing specific difficulties within particular contexts" (p. 159). This finding may also have implications for self-esteem and self-confidence.

Higgins and Raskind (1995, 1997) and Raskind and Higgins (1995) as reported by Higgins and Zvi (1995) found a decrease in the dropout rate for persons in their studies when compared to a control group and to students from the non-disabled population. While the increase in retention for students in the three studies may be partly due to the use of AT there are additional variables that may have influenced participants' retention rates, with one possibility being they were part of a 3-year study that provided supports that students not in the study did

not receive. Based on this it cannot be assumed that the use of AT alone decreased the drop out rate, but it may have influenced it.

Although VRS did not prove to be an effective compensatory strategy in one study (Wetzel, 1996) it was in one other (Higgins & Raskind, 1995). A possible reason for VRS not being effective in the 1996 study by Wetzel is that voice recognition software and hardware was in its infant stages. It has improved since then. Dragon Naturally Speaking (DNS) can now be minimally trained in about twenty minutes. With this minimal training DNS has about 98% recognition accuracy (S. Krysler, personal communication, April 30, 2001). This is providing the computer has a good quality sound card and a fast processor. The 98% recognition accuracy is also based on the users consistently and clearly enunciating their words. VRS has improved since the studies reviewed were performed. Thus, today, the implications for persons with learning disabilities and or learning difficulties are far greater. To be able to speak ones ideas and not get caught up in the intricacies of spelling and grammar can, as indicated by Higgins and Raskind (1995), improve written composition.

There are numerous weaknesses in the studies reviewed. For instance, three of the studies (Higgins & Raskind, 1995; Leong, 1992; and Leong, 1995) did not indicate pertinent demographic information. Likewise, effect size was not indicated in any of the studies reviewed. In addition, if there were more empirical studies available there may be more variety in the populations investigated that may provide different results. For example, persons with learning disabilities from culturally and linguistically diverse backgrounds may not fare as well with VRS, OCR, and SS due to their linguistic differences.

In addition, the study variables include a wide range of ages, academic levels, and research procedures that make it difficult to compare studies. Small sample sizes in all of the studies inhibit the ability to generalize the results to other settings and demographics.

Limitations

Overall, the greatest limitation of this literature synthesis is that there are so few empirical studies investigating the use of AT as a compensatory strategy for persons with learning disabilities. One reason for the lack of research may be that the technology is relatively new. Other possible reasons may include lack of teacher experience in using technology and a lack of awareness in the workplace. With the lack of empirical research available it is necessary to keep in mind that the results indicated in this synthesis cannot be considered conclusive.

Direction for Future Research

As indicated by Raskind (1993) the appeal of immediate solutions to particular problems is a very good reason to begin researching the use of AT. This is particularly true in employment settings when individuals need to perform and do not have time for remediation. Many (Day & Edwards, 1996; Golden, 1998; Riviere, 1996) have indicated the effectiveness of AT, but research supporting this is limited. The problem of determining whether AT is consistently an effective compensatory strategy for persons with learning disabilities and difficulties, thus enabling them to succeed in educational and workplace endeavors, requires ongoing, systematic

investigation. Future research should replicate the current studies in multiple settings to determine if the results are generalizable. This may include a larger mix of ethnicity, gender, and socioeconomic status.

In addition, researchers need to begin to assess the use of AT in the workforce. Individuals with learning and other types of disabilities use AT, but its effectiveness and the variables that influence its use have not been researched. The technologies investigated, as they continue to improve, should be incorporated into the workplace and educational arenas. Voice recognition may also be beneficial for individuals with quadriplegia, visual tracking problems, fine motor control problems, and cerebral palsy. Additional research is needed to document effective and ineffective strategies across all disability categories and in multiple settings.

Conclusions

Research studies investigating the use of AT as compensatory agents in the work place are more limited than studies done in educational settings. In fact, the researchers were not able to find any research studies that investigated the use of AT in the workplace. The studies implemented with postsecondary education students offer the closest similarity to work settings but are still significantly removed. While generalizations can take place they should be made with caution. For example, in the studies reviewed the research participants were provided with support that would not necessarily be available in non-research based settings. If VRS, SS, and OCR software programs are to be used in educational and work settings, facilitators and or potential users should be aware that ongoing support and training might be necessary for the AT to be used consistently and effectively. In addition, the use of VRS may interfere with other employees or students as the person using the software is speaking into the microphone. Likewise, using SS in a shared space may annoy others as the computer "reads" back what has been scanned or typed. This could be avoided by using headphones.

Based upon the findings from the articles reviewed it is apparent that AT should be used by persons with learning disabilities and difficulties as a compensatory strategy in postsecondary educational settings. AT should also be used, but with greater caution, in K-12 settings. The need for caution is due to the concern that compensating for a learning difficulty may interfere with remediation. The benefits of compensation need to be weighed against the benefits of remediation. As indicated by Raskind (1993) years of remediation often lead to frustration that the use of AT may be able to alleviate.

The use of AT has been shown to improve postsecondary education outcomes for students with learning disabilities. If AT increases the retention and graduation rates of postsecondary education students with learning disabilities these individuals should be able to transfer the use to work settings thus increasing employability and retention in the work force. Perhaps more importantly, if people with learning disabilities are able to complete postsecondary education, statistics show they have a better chance of obtaining gainful employment.

Individuals need to understand their own strengths and weaknesses to know which types of assistive technologies may be beneficial. In addition a determination of what tasks the individual cannot perform should be assessed prior to any AT recommendations and

implementation. For example, in the studies reviewed that used VRS a determination was made that the subjects were deficient in written composition performance. Logic dictates that if there is not a deficit then the AT will not be necessary. This is aligned with the Higgins and Raskind (1997) finding that a significant correlation existed between silent reading scores and improvement under the technology conditions such that the greater the difficulty the more the technology enhanced performance. It is important to remember that there is great variance between individuals diagnosed as learning disabled. Determining an individual's strengths and weaknesses should be the first priority. Using AT to compensate for the deficient areas should be the second consideration.

