This paper describes the use of "computer-supported studying" as an approach to helping students with disabilities develop and apply skills needed for successful transition from secondary to postsecondary education. The paper provides vignettes of three students with learning disabilities who participated in one of three federally funded projects designed to research the impact of computer-supported studying on student retention and academic achievement. Each vignette describes the way in which technology was used to minimize the negative impact of the student's disabilities and build upon the student's learning strengths. Results revealed that students who successfully adopted a computer-supported approach to studying also successfully adapted to the instructional demands of postsecondary education. Results are interpreted in terms of the literature on cognitive strategy instruction as well as the literature on social constructivism.

Students with learning disabilities comprise approximately 50% of all students with disabilities in the United States. By definition, they are individuals with average or above average intelligence who, as group, have the capacity to pursue and benefit from postsecondary education (Brinckerhoff, Shaw, & McQuire, 1993; Vogel & Adelman, 1993). Unfortunately, when compared to their non-disabled peers, students with learning disabilities (LD) are more likely to drop out of high school before graduating (Wagner, Blackorby, & Hebbeler, 1993), less likely to pursue some form of postsecondary education, and less likely to graduate with a certificate or degree when they do.

For example, data from the National Longitudinal Transition Study of Special Education Students (Wagner, D'Amico, Marder, Newman, & Blackorby, 1992) found that nearly 31% of youth with LD enrolled in postsecondary school, but only 15% earned a certificate, degree, or license. Of the 31% who had pursued some form of postsecondary education within five years of leaving school, less than half attended postsecondary school within the first two years (Blackorby & Wagner, 1996). Positive predictors of postsecondary school enrollment following high school included the student's GPA, parental expectations that we student pursue higher education, and the presence of a transition plan that included postsecondary education as a goal. More recent studies have produced outcomes that are considerably brighter. For example, Halpern and associates found that approximately 60% of the students with disabilities in their three state sample (N=987) attended some form of postsecondary education after high school, when postsecondary education was broadly defined to include programs specifically for students with disabilities as well as postsecondary institutions for the general population (Halpern, Yovanoff, Doren, & Benz, 1995.) Positive predictors in their study included students receiving instruction and achieving competence in five curricular areas (reading, writing, math, problem
solving, and getting along with others) as well as student participation in relevant transitional planning and student satisfaction with high school instruction.

In recent years, various factors have converged to increase the percentage of students with LD who pursue postsecondary education. These include (a) an increased focus on quality academic preparation at the secondary level (Brinckerhoff et al., 1993; Vogel & Adelman, 1993); (b) an increased willingness on the part of colleges and universities to evaluate student applications in ways that take into consideration the impact of their specific disabilities (Shaywitz & Shaw, 1988; Vogel, Leonard, Scales, Hayeslip, Hermansen & Donnells, 1998); (c) an increased awareness of appropriate and effective accommodations (Raskind & Higgins, 1998); and (d) increased availability of specialized services and supports for students with disabilities on postsecondary campuses (Bursuck, Rose, Cowen, & Yahaya, 1989; Mellard, 1994; Vogel, 1993). Many of these changes are the direct or indirect effect of federal legislation mandating a free appropriate public education that provides for individualized educational planning, equal access, and accommodations designed to assist students in participating in the general education curriculum to the maximum extent possible. Together, these changes have meant that the number of students with learning disabilities entering postsecondary education has increased more than any other disability classification (American Council on Education, 1992).

Since the 1980s, federal legislation relevant to the education of students with disabilities has increasingly addressed the need to plan for the transition of students from secondary schools to career-related employment or postsecondary education (Halpern, 1992; Repetto & Correa, 1996). Programs designed to foster the successful transition of special education students have led to increased examination of the environments to which students are headed (e.g., places of employment, postsecondary schools), specifically identifying the performance expectations in these environments. Once identified, transition programs can be designed to prepare students to succeed in the settings to which they aspire (Rusch, Chadsey-Rusch, & Szymanski, 1992). For students going on to postsecondary education, this means examining the various expectations related to academic activities that students are expected to engage in and designing programs at the secondary level geared to preparing students with disabilities for success in these activities (Cowen, 1993; Repetto & Correa, 1996.)

This task is complicated by the fact that secondary and postsecondary schools are vastly different on a number of important dimensions (Brinckerhoff, Shaw, & McQuire, 1993; Dahlke, 1993). Furthermore, the types of skills required for success at the postsecondary level are exactly those skills that students with LD often have difficulty acquiring. For example, success at the college level requires that students be able to manage their own time, read and understand textbooks in a variety of disciplines, record, comprehend, and study lecture notes, integrate information from a variety of sources, conceive and write papers independent of teacher direction, and pass tests that require the application of information as opposed to rote memorization. Unfortunately, research on students with LD suggests they often have difficulty managing their own time, frequently fail to understand what they read, usually struggle with the task of taking useful notes, demonstrate problems when asked to integrate prior knowledge with new information, and experience frustration with the process of writing papers and reports (e.g., Lerner, 1993; Newcomer & Barenbaum, 1991; Reid, 1988; Reyes, Gallego, Duran, & Scanlon, 1989; Saski, Swicegood & Carter, 1983).

Many of the skills that are both problematic and necessary to students with LD fall into a category that we call "studying." Studying refers to a combination of cognitive and self-management activities whereby students acquire information, construct knowledge, and fulfill
the expectations of school. Effective studying requires that students cognitively manipulate the information they are trying to learn, accurately monitor their study progress, and take personal responsibility for the study process (Anderson-Inman, Knox-Quinn, & Horney, 1996). An area of considerable research over the past 15 years has focused on the identification and evaluation of both cognitive and self-management strategies that promote effective studying, strategies that lead to the academic success of adolescent students in general and adolescents with learning disabilities in particular (e.g., Graham & Harris, 1989; Harris & Pressley, 1991; Schumaker & Deshler, 1995; Shannon & Polloway, 1993; Stoddard & MacArthur, 1993).

