Study of Assistive Technology and California Community College Students with Learning Disabilities

Preliminary Report - March 2004
Final Report - October 2004

High Tech Center Training Unit
of the California Community Colleges Chancellor's Office

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The authors wish to express their appreciation for the enthusiasm and hard work of the students and faculty of the California community colleges participating in the study. It is our hope that their efforts will help to advance the academic success of students with learning disabilities.

Executive Summary

This study was designed to examine whether the use of assistive technology—a screen reader—could improve the academic performance in reading-intensive social sciences courses of students with a learning disability profile that includes deficits in processing speed.

Much of the research carried out to date that attempted to establish the efficacy of assistive reading technologies in improving the academic performance of students with learning disabilities has been generally small-scale or anecdotal in nature. Further, existing research has not attempted to define the specific characteristics of a learning disability that would effect reading speed and comprehension. Neither has any previous research attempted to match specific types of learning disability with the specific characteristics of assistive reading technologies designed to address the unique expressions of those disabilities.

In June, 2003, the High Tech Center Training Unit in conjunction with six California community colleges and an advisory group composed of leading experts in the field of learning disabilities from within the California community colleges, began a large-scale research project intended to address the following question:

> Do students with a specified profile of learning disabilities that effects reading speed and comprehension benefit from use of assistive reading technologies that address the unique deficit areas characteristic of such learning disability profiles? More specifically, how do students with such specific learning disability profiles perform in the reading intensive academic environment of social science courses both before and after introduction of the assistive reading technology?

Learning disability specialists at participating colleges were able to identify a pool of 210 students whose LD assessment testing matched the specified profile. Of these students, 141 had taken one or more social science courses in the academic year Fall 2002-Spring 2003. These became the baseline sample. A training protocol was developed that would be used to deliver student training in exactly the same fashion for every student who wished to participate in the

study. Colleges were given a site license for the assistive reading software (PDFaloud) that allowed the institutions to install the software both on campus computers and on the home computers of students participating in the study.

Analysis of the data collected in order to establish baseline grade-point averages for the study group revealed a surprising and unexpected finding. The performance of students who had been identified as having a learning disabilities profile likely to produce significant difficulty with reading speed and comprehension performed virtually identically to their nondisabled peers. The grade-point average for social science courses completed by the study group was 2.5 or a C. The grade-point average acquired through data from the California community colleges Chancellor's for all nondisabled students in the California community colleges taking social science courses during that same period was also 2.5 or a C. In order to seek additional validation for this finding, we secured from the California community colleges Chancellor's office the grade-point average for all students with learning disabilities taking social science courses during that same period. Again, the grade-point average for this group was 2.5 or a C. Grade distributions and persistence rates for all groups were not significantly different.

This puzzling finding leads to possible hypotheses, and additional exploration, that are beyond the scope of this study. One of the possible explanations is that learning disabilities specialists within the California community colleges are providing services that allow students with learning disabilities to compete on an academic par with their nondisabled peers. The accommodations currently provided to students by learning disability specialists may be making significant contributions toward their academic achievement. And in fact, most of the students in the study who responded to a final survey (though this is not a representative group of students with learning disabilities) did use testing accommodations, most having more than one accommodation. It is also possible that the predictive value of the characteristics drawn from LD assessment data for the study is less accurate than previously imagined at identifying the likely effect of these deficit areas on reading speed and comprehension.

The study was designed in two phases. The first phase involved identification of participants, solicitation to participate, training in the use of assistive reading software and several months of

practice with the assistive reading software. The second phase of the study was intended to evaluate whether or not there was any significant change in the grade-point average of social science courses taken by students participating in the study after they had been trained and were using the assistive reading technology.

As with many long-term, real-world studies, intervening circumstances can have unexpected and complicating consequences on the study outcomes. In this case, the initial distribution of the software provided by the vendor proved to be buggy and required explanation and redistribution. Redistribution occurred over a one-month to six-week interval. Unfortunately, some students who had initially agreed to participate in the study became frustrated by the delay and technical difficulty of acquiring and installing the revised edition of the software and decided not to participate further in the study. Additionally, some campus learning disability specialists also experienced initial difficulty with the installation and use of the software and lost enthusiasm for the study.

Another real world challenge was that many eligible students, when invited, were not interested in acquiring or learning to use the new assistive technology. The learning disability specialists invited the students identified in the original study sample usually by letter and by phone, often repeatedly. The response was lower than anticipated. One campus, for example, with an enthusiastic learning disability specialist invited 90 students; 20 responded and 11 attended the training. On other campuses the response was equally small.

When the second phase of data collection was completed during the summer of 2004, the total number of students who had participated in the training, received the software, installed it successfully, used it regularly and completed a social science course during the Spring, 2004 semester was statistically to small to produce any meaningful data analysis.

A significant fraction of participating students did, however, complete a survey providing additional information about their experiences. Of the students in the original pool who went through the training and took a final survey (which is the only way to get a sense of use of the technology) there were eleven student who, having completed the training, reported using the

assistive technology “regularly” and 13 more who reported using it “occasionally.” One of the most significant findings gleaned from the narratives of these surveys suggested that incorporating a new technology into the array of study skills and compensatory strategies employed by the use students was a much slower process than we had previously anticipated in our initial projected practice to gain familiarity time of several months. Both faculty and students suggested that, even though the initial training is quick, regular use depends on repeated cycles of use and positive experiences.