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References

Adams, M. J. (1990). *Beginning to read-thinking and learning about print*. Cambridge, MA:
    MIT Press.

Blalock, J. (1981). Persistent problems and concerns of young adults with learning disabilities.
    In W. Cruickshank & A. Silvers (Eds.), *Bridges to tomorrow: Selected papers from the
    17th international conference of the Association for Children with Learning Disabilities.
    The best of ACLD, Vol. 2* (pp. 31-45). Syracuse, N.Y.: Syracuse University Press.

Gerber, P. J., Ginsberg, R., & Reiff, H. B. (1992). Identifying alterable patterns in employment
    success for highly successful adults with learning disabilities. *Journal of Learning
    Disabilities, 25*, 475-487.

Henderson, C. (1992). *College freshmen with disabilities: A statistical profile*. Washington, DC:
    American Council on Education, HEATH Resource Center (ERIC Document
    Reproduction No. ED 354 792).

Higgins, E., & Zvi, J. (1995). Assistive technology for postsecondary students with learning
    disabilities from research to practice. *Annals of Dyslexia, 45*, 123-142.

Higgins, E., & Raskind, M. (1995). Compensatory effectiveness of speech recognition on the written composition performance of postsecondary students with learning disabilities. *Learning Disability Quarterly, 18*, 159-174.

Higgins, E., & Raskind, M. (1997). The compensatory effectiveness of optical character recognition/speech synthesis on reading comprehension of postsecondary students with learning disabilities. *Learning Disabilities, 8*(2), 75-87.

Johnson, D. J., & Blalock, J. W. (Eds.). (1987). *Adults with learning disabilities: Clinical studies*. Orlando, FL: Grune and Stratton.

Leong, C. K. (1992). Enhancing reading comprehension with text-to-speech (DECtalk) computer system. *Reading and Writing: An Interdisciplinary Journal, 4*, 205-217.

Leong, C. K. (1995). Effects of on-line reading and simultaneous DECtalk YESauding in helping below-average and poor readers comprehend and summarize text. *Learning Disability Quarterly, 18*, 101-116.

Lyon, G., Fletcher, J., Shaywitz, S., Bennett, A., Shaywitz, B., Torgesen, J., Wood, F., & Olson, R. (2000). Rethinking learning disabilities. Retrieved on December 8, 2001 from http://www.edexcellence.net/library/special_ed

Murphy, H., & Higgins, E. (1994). *An investigation of the compensatory effectiveness of assistive technology on postsecondary students with learning disabilities.* California State University Northridge (ERIC Document Reproduction Service No. ED 414 681).

Murray, C., Goldstein, D., Nourse, S., & Edgar, E. (2000). The postsecondary school attendance and completion rates of high school graduates with learning disabilities. *Learning Disabilities Research & Practice, 15*(3), 119-127.

Raskind, M. (1993). Assistive technology and adults with learning disabilities. *Learning Disabilitiy Quarterly, 16,* 185-196.

Raskind, M., & Higgins, E. (1995). Effects of speech synthesis on the proofreading efficiency of postsecondary students with learning disabilities. *Learning Disability Quarterly, 18,* 141-158.

Raskind, M., & Higgins, E. (1999). Speaking to read: The effects of speech recognition technology on the reading and spelling performance of children with learning disabilities. *Annals of Dyslexia, 49,* 251-281.

Riviere, A. (1996). *Assistive technology: Meeting the needs of adults with learning disabilities*. Retrieved June 8, 2002 from, http://www.ldonline.com/ld indepth/technology _ /nalldc_guide.html.

Schumaker, J., Deshler, D., & Ellis, E. (1986). *Intervention issues related to the education of LD adolescents.* In J. Torgesen & B. Wong (Ed.), Psychological and educational perspectives on learning disabilities (pp. 329-360). Orlando, Florida: Academic Press.

Stanovick, K. E., Cunningham, A. E., & Freeman, D. J. (1984). Intelligence, cognitive skills, and early reading progress. *Reading Research Quarterly, 21,* 360-406.

The Alliance for Technology Access. *Computer resources for people with disabilities.* (1994). Alameda, CA: Hunter House Inc.

The Education of the Handicapped Act of 1975, Pub. L. No. 100-407. U.S. Department of Education.

The Technology Related Assistance for Individuals with Disabilities Act of 1988, Pub. L. No. 100-407,29 U.S.C. 2201, 2202.

The United States Office of Education. (1977). Register, 42:250, p. 65083. Washington, DC: U.S. Government Printing Office.)

Vogel, S., & Adelman, P. (1992). The success of college students with learning disabilities: Factors related to educational attainment. *Journal of Learning Disabilities, 25,* 430-441.

Wagner, M. (1992). *Being female - A secondary disability? Gender differences in the transition experiences of young people with disabilities.* Menlo Park, CA: SRI International.

Wetzel, K. (1996). Speech-recognizing computers: A written-communication tool for students with learning disabilities? *Journal of Learning Disabilities, 29*, 371-380.

White, W. J. (1985). Perspectives on the education and training of learning disabled adults. *Learning Disability Quarterly, 8,* 231-36.

Ysseldyke, J. E., Thurlow, M., Graden, J., Wesson, C., Algozzine, B., & Deno, S. (1983). Generalizations from five years of research on assessment and decision making: The University of Minnesota Institute. *Exceptional Education Quarterly, 4,* 75-94.