With the advent of computers and other forms of advanced technology, special educators and researchers have increasingly looked for ways in which technology might contribute to the academic success of students with disabilities (Woodward & Reith, 1997). Much of this effort has focused on the use of technology to help students acquire the necessary literacy skills for success in school, with special attention to the ways in which technology can enhance the strategies students use for reading, writing, and studying (Anderson-Inman, Redekopp, & Adams, 1992; Bangert-Drowns, 1993; Elkind, Black, & Murray, 1996; Graham & Macarthur, 1988; Macarthur, Schwartz, & Graham, 1991; McNaughton, Hughes, & Ofiesh, 1997). As secondary and postsecondary schools grapple with providing the types of accommodations and services most suitable for adolescent and adult students with disabilities, they have more and more frequently turned to technology as a way of supporting students' efforts to succeed. These academic environments require considerable self-regulation in a curriculum that demands well-developed skills for studying and learning (Bryant, Rivera, & Warde, 1993; Raskind & Higgins, 1998.) we have adopted the term "computer-supported studying" to describe one such technology-oriented approach.

COMPUTER-SUPPORTED STUDYING: THE CONTEXT

Computer-supported studying is an approach to learning that provides students with the technology tools they need to be professional students. More importantly, it is an approach that teaches students strategies for using these tools in the interest of succeeding in school. There are at least three major attributes of studying that influence the manner in which computer-supported studying works and the types of strategies that students find effective (Anderson-Inman & Tenny, 1989; Anderson-Inman, Horney, Knox-Quinn, Ditson, & Ditson, 1997). Each is described below briefly.

First, studying is basically an independent task. Although students may be asked to study by the teacher ("You will need to study hard to pass this test."), the studying itself is usually done alone, or perhaps with a peer. Because of this reason, strategies for computer-supported studying have to be ones that students can and will do while alone. Second, studying is usually initiated by students because they are going to be held accountable for learning something. Students rarely spend time studying unless it is directed at some activity (e.g. taking a test, writing a paper, speaking lines in a play) indicative of whether or not learning has occurred. Therefore, computer-supported studying must be compatible with the accountability mechanisms that exist in schools. A third point is that studying assumes that the goal is mastery of some content or skill that was not mastered before studying occurred. Obviously, students do not engage in studying in order to do something poorly, rather, they do so in order to do something well. Hence, effective strategies for computer-supported studying must lead to improved performance and meaningful learning, not just keep students on task.
For the past seven years, researchers at the Center for Electronic Studying in the College of Education at the University of Oregon have been investigating ways in which technology can be used to promote successful studying and learning in content-area classes. Although the Center for Electronic Studying is interested in the learning skills and strategies of all students, much of our work has focused on the specific studying and learning needs of students with disabilities. The majority of this work has been funded by the Office of Special Education and Rehabilitation Services (OSERS) in the U.S. Department of Education.

Underlying our investigation into Computer-Supported studying are two converging models of learning. The first emphasizes the information processing and metacognitive skills needed by students for academic success. The model builds from a line of research that focuses on developing effective cognitive strategies for students to adopt and implement as they study textbooks, write papers, and complete school assignments (Harris & Pressley, 1991; Pressley & Woloshyn, 1995). The second emphasizes a more social cognitive perspective on school success in general, and with literacy development in particular (Trent, Artiles, & Englert, 1998).

Research from both of these fields is reflected in our emphasis on instruction that is contextualized and authentic as well as our tendency to scaffold instruction in ways that help students become motivated learners, able to regulate their own academic lives. Technology is seen as a tool to help students with learning disabilities bridge the gap between their current levels of literacy and the literacy expectations of secondary and postsecondary settings in which they are trying to succeed. Technology is not used to remediate student deficits, but rather to support student strengths and enable new types of academic behavior.

In the following paragraphs, we provide a brief overview for three of the projects conducted at the Center for Electronic Studying, each of which contributed to our understanding of how technology can be used to promote successful transition from secondary to postsecondary settings.

Project SUCCESS

Project SUCCESS (Students Using Cognitively-based Computer Enhanced Study Strategies) was a three-year model demonstration project at the secondary level. Individual students at participating middle and high schools were provided with a laptop computer and taught a range of strategies for using the computer as a study tool. Emphasis of the project was on developing and evaluating computer-based study strategies that could help students compensate for their disabilities, while at the same time utilizing their learning strengths. The overall goal was to help students become independent lifelong learners through the use of technology. Instruction was geared to the demands of students' general education classes but usually took place in either a resource room or technology class scheduled specifically for participating students. Details of the three schools involved as demonstration sites, and information about the types of computer-based study strategies taught, can be found in Anderson-Inman, Knox-Quinn, and Horney (1996).