The quality of synthetic speech produced by the assistive reading technology was problematic for many students. While we were able to provide high-quality speech synthesis software for instances of software installation on-campus, the student version of the software used synthetic voices of a somewhat lower quality. It is probably reasonable to assume that students who depend heavily on auditory learning might experience comprehension difficulty in some instances.

Interestingly enough, almost every student who completed the study, even those who did not use the technology regularly, saw the potential value of the assistive reading technology and how it might assist in improving reading speed and/or comprehension. A number of students commented on the auditory option as a means of reading text when their eyes became weary or they began experiencing difficulties with visual comprehension.

The window of opportunity for introducing new technologies to both faculty and students can be narrow. Although every effort had been made to evaluate and pretest the assistive computer technology employed prior to distribution, the testing environment could not accurately anticipate all the variables that were encountered by the six participating colleges nor the failure of the software provider to anticipate and correct a potential problem in the software installation process.

Further, faculty and students have limited time to explore new technical and learning resources. For best results, a new product or strategies must work exactly as advertised right out of the box, the first time and every time. Colleges and students who were able to persist through the initial

frustrations of the study reported high levels of satisfaction. Colleges and students who did not have the time or willingness to persevere through some initial technological frustrations, still saw the potential of the assistive technology to improve academic performance but had no concrete experience of that assumption.

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Preliminary Report - March 2004

Background

Students with learning disabilities in community colleges

A 1997 study of 672 community colleges by the American Association of Community Colleges found that of students receiving disability services 37% had learning disabilities. The same study found that although 53% of all students in higher education are enrolled at community colleges, 71% of students with learning disabilities are in community colleges. That number is expected to grow as students who have been mainstreamed in secondary school pursue higher education.

More specifically, California Community College Chancellor's Office data for 2001/2002 indicates that a total of 81,835 students with disabilities received services. Of that number, 22,011, or almost 27% of the total, were students with learning disabilities.

Extensive research exists on the nature of learning disabilities and on some accepted accommodations such as the effects of extended testing time. However, there is little research to inform and refine the use of assistive technologies by students with learning disabilities in community colleges. There are, in fact, very few assistive computer technologies which address the specific needs of students with learning disabilities. Additionally, the research that has been conducted to date has been small scale and laboratory-based.

A series of studies by Jerome Elkind and colleagues at the Lexia Institute has examined the use of screen readers that synchronize visual and auditory presentation of text for adults with learning disabilities including dyslexia, as well as attention deficit disorders. These studies were conducted in laboratory settings, and the outcome measures were changes in reading rate and comprehension on standardized reading tests as well as reported changes by students in comfort and stress levels. The findings overall indicate the possibility that screen readers can enhance reading speed and comprehension and can decrease stress and increase enjoyment of reading.

A 1996 study by Elkind et al. examined 50 adults, all of whom had been diagnosed as learning disabled. This sample included students at four-year and community colleges and working adults. Study participants were given the Nelson-Denny Reading Test to determine reading comprehension and speed. In the pretest, both reading speed and timed comprehension were lower than the grade-level norms on the test. The median of their unaided reading speed of the sample populations was 155 words per minute. This score is considerably lower than the normal mean reading rate of high school students, which is 255 words per minute and of college students, which is 300 words per minute. The average timed comprehension scores were also considerably lower than normed adult scores. Half of the participants had comprehension scores at or below the 25th percentile. However, when additional time was allowed, comprehension increased; untimed comprehension scores were at the 66th percentile.

Participants were then given training on the assistive technology and retested for speed and comprehension on a different form of the test. On the post-test, use of the screen reader increased reading rate up to 180 words per minute (approximately the speed of normal speech). This is a significant difference above the unaided reading rate (155 words per minute), but still below peer norms. Increases in comprehension were small and not significant. Those participants with lower reading scores improved the most, while those whose reading rate or comprehension was relatively good benefited less, and even found that the technology interfered with their performance.

Fourteen participants of the original fifty were given the assistive technology for an extended period of time (three months to one year) and were then given a structured questionnaire about use of the technology. Almost all participants (93%) reported that reading was easier, less stressful and less tiring, even when there were no gains in reading rate or comprehension. Only one participant indicated difficulty integrating auditory and visual information. [source: *Computer-Based Comprehension of Adult Reading Disabilities* Jerome Elkind, Molly Sandperl Black and Carol Murray, published in *Annals of Dyslexia*, vol. 46, Nov 1996]

A second study by Elkind in 1998 using more developed screen reader technology studied the same reading variables: speed, comprehension and perceived comfort. The sample was twenty-

six community college students who had been found to have learning disabilities. On the Nelson Denny standardized reading test, the median reading score of the sample was 149 words per minute, compared to a median of 250 words per minute for community college students. These students reported that they not only read slowly, but could not read for long periods of time without a break. The median timed comprehension score was at the 15th percentile, while untimed comprehension was at the 64th percentile.

As in the 1996 study, students with slowest reading speeds increased their reading rate the most, but those with good reading speeds did not benefit significantly. Those with reading rates below the speed of normal speech read faster, those with faster speeds might even lose performance. Those with poorer comprehension (tenth grade or below) similarly benefited more than students with stronger comprehension. In a structured questionnaire at the time of training, participants thought that the technology might make reading less tiring and stressful and might contribute to sustained reading. Three participants reported difficulty integrating auditory and visual information. {Source: *Computer Reading Machines for Poor Readers,* Jerome Elkind, Lexia Institute January 15, 1998]

The Current Study

This report describes the initial stages of a study conducted in the California Community Colleges on use of assistive technology by students with a particular pattern of learning disability. The assistive technology consists of a screen reader designed to compensate for deficits in reading speed. The study was organized by the High Tech Center Training Unit that provides training and technology support for California Community College faculty and staff in the use of assistive computer technologies.