The following is an example of how instruction on computer-based study strategies was integrated into the curriculum. At one of the participating high schools, the U.S. History teacher asked students to learn the sequence of U.S. presidents and key information about each presidential term. To assist a student in Project SUCCESS who was in the class, project staff taught her how to create an electronic outline that could be used for self-testing. The outline listed the years of each U.S. president's term in office as first order topics. Under each topic the student was instructed to list as subtopics the information the teacher wanted the class to learn:
e.g., the president's name, the vice president's name, and the major issues dealt with during the term. Once the student had created the electronic outline, project staff modeled how to study the information in the outline using the "Self-Testing Strategy," an iterative process that requires students to engage in three different steps: (a) Expand and Study, (b) Hide and Rehearse, and (c) Check and Repeat. To implement this strategy the student worked systematically through the outline, hiding and then showing the information under each major topic, testing herself on the content, and then verifying her accuracy by expanding the outline to reveal the material just covered. After using the Self-Testing strategy to prepare for her history test on presidents, the student was encouraged to use the same strategy to prepare for other tests that required remembering a pre-established body of information. Project staff helped her to identify appropriate situations in which to apply the strategy and provided feedback as she adapted it to the varying expectations of other teachers and to new content.

To help other teachers adopt this approach to supporting students with learning disabilities, we developed a manual entitled Computer-Based Study Strategies: Empowering Students with Technology (Anderson-Inman, Horney, Knox-Quinn, Ditson, & Ditson, 1997). Now undergoing its third revision, the manual provides teachers with step-by-step instructions for each computer-based study strategy as well as an array of tips for integrating a program of computer-supported studying into the secondary level curriculum. The study strategies are grouped into five categories: Organizing for School, Reading to Learn, Completing Assignments, Writing Papers and Reports, and Studying for Tests. Underlying all of the strategies is the assumption that reading and writing in an electronic environment is helpful to students with learning disabilities because electronic text is both impermanent and modifiable (Anderson-Inman & Reinking, 1998). Its impermanence fosters confidence because mistakes can easily be eliminated, and its modifiability can be harnessed for learning activities that require information organization and manipulation (e.g., synthesizing information and self-testing).

Project ASSIST

Project ASSIST (Academic Study Strategies using Interactive Supportive Technology) was a three-year model demonstration project similar to Project SUCCESS but focused on implementing a program of computer-supported studying for students with learning disabilities at the postsecondary level. Two schools served as demonstration sites; a two-year community college and a four-year research university, both in a moderate sized city in Oregon. Students participating at each site were loaned a laptop computer to use as a study tool and taught an array of strategies in a three-term course entitled "Computer-Based Study Strategies." The curriculum of this course helped students develop proficiency in computer-based strategies designed to facilitate such activities as time management, analyzing complex assignments, taking notes in class, taking notes from different types of reading material, studying for a test, completing assignments, and writing term papers.

Over the three terms, instruction in the course was increasingly personalized to meet the specific academic needs of each student. By the third term, students were encouraged to purchase their own hardware and software, and project staff provided them with assistance in choosing equipment that matched their individual academic needs and learning strengths. An outreach component of the project was designed to familiarize secondary level teachers and counselors with the program, so they could refer students to postsecondary schools where this form of assistance is available. Although federal funding for Project ASSIST has recently ended, the computer-based instruction and individual guidance it provided to students with learning disabilities have been successfully integrated into the curriculum and support services of both
demonstration sites, ensuring long-term continuation of the program. Recent federal funding from OSERS has also enabled staff at the Center for Electronic Studying to construct an interactive instructional website focused on computer-based study strategies. One of the goals for this website is to provide teachers and students across the nation with the ability to acquire or extend their knowledge and proficiency in the use of computer-based study strategies.

Project CONNECT

Project CONNECT (Computer-based Networked Notetaking for Exceptional Children and Teachers) was a three-year research project designed to investigate the effects of networked notetaking on the content-area literacy and academic performance of students with three types of disabilities: learning disabilities, hearing impairments, or upper extremity dysfunction. Since notetaking is such a common expectation in postsecondary education, becoming skilled in it is essential for success. For participating students with learning disabilities, the goal was to model good notetaking skills within the context of the classroom where notetaking was an expected skill. Secondary and postsecondary students participating in this project were each provided with a notetaker who accompanied the student to content-area classes where notetaking was an essential part of the instructional routine. Both student and notetaker were provided with laptop computers and their computers were wirelessly linked together using small infra-red devices that hooked to the top of the screens. These devices, plus the use of conferencing software that enabled both student and notetaker to share the same workspace, made it possible for notetakers to model good notetaking to students with disabilities in real-time, i.e. while teachers were lecturing and discussions were taking place (Knox-Quinn & Anderson-Inman, 1996).

Figure 1 (below) provides an example of how the computer screen appeared to both notetaker and student. Students were encouraged to read the notes taken by the notetaker, to take their own notes, and also to interact with the notetaker when they needed clarification or assistance. The goal for participating students with learning disabilities was to improve their notetaking skills to a point that enabled them to be gradually weaned from this type of support. Although federal funding, for Project CONNECT has come to an end, networked notetaking has been adopted by at least three school districts and three community colleges in Oregon as a permanent support option for their students with disabilities. In addition, there has been widespread interest in the Project CONNECT dissemination packet, available through the project's website at http://ces.uoregon.edu/connect/dissemform.html. This packet provides teachers and technology coordinators with complete specifications to implement a program of networked notetaking in their schools or colleges.

STUDENTS’ STORIES OF SUCCESSFUL TRANSITION

Described below are the stories of three students who participated in one or more of the above projects. For each student, we have included information about the student's background (student characteristics), information about the type of technology support provided (intervention), and a description of the impact this intervention had on the student's successful transition from secondary to postsecondary school (results). The stories of these three students were selected because (a) each student had a unique set of learning strengths and weaknesses,
(b) the students used technology in different ways and at different times to support their transition from secondary to postsecondary school, and (c) all three students were successful in adopting and applying the technology in a way that appeared to result in improved academic performance.