The study is designed to examine whether the use of a screen reader can improve the academic performance of students with a learning disability profile that includes deficits in processing speed, in particular, the population of students in the community colleges with a very specific set of learning disabilities who are taking reading-intensive courses in the social sciences.

The Technology

The screen reader employed in the study (PDFaloud) was designed specifically for use by people with learning disabilities. The program contains a number of features similar to many assistive computer technologies designed for use by students with learning disabilities. The screen reader can:

- read text out loud by word, by sentence or by paragraph
- adjust reading speed
- magnify text
- highlight text, and
- access a dictionary that can look up words and read the meaning out loud.

The program selected, PDFaloud, reads documents stored in the "image over text" PDF format. In California Community Colleges, books and other materials are readily available in the PDF format from the Alternate Media specialist at participating colleges, the statewide Distributed Scanning Network or the Alternate Text Production Center (ATPC).

Colleges participating in the study received a site license including the rights to install the software on any campus computer as well as the home computers of all students participating in the study. The intent was to provide the same level of access to books for students using assistive computer technologies as that enjoyed by users of hardcopy books.

Research Methods

This study was designed to be a systematic exploration of the use of assistive technology as a methodology for enhancing the academic performance of students with specific types of learning disabilities. However, the study has been shaped by limitations of doing research in the real world rather than in a controlled or laboratory setting. This study is more in the tradition of action and participatory research, an attempt to see the possible outcomes in real life situations.

The director of the High Tech Center Training Unit invited a research consultant and four experienced Learning Disability (LD) and Assistive Computer Technology Specialists from California community colleges that would not be part of the study sample to join him on an advisory research team. Advisory members include: Marcia Krull from Mount San Jacinto College, Pauline Waathiq from DeAnza College, Susan Matranga from Los Angeles City College, Ellen Cutler from Santa Monica College, Dr. Rose Asera from the Carnegie Foundation and Carl Brown from the High Tech Center Training Unit. This team of six met in May 2003 to decide on the design of the study and the sampling strategy for campuses and students. As a measure of interest and commitment on the part of the LD specialists on the advisory team, three attended in person and one via conference call.

The team of LD specialists discussed how to match the learning deficits of students with learning disabilities with the specific capability of the assistive technology proposed for use. The specialists described particular students they had worked with who could benefit from increased access to text via listening. These would be students who, based on assessment scores, had reading difficulties caused by slow visual processing. This speed deficit would show up in their processing speed index or as a noted difference between timed and untimed comprehension.

They determined that the profile and process for identifying such students would include the following factors:

1. Verification through the formal diagnostic process as having a learning disability;

2. An aptitude score of 90 or above on any of the scales used in the LD eligibility model. (Three tests are commonly used in diagnostic testing-- WAIS III, Woodcock Johnson-Revised, or an updated WJIII.) A score of 90 would suggest that the student has the potential to transfer to a four-year institution;
and

3. Having one of two indicators of a processing deficit in reading —
a significant processing speed deficit as defined by the California Community Colleges LD Model;
or
a difference of more than two grade levels between timed and untimed comprehension on the Nelson Denny test, which may indicate a visual processing deficit or a weakness in decoding.

The advisory committee determined to select six campuses for the study. The campuses were chosen to be mid- to large-size colleges, mostly in urban or suburban settings, with well established Learning Disability programs. This size and location were chosen because such colleges would have a larger number of students meeting the profile, and those students would be more likely to have computers. The team arrived at a list of twelve possible campuses. All twelve campuses were invited. Those interested responded with letters of application including the signatures of the Learning Disability Specialist, the Director of DSP&S (Disabled Students Programs and Services), and the President of the College. Six campuses were chosen for participation. In the interests of privacy, the names of participating colleges will not be included in the study.

The training for use of PDFaloud was designed by a California Community College LD Specialist, Stacey Kayden from Laney College, who has been involved in technology training for several years. The training was designed specifically to integrate use of the technology into the day-to-day academic setting rather than simply teaching students how to use the technology. This approach was based on an observation by the research team that technology is often regarded as an add-on, separate from academic skills and curricular content. This training was meant to present the technology as an integrated part of academic study.

In July, the HTCTU organized a one-day training attended by one to three people from each participating campus, research team members, and the software developer. The designer of the training curriculum went through the training step by step. Each campus LD Specialist had a chance to become familiar with the program, and each campus was given a copy of the software.

The Learning Disability Specialist on each campus searched through student records to identify no less than 20 and up to 50 students who met the profile and who had taken a social science course in Fall 2002 or Spring 2003. These students made up the baseline group, and their academic achievement would provide the comparison for subsequent students using the screen reader. The Learning Disability Specialists were encouraged to invite these students to take the training, but they were also free to give the training and software to any student who they thought would benefit from using the technology.

Conditions and Limitations of the Study

In designing this study we recognize a number of limitations that constrain not only the design possibilities, but in turn limit the breadth of outcomes. They are the limitations that are associated with doing research in real educational settings. In a nutshell, over a one-year period, the study was designed to evaluate the academic performance (grade point averages) of students with very specific learning disabilities participating in reading intensive courses before and after the intervention of a specific assistive computer technology designed to enhance reading capability.