The stories are presented as vignettes, rather than complete case studies. As such, they are meant to give a glimpse into the experiences of three students as they participated in a program that emphasized Computer-Supported studying as an approach to enhancing academic success at the secondary and postsecondary levels. The vignettes are descriptive in nature, and therefore only suggestive of the impact that computer-supported studying might have on student success.

Veronica' from Project SUCCESS

**Student Characteristics**

Veronica joined Project SUCCESS at the beginning of her sophomore year while attending a four-year comprehensive high school in a moderate-sized city in Oregon. She had received special education services as a student with learning disabilities since the 4th grade. Although her early IEPs targeted reading, writing, and math, her most troublesome areas were reading and writing. Standardized tests consistently found her reading skills to be at least two grade levels below the mean for her age group, and written expression was seriously delayed as well. A reevaluation during middle school led the psychologist to say that she qualified for special education assistance based on her problems in writing alone, with special mention of her significant difficulties in spelling. IQ tests administered when she was 16 revealed a full scale IQ
of 113, with a 24-point spread between her verbal IQ (101) and her performance IQ (125). Veronica had difficulty learning things auditorily and also had problems following a sequence of directions presented verbally.

On the other hand, Veronica was a cooperative student who was still motivated to put forth effort in school. She was painfully aware of her disabilities but continued to believe she could succeed if she tried hard. Through persistent effort she had managed to achieve a grade point average of 2.42 at the end of her freshman year, matching the 2.44 GPA she had graduated with from middle school. She excelled in tasks that relied on visual memory, had strong reasoning skills, and was able to maintain attention to academic tasks that interested her.

**Intervention**

As a participant in Project SUCCESS, Veronica was given a relatively low-end, black and white Macintosh laptop computer (PowerBook 145) for use in her classes, in study hall, and at home. During the class period that she was scheduled to receive resource room assistance, Veronica and nine peers were taught how to use their computers as study tools. In addition to using applications such as word processing to complete assignments, Veronica was taught to use a calendar program for keeping track of her assignments, an electronic outlining program for notetaking and information organization, and an electronic dictionary for searching out definitions to unknown words.

As needs arose in her classes, project staff taught Veronica computer-based study strategies that were likely to be of assistance to her in meeting the demands of her instructors. Each study strategy focused on one type of academic assignment or expectation and was presented in a way that was likely to result in adoption. Project staff followed a process of (a) communicating a set of steps that embodied the strategy, (b) modeling the strategy, (c) guiding the student's first use of the strategy, and (d) encouraging repeated use by helping the student to identify settings in which the strategy was appropriate. Whenever possible, Veronica and other students in Project SUCCESS were encouraged to identify specific academic tasks that seemed problematic and to work with project staff to find technology solutions that could eliminate or reduce the barriers that were preventing success. This was the method that allowed new computer-based study strategies to come into being, i.e., they were formative responses to the very authentic and urgent needs of students with learning disabilities trying to get through high school. When a new study strategy was found to be successful for one student, it was taught to the other participating students as they faced similar academic expectations.

**Results**

Veronica willingly participated in the instruction described above and used the laptop to type her course assignments whenever appropriate. However, it was not until she had an urgent need to write a large scale report using multiple resources that she came to us seeking guidance about how the technology could help her accomplish a specific task. In response to her need, project staff taught Veronica the strategy called "Synthesizing Information" (see Figure 2). This strategy provided students with a four-step process in which details from multiple source materials were inserted into an ever expanding electronic outline comprised of the report's major topics, and then restructured to reflect the student's personal spin on the material (Anderson-Inman, 1995; Anderson-Inman & Zeitz, 1994.) For Veronica, learning this strategy resolved years of confusion over how to go about writing a report in which material from different writers had to be integrated into a whole-- a whole that was clearly linked to the original sources, but also
reflected her personal observations and conclusions. Learning this strategy for organizing and synthesizing information was an "aha" experience for Veronica and one that led to her wholesale adoption of other computer-based study strategies (more details on Veronica's use of the Synthesizing Information strategy can be found in Anderson-Inman, Knox-Quinn, and Horney, 1996, pages 471 & 472).

A review of Veronica's computer files at the end of two years in Project SUCCESS supports the conclusion that she became a "Power User" of the computer for studying and learning (Anderson-Inman, Knox-Quinn, & Horney, 1996). Power Users (as opposed to "Prompted Users" and "Reluctant Users") were those students in Project SUCCESS who developed extensive repertoires of computer-based study strategies and selected effective strategies from their repertoires when faced with a specific academic task or assignment. Furthermore, Power Users were able to use their computers more or less independently and took the initiative to develop new strategies when faced with new learning situations. These students were internally motivated to use their computers for studying and, therefore, willing to overcome the occasional obstacles that always seem to come up when using technology. Power Users truly partnered with their computers and sought additional resources (hardware, software etc.) when they were able to envision new uses for their electronic study tools.

For example, when Veronica started taking French in her junior year, she realized that there must be a spell checker for this language as well. She asked project staff about the existence of such software; they were able to order a French spell checking program that was compatible with her word processor. While waiting for the software to arrive, she asked about it every day, and later, when she had difficulties getting it to work, she sought our help. Veronica had become a motivated learner who believed in the power of computer-supported studying to assist her as a student and wasn't going to let anything stand in the way. Veronica's resource room teacher said she couldn't imagine her as a student without the computer, so completely had she integrated it into her life.