In this study, for practical and ethical reasons, it was not possible to randomly assign students to an intervention or control group and then compare the academic results. Because of legal mandates it was not possible to deny services to any eligible student, and so even a design with a delayed start by one group was not an option. The choice to use an historic control was a pragmatic way of comparing academic achievement of a similar group of students in social science classes to the academic achievement of a subsequent (and in some cases, overlapping) group of similar students in social science course using the intervention software (PDFaloud).

As an outcome measure, grades are a blunt instrument. They have a very limited range and when taken in average are likely to show very small differences. In addition, many things influence academic achievement in a course, so the effect of one factor—such as use of a particular technological tool—may be minor. We acknowledge the complexity of influences on course

completion and grades, especially among community college students. However, grades are the current academic currency, and any study that did not examine academic achievement based on grades would not be taken seriously. Therefore, we undertake this study looking for any small indicators of possible effect.

Social science courses were chosen because they are reading intensive. The research team initially considered using academic performance in English 1A (Freshman Composition) as the basis of the study. An informal review of grades in English 1A at DeAnza College showed a differential of approximately one half grade point between general class average and students with learning disabilities. However, English 1A is a writing intensive course, rather than reading intensive. Courses that are included that meet social science requirements varied slightly by campus, but in general included anthropology, sociology, psychology, history, geography, cultural studies, economics, political science and in some cases, child development.

In describing the baseline population, we have included the variables of age and gender, but have not included other descriptors. We did not include ethnicity and race because of the ambiguity of interpretation of the categories and because in a relatively small sample, small numbers might have inaccurate implications. In addition, we did not track full- or part-time enrollment; a review of transcripts verifies that some "full-time" enrollment was filled with courses outside of the transfer or Associate of Arts curriculum, such as physical education or learning disability support courses. Many students' transcripts included some semesters of full- or part- time enrollment, so there is no singular descriptor that would identify their enrollment pattern.

This study design depends upon a significant number (fifty or more) of students from the six participating colleges who possess the appropriate learning disabilities profile taking a social science course in Spring 2004. As we collate survey data from students who have been through the training, meeting this number may be problematic.

In addition, the Learning Disability Specialists can give the program and training to the students, but cannot guarantee level of use by students. Thus the treatment has some aspect of unevenness.

The decision was made to designate the Fall 2003 semester for training and time for students to become familiar with the technology. This was fortunate because there was a technical difficulty in Fall 2003; some of the program discs for students to copy the program to their home computers were defective and had to be replaced, in some cases more than once.

Finally this study is being conducted at a time when external and internal conditions within the California Community Colleges are stressful. The state has a major economic deficit that may affect funding, staffing and services.

Initial findings from baseline data

The six campus Learning Disability Specialists identified a total of 210 students who met the LD profile and had taken a social science course while a student at the college. Of these, 141 had taken a social science course in the academic year Fall 2002-Spring 2003. This group provides the baseline data. Other students in the total sample remain eligible to be part of the study if they complete training with the technology and subsequently take a social science course in Spring 2004. Additionally, newly identified students who match the learning disabilities profile, complete the training, use the software, and take social science courses in spring 2004 may also be included.

The following data are preliminary; some data are missing and will be included in the final report.

Of the 141 students, 76 are female, 65 male. The age range, as is typical in community colleges, runs from 18 (10 were 19 or younger) to over 50 (4 were 50 or above). The mean age is in the mid- twenties, twenty-six to twenty-seven (note, this age is slightly variable reflecting the time duration between data submitted and analysis).

Of the students who have taken social science courses, 75 students have taken one class, 39 students have taken two classes, 17 students have taken 3 classes and 6 students have taken four classes. Social Science courses include those given in general social sciences, women's studies,

anthropology, ethnic studies, archeology, economics, history, geography, political sciences, sociology, and assorted other courses in psychology or justice that are designated as meeting a social science requirement by a campus.

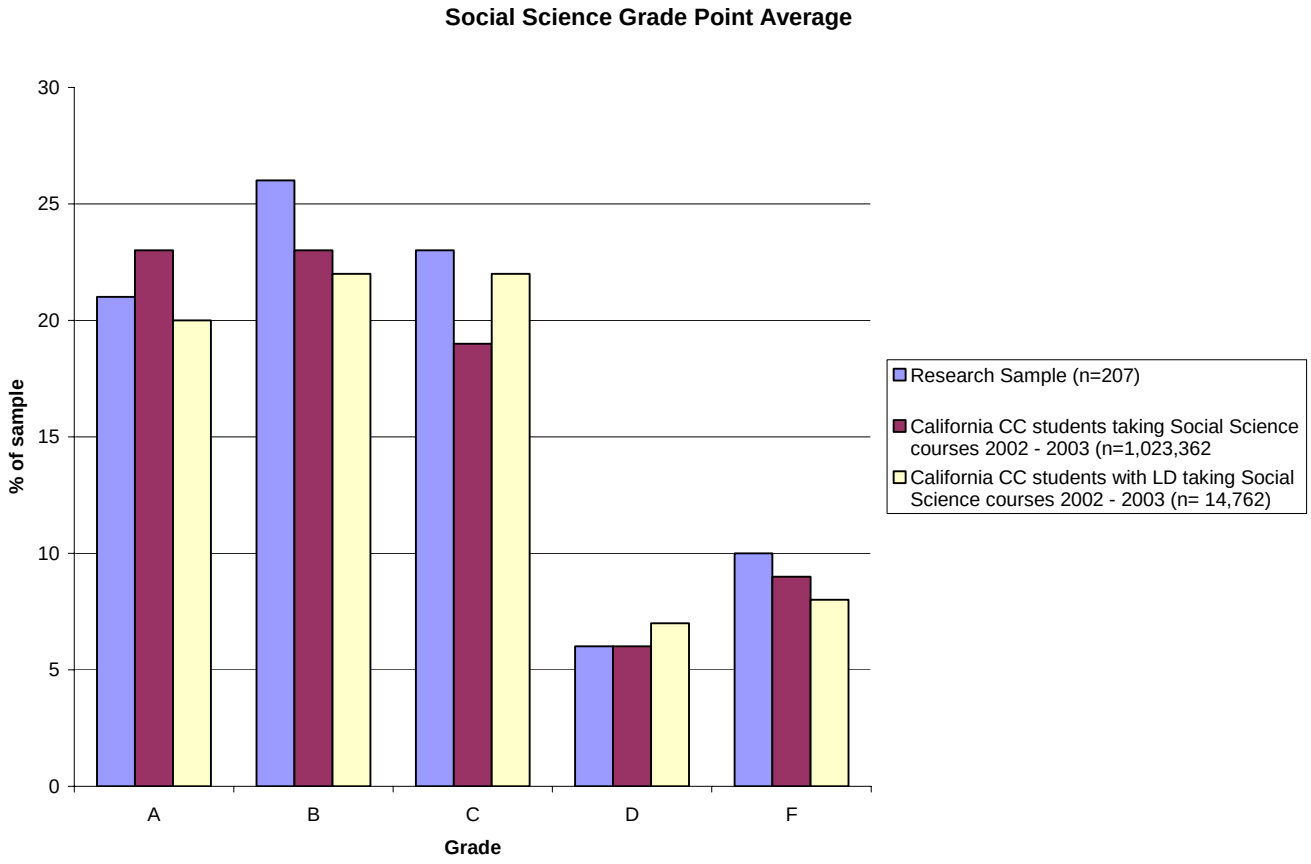
The most commonly taken classes by students in the sample are Introduction to American (or US) Government, Physical Geography, US History through Reconstruction, US History since 1876 and Introduction to Economics. The rest of the course-taking pattern covers a very wide range of social sciences.

The students in the sample took a total of 239 social science courses. Of these, 207 (86%) were completed with a grade of A, B,C, D, or F; two received grades of Incomplete; and 32 (13%) were not completed, receiving a W. Of the 207 classes completed with a grade, 21% of the students received an A; 26% received a B; 23% received a C; 6% received a D, and 10% received an F. The average grade of this distribution is 2.5 (C).

In order to compare this information to a broader student base, we were able to secure systemwide data from the California Community Colleges Chancellor's Office. Interestingly, this study's findings of grade distribution and grade point average of the 207 participating students is very similar —similar enough that no statistical test seems needed— to the California Community Colleges system-wide distribution and average for 1,023,362 students taking social science courses for 2002-2003. The average grade was 2.5. In the entire system, 23% of students received an A; 23% receive a B; 19% received a C; 6% received a D, and 9% received a grade of F; 17% withdrew and did not complete the course. (1% received Incomplete; 1% Pass, and 1% No Pass)

Further, of the 14,762 students with learning disabilities taking social science courses in the California Community College systems during 2002-2003, the average grade was 2.49. In the entire system, 20% of students received and A; 22% received a B; 22% received a C; 7% received a D and 8% received an F. Seventeen percent (17%) withdrew and did not complete the course; 1% received incomplete; 1% received Pass and 1% received No Pass. While the overall grade point average was .06% lower, 2% fewer A’s and 3% more C’s were awarded, the grade

point averages of students with learning disabilities remains remarkably similar to those of their nondisabled peers.



Survey data: In addition to baseline data, students who took the training were asked to complete a short survey. At the moment we have surveys from 60 respondents, all of whom meet the learning disability profile. Most, but not all, were part of the baseline sample, and there is no way to predict whether they will take social science courses in the Spring 2004 semester. Responses to two questions illustrate the potential for technology with this population. Of the 60 students, 54 have access to computers at home. Of the 60, 42 have never used assistive technology, twelve have used it occasionally, and six have used it regularly.

This is an ongoing study. Our initial conjecture, that students with the learning disability profiles we have identified would most likely have lower grade point averages in social science courses,

has proven incorrect. In fact, the students appear to be virtually identical in their academic performance within social science courses to students system-wide. Additionally, the data suggests that a very large number of students who have computers at home and may potentially benefit from assistive computer technologies are not currently using such software.

The final portion of the study will be completed during Summer 2004. Hopefully, we will have collected sufficient data to comprise a meaningful sample with which to compare the academic performance of this group with the academic performance of our baseline group within the framework of social sciences.

Study of Assistive Technology and California Community College Students with Learning Disabilities

Final Report - October 2004

Background:

As described in the interim report (March 2004), this study was designed to determine if use of screen reader technology would increase the academic performance of community college students with a particular learning disability profile enrolled in reading-intensive social science courses. Learning Disability Specialists at six campuses were invited to participate. They received software licenses that allowed them to put the assistive program (PDFaloud) on any campus computers. The license also provided for a student version which could be installed on any participating student's home computer. The LD Specialists also were given a one day training in use of the assistive technology. The learning disabilities specialists at participating campuses identified between thirty and fifty students who fit the LD profile and received service through DSP&S. The majority of these students had already taken social science courses, but slightly less than half had taken them in the academic year 2002-2003 thus providing the achievement baseline for subsequent comparison.