Another example of the impact of computer-supported study strategies was observed during Veronica's junior year when she teamed with another student in the project to complete class work and homework assignments collaboratively. Each student had been given a demonstration on how to network their laptop computers using phone cords and how to use a collaborative writing program for synchronous communication and simultaneous work in a shared writing space. This process used the same software configuration developed for Project CONNECT (see Figure 1). The original idea was that Veronica and her partner could assist each other during study hall without bothering other students. However, the two students went well beyond this original conception by independently transferring it to other settings, working out an arrangement with their history teacher to work collaboratively during class as well. Project staff learned of this new development when we received a request from Veronica and her partner for infra-red devices that would allow the two to work collaboratively during history class without having to be wired together. In their words "we use [the collaborative writing software] every day in history class and the wires are a pain.

Using the system they had designed for themselves, Veronica and her partner were able to keep each other on task during class, support each other's understanding, and complete their work in a timely manner. The history teacher also was very positive about the arrangement, felt Veronica and her partner were doing a great job in class, and indicated that both students now got their work done and in on time. By working together, the students seemed to make up for each other's learning weaknesses while at the same time prompting each other to achieve a higher standard of
performance. Veronica, for example, was constantly exhorting her partner to answer the textbook’s comprehension questions using more complete sentences. Her partner, on the other hand, would tell Veronica to read the text more carefully when she asked him for answers to questions that were clearly covered in the textbook.
Veronica continued to apply what she knew about computer-supported studying through the remainder of her high school career. Her GPA improved each year she was in the program and she graduated from high school with honors. Her parents were so impressed with her improved grades that they helped her to buy a computer. Although accepted at several colleges out of state, she enrolled in the University of Oregon so that she could continue to receive support for her studying by participating in Project ASSIST. From Veronica’s perspective, computer-supported studying had proven to be the path to success in high school; she anticipated that it would serve in a similar fashion as she transitioned from secondary to post-secondary education. Veronica participated in Project ASSIST for one term. At that point, she felt she had obtained the skills she needed to succeed in higher education and decided to continue as a student without the extra support. She is now a successful biology major looking toward graduation, and will be the first in her family to attend and graduate from college.

Joan from Project ASSIST

Student Characteristics

Upon entering community college as a freshman, Joan applied to the Disability Services Office for assistance and was recommended for Project ASSIST. Information from an intake interview during her first week and data gleaned from her school file revealed that Joan had received special education services in high school as a student with learning disabilities and that she identified herself as a "nonreader." Her phoneme recognition was extremely weak, her word identification was very poor, and she seemed to have given up on learning to read. In high school, Joan's reading instruction had focused on phonetic drills and isolated word recognition skills, an approach that had apparently been used in one form or another since elementary school. To acquire content knowledge she listened to books on tape but made no effort to read along with the tape. Joan felt she needed extensive individual support services for reading, writing, and test-taking and was reluctant to try academic tasks on her own.

On the plus side, Joan was articulate as well as inquisitive. She embraced problem-solving challenges and had strong skills in deductive and inductive reasoning. She was able to monitor her own level of understanding and was in tune with her learning strengths and weaknesses. Joan's self-regulation skills were strong and she had no trouble sustaining attention in her academic work or following an instructor's line of reasoning. Joan was also an engaging person, spoke openly about succeeding in college, and was enthusiastic about school in spite of her learning difficulties.

Intervention

Using the information we had, project staff developed a support program for Joan centered around the use of computer-based study strategies. Instead of emphasizing the continued remediation of her deficits related to reading, we focused on maximizing her learning strengths and helping Joan to use her existing language and literacy skills for authentic and meaningful purposes. To accomplish this, Joan was enrolled in the "Computer-Based Study Strategies" (CBSS) class offered for students accepted as participants in Project ASSIST, with the goal of helping her to develop the literacy and learning skills necessary for a successful transition to college.

Joan was provided with a Macintosh laptop computer (PowerBook 145) and attended the class three times a week to learn how a computer can be used as a study tool. She had no previous
experience using a computer, although she had occasionally used a screen reader in high school. In the CBSS class, Joan was taught to use a variety of software programs, with particular emphasis on tools for information organization and manipulation. Classes covered such topics as electronic assignment planning, brainstorming, templating, notetaking from books and in class, and using a variety of self-testing strategies for learning information. The long-term goal was to have Joan adopt the computer as a study aide and gradually eliminate her extreme reliance on various types of human assistance (e.g., scribes and readers).

Results

During the first two weeks, Joan struggled with the computer environment and the pace of instruction. At one point, she left class crying and ready to quit. Part of the problem seemed to be an incompatibility between the study strategies that she was learning in class (that focused on independence and personal responsibility) and the assistance being provided to her by an in-class reader (fostering her continued dependence on others). This arrangement was cumbersome at best, and after three weeks we slowly reduced the time that the aide was present in class. Gradually, Joan began to feel comfortable with our instruction, and she increasingly experienced success with the computer. By the end of the course, Joan had successfully learned and applied a variety of computer-based study strategies to the learning challenges presented in her courses. More importantly, through trial and error, Joan had developed a personalized combination of computer skills and study strategies that she used in very specific ways to minimize the negative impact of her learning difficulties and achieve success in her courses.

Two of these study strategies were (a) the use of symbol-rich concept maps and (b) the use of electronic reading environments. In the former, Joan created concept maps for all her classes using graphic symbols instead of (or in addition to) text in order to represent ideas and their relationships. Figure 3, for example, is a symbol-rich map created by Joan when studying the concept of relative pronouns. When constructing her map, Joan had chosen to represent each relative pronoun by a specific graphic that would prompt her memory through mnemonic association. So, “who” was represented by an owl because of the similarity between the sound it makes (“hoo”) to the word “who.” In a similar fashion, “whom” was represented by a firecracker (“boom”), “whose” was represented by two people (“choose” between the two), “that” was represented by an arrow (it points “that” way), and “which” was represented by a “witch.”