The research question was straightforward: does use of assistive technology that can read text aloud and highlight words on screen increase academic achievement for students in reading intensive courses? Even though the research design was simple, every stage of intervention provided its own challenges and unanticipated circumstances. Although the numerical results of the study do not provide sufficient statistical data for meaningful quantitative analysis, the study does, as is often the case, raises more and intriguing questions about the dynamics of assistive technology and disability. In many respects, we learned more about the obstacles and challenges of using such technologies rather than about the academic effect such technology might have for students with learning disabilities.

Although it was not possible to draw conclusions about quantitative effects on academic achievement, specifically, performance of students with learning disabilities who had received

training in the use of PDFaloud, installed the software on their home computers and enrolled in social science courses during spring, 2004, analysis of patterns of use (or lack of use) and students' comments on surveys are useful in considering both future possibilities of assistive technology and research on its use. The two areas of greatest commentary on the surveys addressed technical difficulties using the software and areas of usefulness.

Observations from the study

Invitation and response

The LD specialists on six campuses invited students who matched the LD profile to take part in the training. These invitations usually went out by letter, and often with follow-up phone calls. Several of the LD Specialists noted that response rate was low—usually between one-quarter and one-third of the invited students—and attendance at trainings was somewhat lower. For example, on one campus, 90 students were invited, (59 meeting the LD profile plus 31 others) 20 responded and 11 attended training.

On another campus, 51 students matching the profile were identified, and 31 were enrolled for the following semester. All 31 were invited and seven responded and came for training. The remaining 24 were more assertively invited with phone calls, letters, and incentives like priority enrollment. Eight more students responded, for a total of 15, some of whom later dropped out. The LD specialist noted that "Only a small subgroup of the LD population who are eligible for *etext* are actually interested in using it. Those with the best study skills, self-motivation, and self-management tend to be those who will take advantage of this technology."

On the smallest campus, from a pool of 31 students in the baseline pool, only six students completed the training.

Although the numbers of students participating in the study was not large relative to the potential pool, the LD specialists, accustomed to working intensively with individuals, rather than large classes, saw the introduction of the technology in more gradual terms and requiring more time.

One enthusiastic LD specialist noted: *We invited the 59 students in the baseline group plus 31 others with reading disabilities. Twenty responded and signed up for training; 11 finished the training, 8 took PDF home to install, and 5 installed it satisfactorily.*

> "Obviously, the numbers keep decreasing, so it appears that students are uninterested or have other commitments; but this is not really true. Actually of the 11 who finished, 5 or 6 are asking for their texts in PDF format this semester. In addition we are starting a workshop for other students who now desire to learn the program. The booklets that I initially made for workshops shall be used for these inservices, And the program has been installed on all new computers (10) in our High Tech Center so that they are 'standard application fare' Thus as the program and its benefits becomes better known to our students, it should become a regularly requested application. I truly believe this takes time to measure such benefits. It is difficult to quantify 'change,' but I can see it happening…."

Several of the LD Specialists invited other students with learning disabilities (but who did not exactly fit the identified profile) to use the assistive technology program. The entry and exit practices of students on a community college campus makes it more challenging to keep track of those students who did go through training but did not continue the following semester.

Training was usually delivered individually and by appointment, and usually took less than one hour. One LD Specialist noted that students familiar with computers finished the training in 30 minutes, while others took an hour and a lot of questions.

The study design included a semester for students to receive training and become familiar with the technology before the semester of measuring effect. The training materials were straightforward, and learning the basic use of the technology is fairly easy, however, this is somewhat deceptive. The need is not just for the training time, but for the activities that fill the time. Simply learning the use of the assistive technology is not the same as practicing using it in a specific content area, becoming comfortable with it and acquiring the habit of use. As the LD specialists pointed out, students need to both practice with and use the technology.

Patterns of use

Thirty-five students completed training and a final survey (note, this is not necessarily the number of students who completed training, but those who both completed training and were available to complete a follow-up survey), whether they took a social science course in the target semester or not. There were also surveys from six students who went through training but were not part of the pool, and eight students who were part of the baseline pool and took social science courses, but did not complete surveys. On one campus six students who had gone through training completed the final survey, on another seven students completed the survey (and five others who were not part of the baseline pool), one had ten students completing surveys and one had twelve students completing the surveys.

Of the students in the baseline group who received training and completed surveys, 11 report using the program regularly (and one qualified regularly as four times a week for a couple of hours), 13 use it occasionally (with no description of what occasionally means) and 11 never use it (though two of those qualified that they had used it the prior semester but are not using it now).

As previously mentioned, it is not possible to discuss effects on grades because the intervention did not include a statistically significant number of students. Although there were more than forty students in the baseline pool who did take a social science course in the target Spring 2004 term, only 11 students used the assistive technology regularly, and this number is too small to suggest any quantitative effect on grades. The grade average for those students in the baseline pool who took social science courses in 2004 (including users and non-users of the assistive technology) was 2.74, slightly higher, but not significantly higher than the baseline average and system-wide average.

Of those who use the technology either regularly or occasionally (and a few who had used it the prior semester but were not currently using it) 15 used it on computers at home, 15 used it only on campus, and five both on campus and at home. This reinforces an observation in the first survey that students have computers at home and could use assistive technology there.

Obstacles:

1. Difficulties with the technology

The original intention of the research design was that by placing the technology both on campus and on home computers, students with learning disabilities would have the same access to textbooks as their nondisabled peers. For a number of technical reasons this did not happen. A string of technical difficulties early in the software dissemination process discouraged some potentially interested students and some of the LD specialists from further participation. In many cases the students gave up on the technology, though supportive LD specialists were able to keep a small number of students engaged with the technology in spite of glitches. Students in this group did report that the technology was useful.

The technical difficulties in the program included problems with copies of the student discs that made it impossible to select web-based software downloads on home computers and installation problems with older versions of Acrobat Reader, sometimes the only version available on campus computers. In addition, some older computers, both home and campus, did not have sufficient memory capacity to support the technology. The problems connected to Acrobat Reader were unanticipated and were addressed slowly (by the company that developed the technology) but not in time for some students to overcome their initial bad experiences.

Of the group of students who completed final surveys, 11 reported difficulties using the software on their home computers, and 14 reported no difficulties using the software on their home computers. Student comments[1] described these difficulties:

> Could not make it work on my computer… did not have the right Acrobat Reader program

> Could not install the program correctly. If we could, we would have used it. We would still like to install it on our home computer.

[1] Note that comments from student surveys have been edited for readability.

> PDF did not download in the right file, it took half the semester to find an employee from DSP&S about the technical problem
>
> Did not work as well [on campus HTC computer] because of low memory capacity
>
> As I was installing, somehow it was missing a step. I called the HTC staff and he directed me to the final installation.
>
> Got it installed, but could not get it to work. Couldn't connect to the Alternate media specialist. Am interested in trying it next semester and will bring my laptop to get help with the installation problem
>
> It would not let me change any settings, and other level of technical obstacles.
>
> Sometimes the pages will read only the bold words on the side of the page and not the paragraphs of the page.

On one campus, in the face of such student frustrations, the LD specialist did not continue in the study.

One reason the technology was chosen was that it could read PDF files. However, PDF did not prove to be as easily available as initially envisioned; 19 students reported acquiring text in PDF, although 12 reported no difficulty. From the students' perspective:

> (It was) hard to get texts in PDF and this slowed down the timing of having the text
>
> Math's the only one you can't get formatted (in PDF)

An LD Specialist summed up the process with its pitfalls from her point of view:

> Getting a book into e-text is very time consuming and costly. While we have our Alternate Media Specialist, the ATPC, and the AMX Database, all would go much smoother if we had cooperation and compliance from all of the publishers. A student needs to have purchased a book and given it to the Alternate Media Specialist weeks ahead of the semester.

One tech-comfortable student pointed out that it would be nice to have the capacity to read HTML rather than PDF:

> Most publishers provide CD-ROM versions of their textbooks, but these are in HTML format. Since PDF is very poor for internet applications and HTML is very good this is perfectly understandable, PDF Aloud should become "HTML Aloud" to work with the digital texts provided by publishers. Scanning is very time inefficient.

Another could see the possibility for course materials "for example if a teacher gave me a handout separate from the text I could use the system for it."

A common response among those students who tried the technology—and even those who used it—was that students did not like the mechanical tones of the reading voices.

> Get better speech and spoken word!

> It breaks my concentration as I try to read along because of the voices that I had to choose from. I was not comfortable with the technology voice, unable to track words on screen well; I need a voice that is more human sounding that flows. As I am not a strong mouse user, I would prefer key board controls.

2. Obstacles to conducting the study

Quite beyond the control of the study, the timing in the cycle of the state budget was highly problematic for participating colleges. This year, decreasing budgets, increasing anxiety, hiring freezes, and decreasing morale among community college staff may have resulted in uneven engagement of students participating in the study by campus LD specialists already overextended by existing workloads.

3. A puzzle about grades

The design of the study was based on two assumptions about grades. One was the recognition that grades (especially a system that only uses whole grades) are a rather blunt instrument for measuring impact. However, no such study could be considered seriously without including grades. The second assumption was based on a pilot study that showed that average grades of students with learning disabilities were a half grade point lower than those of their nondisabled peers. However, the unexpected finding that surfaced was that the distribution and average of grades of the baseline LD students in social science courses matched the distribution and average of students system-wide in those same courses.

This puzzling finding leads to possible hypotheses that are beyond the scope of this study to explore. One of the possible explanations is that the accommodations currently provided to students by learning disability specialists make significant contributions toward their academic achievement. And in fact, most of the students who responded to the survey (though this is not a representative group of students with learning disabilities) did use testing accommodations, and most have more than one accommodation. Eight of the eleven regular users have extra or extended time for tests, and five take tests in distraction-reduced settings. Similarly, of the nine occasional users, eight have extended time for tests and four take tests in distraction-reduced settings. Other occasional accommodations included readers, or text-to speech software, and scribes.

One other interesting observation about grades was that the only thing that did correlate with grades was aptitude (as measured by a number of different assessment instruments, most frequently verbal IQ)). Extremity of LD assessment scores was not a negative correlate with grades.

Perceptions of usefulness

When asked about the how use of the technology enhanced reading:

- Three students chose the option that using technology made it possible to read more quickly.
- Twelve students who used the technology regularly or occasionally responded that they could read more quickly and understand the material better.
- Twenty-one students who used the technology regularly or occasionally (or used it in the prior semester) found listening and tracking the spoken word to be most helpful. Six students designated listening as the most helpful aspect. ‘

Only one student said “nothing was helpful” and that using the technology made reading more difficult because “it breaks my concentration as I try to read along because of the voices that I had to chose from.”

Fifteen of the students appreciated having access to the dictionary as they read. In their own words:

> The dictionary was very handy, (you) don’t have to open up one.
>
> Most helpful was listening and tracking the spoken word, the dictionary helping me stay focused on my reading materials.