In addition to the graphically rich symbols in this concept map, Joan accurately studied the meaning of relative pronouns by breaking up the textbook’s definition into a proposition – a sentence-like set of linked nodes where each part of the definition is put into a separate node and all are connected with labeled links (see Figure 3). Using devices such as concept mapping, Joan was able to process the information she was trying to learn. She became very skilled at both understanding and representing the key concepts of a course and the interrelationships among these concepts and additional information presented in class. A significant observation in this scenario is that concept mapping at this level requires higher order thinking skills. Concept mapping was an approach that had not been introduced to Joan by previous teachers because they felt she needed to master lower order text-based skills first. By adopting a symbol-rich approach to concept mapping, Joan was able to manipulate ideas on the computer without having to manipulate the representations of those ideas in text. The computer-supported studying strategy helped her reduce her reliance on text (a deficit area) while at the same time, supported her reasoning skills, her problem-solving approach to tasks, and her inquisitive nature (cognitive strengths). In situations where Joan had to read or write, she developed a way to meet the
demands of working with text by adopting and integrating the features of several other types of software. Specifically, she found that when reading electronic text (as opposed to text printed on paper), she could use various types of software to interact with the text in ways that supported her comprehension. For example, Joan had developed a personalized reading system that drew upon the ability of electronic text to be spoken (using text-to-speech software), modified (highlighted, underlined, etc.), linked to other programs (a dictionary and thesaurus), and manipulated into alternative structures (using an electronic diagramming program). She used these programs in an organized and integrated way to help her understand what was written and to complete her assignments.

Another example of Joan's use of computer-supported strategies to assist her reading challenges occurred in the last semester of her first year in community college. Joan's study skills instructor had advised her to skip a phonetic spelling class and to enroll in a grammar class instead. He felt that Joan possessed the ability to understand the relationships between words and segments of text (i.e., clauses) even though she had difficulty decoding words and spelling them. In other words, she had difficulty understanding symbols (text), not relationships between the symbols (grammar).

The textbook used in the grammar course was written by the instructor who, therefore, had an electronic copy and was able to provide the book to Joan on disk. Joan loaded the electronic version of the book onto her laptop computer, enabling her to have electronic copies of all the

Figure 3.
A symbol rich map created by Joan on the concept of relative pronouns, created in Inspiration (Inspiration, Inc.).
reading and homework assignments with her during class. She was then able to utilize her multi-
tasking approach to reading to support her participation in class and her completion of assignments. First, Joan would "read" the assigned pages by using the text-to-speech capabilities built into the computer's operating system. To do this, she would select a section of text to be read, insert the text into SimpleText and then listen to it being read in synthesized speech, using an ear plug to prevent the disruption of other students. When necessary, this process was repeated until she felt the content was totally understood.

To assist with her comprehension of textual meaning, Joan sometimes needed to go beyond merely listening to the text. If there was a word in the text she didn't understand, Joan would highlight the word, and then "copy and paste" it into a desktop dictionary. The dictionary would provide a definition for the word, or synonyms if Joan chose to use the thesaurus portion of the program. Figure 4 illustrates Joan's use of an electronic dictionary to help her construct meaning from the words in her reading assignment. On the left is a window containing a portion of the textbook chapter that Joan is reading. The lower right window shows the American Heritage Electronic Dictionary and its definition for an unfamiliar word that Joan found in the paragraph. By using these resources, Joan could work her way through reading assignments independently, learning the course's content and building her vocabulary at the same time.

Figure 4.
Joan's use of text-to-speech and an electronic dictionary (American Heritage) support her reading.

To complete her grammar assignments, Joan used simple formatting features built into her word processing program (e.g., Bold, Italics, and Underlining), allowing her to isolate segments of text visually and highlight their grammatical relationships. To help her remember the key concepts in the course and the relationships between and among these concepts, she created symbol-rich
concept maps (as described previously), representing the text with graphical equivalents (see Figure 3). Ironically, working within an electronic environment that minimized Joan's need to read and write text helped her succeed in a course that extended her understanding of language and how it is structured.

Joan's use of the computer as a study tool was associated with success in college and increased independence as a learner. By the end of her first year, Joan was not only skilled in applying the computer-based study strategies she had been taught, but also competent at developing strategies of her own. Furthermore, she had learned how to use computer-based study strategies in appropriate contexts and was adept at combining strategies when the task demanded it. Joan is currently pursuing a degree in graphic arts and holds a 3.8 GPA. (She fell one point short of an "A" in the grammar class.) Because of her obvious need for and success with Computer-Supported studying, the Oregon Department of Vocational Rehabilitation recently purchased a Macintosh G3 computer for Joan to use while completing school and transitioning to employment as a graphic artist.

Adam from Project CONNECT

Student Characteristics

When Adam came to our attention, he was a 22-year old undergraduate with learning disabilities majoring in Political Science at a large research university. From elementary school on, Adam had struggled with a severe form of dysgraphia and experienced considerable difficulty making distinctions between his letters when writing by hand. Adam indicated to project staff that he had not learned to take notes in high school and depended on his memory and a lot of hard work to get him through his classes. During his freshman year in college, Adam had played for the varsity tennis team, but he soon became anxious about his less than satisfactory grades. Therefore, he quit the team so he could have more time to study. Adam was very worried about his ever-present low grades and expressed a great deal of self-doubt concerning his capabilities as a student, even though he was extremely attentive in class, appeared to spend long hours studying, and was genuinely motivated to learn. An examination of the handwritten notes Adam had taken in his college courses revealed that they were almost unreadable—even by him—and reflected none of the structure inherent in his professor's lectures.

Intervention

Adam was provided with networked notetaking support in three of his classes at the University of Oregon as part of Project CONNECT. Bob was assigned to Adam as a notetaker and taught him the fundamentals of the computer system as well as how to use the various features of the conferencing software known as Aspects (Group Logic, Inc.) (see Figure 1). Bob first worked with Adam in a Political Science course entitled "Civil Rights and Liberties." The class met three times per week for fifty minutes, and the instructional format was primarily one of lectures with ample opportunity for students to ask questions at any time. During each session, Bob and Adam would wirelessly link their computers, launch a conference using the synchronous writing software, and then proceed to take notes in their respective windows. In addition, Bob established weekly meetings with Adam where they could compare and synthesize notes, literally cutting and pasting from the two computer files they had created in class to create one ideal study guide per week. They would also use this out-of-class time to exchange questions and ideas and to develop ever more useful notetaking and note-studying strategies.
After using the networked notetaking system for a short time, project staff were able to observe a gradual change in Adam's notetaking skills and style. At first, Adam would take very few notes independently, preferring instead to follow his notetaker's lead. That is, when Bob began to type notes in response to something the professor said, Adam followed this "cue" and likewise began taking notes. Within three weeks, however, Adam was able to recognize when the professor said something that was noteworthy. By the end of the first month, Adam was able to take notes simultaneously with or even in advance of Bob's notes appearing on the screen. He no longer needed his notetaker's words as a cue that something important had been said and needed to be recorded.

Even though Adam was gaining confidence in his ability to identify important points in the professor's lecture, he was still unable to translate the professor's ideas into his own words. Adam needed a method to reify the professor's cogent detailed lectures; a way to make the professor's words his own. To help Adam with this, Bob began to employ shortened phrases and a variety of abbreviations to speed up the notetaking process and thereby force a summarization of the information presented, rather than a verbatim replication. Adam became intrigued with this process of writing in short phrases and abbreviations and was soon working to emulate it. In a relatively short period of time, Adam had developed the ability to create and use abbreviations on his own while taking notes from the instructor's lecture. By midterm, Adam was able to take notes using his own sentence structure and his own words, recorded with the abbreviations he and the notetaker had developed for this specific course.

In addition to his difficulties recording the content of a lecture, Adam initially lacked an organizational framework for representing the structure of the lecture. To assist Adam in representing the lecturer's ideas in an organized way, Bob modeled taking notes in the form of a hierarchical outline (with Roman numerals, letters and numbers, etc. marking the various levels.) Although Adam was immediately attracted to this structured way of representing information, he had limited success imitating it while taking notes in class. At home, however, Adam worked to redraft his lecture notes by synthesizing them with the notes Bob had taken, making a single set of electronic notes that retained the outline his notetaker had used. This process helped Adam to understand the organizational structure of the professor's lectures, and he was soon imposing the same kind of structure on the notes he took in class. By midterm, Adam was able – oftentimes quite independently--to take notes during class that closely resembled the structure and content of the professor's lectures. Figure 5 illustrates this change in notetaking skill. On the left is an example of the notes Adam took in class during his first week in Project CONNECT. On the right is an example of the notes Adam created in class during his final week in the project. Project staff also observed that Adam did not ask questions in his class on Civil Rights and Liberties. When questioned about this after class one day, Adam said that he did not feel comfortable asking questions in any of his classes because he felt he didn't "know as much as other students who [did] ask questions." During one of their weekly meetings, however, Adam asked Bob an insightful question related to the First Amendment about legal cases based on the "establishment clause" versus the "free exercise clause." After discussing the question, Bob pointed out to Adam that such a question would be extremely useful to ask the professor during class. Adam indicated that although his increased ability to take notes in class helped him feel comfortable using the language of the course outside of class, he still felt uncomfortable asking questions in class. Nonetheless, during his second term with networked notetaking, Adam's confidence as a student had increased to the point that he was asking questions of his professors in front of the entire class.
By the end of his first term with Project CONNECT, Adam was completely successful at using the computer to take efficient and representative notes in class. For the first time in his life, he felt confident as a student. Bob continued to work as Adam's notetaker for two terms, after which the assistance was gradually eliminated. Adam continued to use the computer to take notes in his courses, right up until the time he graduated from the university. Adam's grades also improved noticeably, reaching a full grade point higher than they had been prior to his involvement in the project. In Adam's words, "I take notes ten times better now." Upon their son's graduation, Adam's parents wrote a thank you note that expressed their appreciation for networked notetaking as the change agent that led to their son's success in college.

DISCUSSION

All three of the interventions described above approach the learning situation as an environment that presents students who have learning disabilities with hurdles that need to be overcome in order for them to achieve academic success. Although there are probably many effective ways for students to overcome these hurdles, we feel that technology can have a profound impact on reducing the size of the hurdle or increasing the student's ability to jump over it. This is a very relevant and functional approach to the problems that students with learning disabilities face as
they transition from secondary to postsecondary school, and one that relies heavily on both explicit instruction (e.g., teaching computer-based study strategies) and implicit instruction (e.g., scaffolding their use in authentic school contexts). The first builds from the literature on teaching cognitive strategies to enhance learning (Harris & Pressley, 1991; Pressley & Woloshyn, 1995), while the second is more compatible with the tradition of social constructivism (e.g., Trent, Artiles, & Englert, 1998; Vygotsky, 1978). Both forms of instruction require students to adopt a problem-solving approach to school-related-tasks, and both function successfully only when students assume personal responsibility for their own learning.