In further commenting on the usefulness of the technology, two students specifically appreciated the increased speed of reading:

> It makes things clearer, makes books more interesting, reads much faster (about 250 words per minute)

> I am a very slow reader. This probably has to do with my extreme far sightedness. Hearing at the same time as reading allows me to read at a more normal rate

Two more students noted the physical ease and support, "when tired it would be useful," and "I don't get as many headaches and blurred vision. I can study longer."

In particular, students noted that the technology made studying easier and helped them concentrate and "….stay focused on my reading materials." In their own words:

> PDF Aloud enhances my ability to read quickly and understand the material better, Even though I did have trouble getting it to work on my computer.

> Occasionally (I) use another screen reader, helps me stay focused on the book

> I was very happy with the program it has worked well for me, I would like to continue using it. I enjoyed reading the text better. Otherwise I would put the text aside and probably would read the text at the last minute.

> I actually take the time to read.

> It reads for me while I follow along.

> Reading words that were unclear were made easier.

> It helps to reinforce the information.

Students using the technology felt that it helped comprehending class materials:

> It was very helpful for me to pull the material off the page and into my head. I think with more of the PDF Aloud, I can increase my reading comprehension.

> It enhances my ability to read quickly and understand the material better even though I did have trouble getting it to work on my computer

> I like the program because it helps me in my classes by understanding the material better

Though a majority of participants liked to listen and track the words on screen, for a few, the auditory input was particularly effective.

> I am a very slow reader this probably has to do with my extreme farsightedness, Hearing the words at the same time as reading allows me to read at a more normal rate.

> It's nice to sit and listen to it, however I can't sit and look at the screen too long, it makes my eye uncomfortable, so I time each chapter. It has made a big difference to listen and comprehend the readings I am assigned. It makes it more pleasant versus reading it on my own. I would like to mention that if the voices could be changed that would be great. Thanks so much for the great help it has been.

> By listening to the material I am able to retain more and do better in class overall

> (I can) close my eyes and listen

> I am an auditory learner and the visual helps reinforce the information. I can read more quickly too

> I feel that the assistive technology has helped me with my class material because I can hear the textbook material.

One student even suggested that what would be helpful would be "to convert my text from PDF to MP3 player so I can listen to it anytime any where."

Even "occasional" and "never" users saw the potential in the technology and a few expressed interest in pursuing them at another time:

> I haven't had the chance to use it enough to know. I plan to get more training.

> I am still exploring the program

> I am interested in trying it next semester and will bring my laptop to get help with installation

> It's good but I don't use it.

> I need more training

One student noted that she probably would have been more motivated to use it if she had been taking a more difficult class, rather than one in which she "had a large knowledge base."

Conclusions

The few prior studies on use of this type of assistive technology that had been conducted were small scale. Although this study was designed as a large scale quantitative study, it defaulted to a small scale study, with more attention to issues of use rather than effects of use. The lesson for research is that before it is possible to understand the effects or contribution of the technology to

student achievement, it will be necessary to understand what it takes (invitation, support, and practice) for students to use the technology consistently.

While technology glitches are frustrating for any computer user, they may be even more daunting for students who are already challenged by the tasks of dealing with text and organizing information. Before a study can really examine effect on student achievement, the technology, which is changing quickly, needs to operate properly and actually function as seamlessly as it is described. Moreover, more human sounding voices, which are rapidly becoming available, will make the technology more inviting and thus more likely to be used.

There did not seem to be a significant key indicator or pattern among the "regular" users of this assistive technology, rather the key interaction seems to be between the student and the LD Specialist. The interactions by Learning Disability Specialists, the level of encouragement, support and comfort with the technology by the LD specialists themselves seemed to make a significant difference in student comfort, willingness and use. Exposing students to training once does not seem to be sufficient, students need time and reinforcement to become familiar and regular users. The LD specialists were somewhat surprised that more of the students who were invited did not respond. However, they were pleased with those students who did respond and used the technology either regularly or occasionally. Since this is a field characterized by the uniqueness of individual modes of learning and the challenge of overcoming individual barriers, the individuals who found the technology useful were viewed as successes, even if the numbers were small. The LD Specialists also thought there were other students, beyond the designated LD profile, who could benefit from this technology.

In addition, the LD Specialists placed the introduction of new technology in a longer time frame. Over time the successful and satisfied users would be a visible resource for other students. In addition, it would be interesting to know if the group of self-identified "occasional"users of the technology continue to use and explore the application and with time, become more regular users.

Those students who got past or did not experience technical difficulties and did use the program found it helpful, reporting that it did make reading easier and (also by self-report) that it increased reading comprehension. Some students reported that hearing it at the same time as seeing it on screen was useful, others reported how effective it was to listen to the text. It would be useful to understand more about the relationship of seeing and listening together or listening alone, particularly as one of the next generation of assistive technology (DAISY) concentrates on sound, separate from visuals. One other finding in this study is that a large percentage of the targeted students have computers at home and would like to find ways to use assistive technology on their home computers.

There is still a need for a large scale study of the effects of using assistive technology on the academic achievement of students with learning disabilities. Despite an attempt to cast a wide enough net, this study was not able to answer that question. Although there were enough students in the baseline pool, the interest and response among those students was limited and even among the relatively small numbers who went through the training, not all used the technology regularly or occasionally. Additionally, not all the users took reading-intensive social science courses (something that the design did anticipate, but could not control). The number of regular users was too small to even attempt any quantitative analysis. The challenge for future research is to understand in more detail the factors that encourage and support regular use of the assistive technology, and then to examine whether that use affects reading comprehension and consequently academic achievement.