The conceptualization that these two approaches to teaching and learning can comfortably coexist has been increasingly discussed in the literature. Harris and Graham (1998), for example, make the case that teaching skills and strategies is not incompatible with a constructivist orientation to learning. Calling for "coherent, integrated instruction," Harris and Graham recognized that the learning challenges faced by students with disabilities are often best met by integrating meaningful forms of explicit instruction within a larger constructivist approach. These researchers advocate for learning communities where students are provided with whatever level of instructional support is needed (e.g., from explicit instruction to self discovery) to result in conceptual understanding and the ability to apply what has been learned. In a similar fashion, Mercer, Jordan, and Miller (1998) describe a "continuum of constructivism" where explicit instruction and modeling are used to introduce a new skill or strategy, scaffolding is used to provide guided practice in authentic contexts, and frequent feedback is used to promote reflection and encourage self-regulation.

Since the beginning, our work on computer-supported studying has been viewed in terms of strategy instruction, with particular emphasis on the metacognitive and procedural strategies that lead to increased content-area literacy and, therefore, improved performance in classes at the secondary and postsecondary levels. More recently, we have begun to appreciate the explanatory power of the social cognitive perspective, in which literacy is viewed as a socially situated problem-solving process. In our work with students, we find evidence supporting the view that literacy is shaped not only by available language practices, partners, and texts, but by the ways people interpret the situations they find themselves in, the goals they set, and the strategies they control (Flower, 1994). A social cognitive view of literacy emphasizes the use of literacy as action; i.e., students using reading, writing, and spoken language in purposeful ways (Resnick & Resnick, 1989.) Consequently, literacy develops when students engage in meaningful literate acts where expression and self-reflective actions are at the center of the meaning-making process.

Successful transition for all three of the students described in this article was closely linked with their improved abilities to handle the reading and writing demands of the postsecondary environment. Supported by technology, each of the students launched into literate activities that were new and challenging. These activities were closely tied to the learning demands of the school environment. Technology was used to help students meet the demands successfully. At times, technology served in the role of "cognitive prosthesis" (Cavalier, Ferretti, & Okolo, 1994), replacing an ability that was missing or dysfunctional. At other times, technology served more in the role of "cognitive partner" (Salomon, 1993), supporting the student's efforts to accomplish a task and shouldering some of the cognitive burden. In both roles, technology seemed to help participating students become more effective as students by (a) increasing their abilities to manipulate information in ways that were personally meaningful, (b) improving their abilities to accurately monitor their study progress, and (c) supporting them as they took personal
responsibility for their own learning—all characteristics of effective studiers (Anderson-Inman, Knox-Quinn, & Horney, 1996; Grabbe, 1988).

As described in the introduction, the use of technology to support students' efforts to succeed in secondary and postsecondary settings has attracted considerable attention over the last several years. What seems to be missing, however, is a coordinated effort to provide students with the technology they need (and the training to use it) as an automatic part of the transition process. More needs to be done to analyze the instructional expectations of postsecondary educational environments and prepare students to use technology in ways that will help them meet those expectations. Of the three students described above, only Veronica had instruction in the use of technology for studying at the secondary level, and then only because she was a participant in a federally funded project.

This failure to consider technology as a tool for supporting success in their secondary school and/or transition to postsecondary settings was typical of all students who participated in the three projects we have described. At best, students had been taught to use a word processor, usually as part of a "computer literacy" course required of all students in the school. The 1997 amendments to IDEA legislation specifically mandate that assistive technology be considered with greater depth when planning a student's IEP. It is our hope that this mandate will also influence the transition planning now expected for all students with disabilities, beginning at the age of 14. For students who expect to pursue postsecondary education, a curriculum of computer-supported studying at the secondary level would provide the skills and experience necessary for students to transition smoothly to almost any institution of higher education. When computer-supported studying is not provided to students at the secondary level, postsecondary institutions should shoulder the responsibility.

There is much to learn, however, about how best to teach and support students in their use of technology for the purposes of studying. Not all participants in the projects described above responded to our instruction in the same way or to the same degree (Anderson-Inman, Knox-Quinn, & Horney, 1996). Although many students adopted the ideas and strategies enthusiastically, some showed considerable reluctance, and a hesitance to change long-held views of "what works." Anderson-Inman (in press) discusses five types of issues that affect adoption of computer-supported studying as an approach to maximizing the success of students with learning disabilities: access issues, motivational issues, curriculum integration issues, labeling issues, and funding issues. Of these, motivational issues are probably the most difficult to solve. Many students with LD have never developed strategies for solving the problems presented them in school and often do not even recognize that specific problem-solving strategies are required. Furthermore, they have not developed the habit of monitoring their cognitive processes and so can not identify which of their usual study techniques are successful and which are not. Changing these habits is not easy and requires instruction that models higher level cognitive abilities and helps to externalize (make visible) the metacognitive strategies required for complex learning (Trent et al., 1998).

Whether or not students adopt and internalize what they are taught, however, is dependent on two important and interrelated factors. First, students need to be engaged in real-world tasks that make sense given the social environment (school) in which they are expected to achieve. In our projects, computer-supported studying was not "add-on" to the curriculum as much as it became a way to help students make sense out of and survive within the existing curriculum. Second, computer-supported studying must be provided to students in ways that give them a sense of power over their own lives. This empowerment requires an adoption process that involves
students in decision-making, promotes self-reflection, and works toward student independence. Once participating students had acquired the technology for effective studying and the knowledge of when to use it, they felt in control of their learning, something most had never before experienced. Computer-supported studying may not be the solution for all students with learning disabilities, but we believe it can have an amazing positive impact on the academic performance and transition success of students and motivate them to succeed.

REFERENCES


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